THE INTEGRATION OF CREATIVE DRAMA INTO SCIENCE TEACHING

by

BRACHA (BARI) ARIELI

B.Sc., Tel-Aviv University, 1979
M.Sc., Tel-Aviv University, 1983

AN ABSTRACT OF A DISSERTATION

submitted in partial fulfillment of the requirements for the degree

DOCTOR OF PHILOSOPHY

Curriculum & Instruction
College of Education

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Manhattan, Kansas

2007

Abstract

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Quantitative and qualitative data analyses demonstrated that students who studied science through creative drama exhibited a greater understanding of scientific content of the lessons and preferred learning science through creative drama. Treatment group students stated that they enjoyed participating in the activities with their friends and that the creative drama helped them to better understand abstract scientific concepts. Teachers involved with the creative drama activities were positively impressed and believed creative drama is a good tool for teaching science. Observations revealed that creative drama created a positive classroom environment, improved social interactions and self-esteem, that all students enjoyed creative drama, and that teachers' teaching style affected students' use of creative drama.

The researcher concluded that the inclusion of creative drama with the FOSS unit enhanced students' scientific knowledge and understanding beyond that of the FOSS unit alone, that both teachers and students reacted positively to creative drama in science and that creative drama requires more time.

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CHAPTER 1 - INTRODUCTION

"What science means and stands for is simply the best ways yet found out by which human intelligence can do the work it should do"

- John Dewey

Introduction

Living at the turn of a millennium, when competency in science and technology is essential for the future workplace, a scientifically literate population is the key to the ability to compete successfully in a global economy (National Research Council (NRC), 1996, 1999, 2000, 2001, 2005; The Secretary's Commission of Achieving Necessary Skills (SCANS) report, 1991; U.S. Department of Education (USDOE), 1991, 1992, 1999; U.S. Department of Education (USDOE), 2000a)). Scientific knowledge and information-based technologies are added into our lives at an enormous pace. Abundant information is acquired through scientific and technological inventions such as computers, optical fibers, digital imaging and the Internet. Information seems almost endless (NRC, 1996; USDOE, 2000a). Every American's workplace has changed a great deal within a time span of a single generation. The character of work itself has been dramatically transformed, largely through the application of information-based technologies and systems. Tomorrow's workers must be flexible and intellectually compliant, multi-skilled, and multi-dimensional (The Getty Education Institute for the Arts (GEIA), 1996; SCANS, 1991; USDOE, 2000a). Business leaders look for knowledgeable and creative employees, considering knowledge as the new wealth and workers as the most valuable resource. Yet, our educational system faces problems of ineffective science teaching, low academic performance in science and mathematics (USDOE, 1992; USDOE, 2000a) National), and low participation rates, especially of females and minorities in advanced science and mathematics classes (Blake, 1993; Monhardt, 2000; Oakes, 1990; Pollina, 1996; Sloat, 1992).

Many factors contribute synergistically to the current situation in science education. First is the character of science itself. The core of science is abstract concepts, which makes science a hard-to-teach subject, especially for young students (Carin, 1997; Gega & Peters, 1998). Second, many teachers view their scientific knowledge as inadequate, and try to avoid teaching it, especially in the primary grades, in which students may not have mandatory tests on their scientific knowledge (UDSE, 2000a). Third, researchers blame students' low academic achievements in science and mathematics on traditional and ineffective teaching (Goodnough, 2001; Leonard, 2000; UDSE, 2000a; Weld, 2000). In teacher-centered classrooms, lectures and reliance on textbooks and worksheets dominate. Students are neither challenged to use inquiry and think critically nor are they encouraged to use creative ways to solve problems. Students' different learning styles (Kolb, 1984) and multiple intelligences (Gardner, 1983; Goodnough, 2001) are not addressed. Science is not appealing or exciting and possesses little relevance for students' everyday lives (NRC, 1996; Penick, 2000; SCANS, 1991; Shamos, 1995).

Concerns with science education are rooted within larger concerns about the effectiveness of schools. Worried Americans have raised concerns about various social, economic, and educational problems and inequities. Nasr (1994, p. 3) describes the state of education in schools as follows:

> We are approaching the twenty-first century and our schools are still performing a very traditional role in an archaic methodology. When everyone - from politicians to community leaders, parents, teachers, universities and the work place – is screaming about the low academic standards, it is really a wonder why all this feedback is not making a dent in the educational system. We are still isolating the school from community life; we are still

> compartmentalizing knowledge; we are still not giving individual attention to students (with all that this implies), and we are still turning student assessment and evaluation into a mechanical routine that does not come close to ascertaining native talent and quality performance.

Calls for reform in science education (American Association for the Advancement of Science (AAAS), 1989, 1993; NRC, 1996; USDOE, 1994; USDOE, 2000a) highlight the need for science to be accessible to all students (Goodnough, 2001; Yager, 2000). According to Goals 2000: Educate America Act (USDOE, 1994), American students were expected to lead the world in their achievements in science and mathematics by the year 2000 and every American adult was to be scientifically literate. These expectations were not reached. The American adult population is still not scientifically literate and does not have a ‘scientific habit of mind’ (Hodson, 1998; Shamos, 1995; USDOE, 2000a, Weld, 2000). American eighth-grade students were fifteenth (together with five other nations, out of a total of 41 nations evaluated) in the TIMSS science and mathematics achievement tests in 1999 (USDOE, 2000a; USDOE, 2000b), and minorities’ achievement and participation in science remain low (Monhardt, 2000).

Research shows that students who were tracked in elementary school into lower level groups in science and mathematics considered themselves unable to succeed and were not likely to take advanced science classes in middle school and in high school (Heck, 1998; Monhardt, 2000; Oakes, 1990). Also, teacher-dominated classrooms, in which science teachers use traditional lectures, demonstrations, a few experiments, and paper-and pencil assignments and tests are not appealing to many students, especially girls and minorities (Monhardt, 2000; Oakes, 1990; Sloat, 1992; Veronesi, 2000). Scientific illiteracy and anti-science opinions are common among the majority of American adults and students, who report that the science they learned in school was boring and not useful (Penick, 2000; USDOE, 2000a).

Three major components should be considered in the search for a solution to ineffective science teaching (USDOE, 2000a). First, the major goal of science education is scientific literacy that leads to scientific knowledge and the acquiring of higher-level thinking and problem solving skills (Shamos, 1995; Zoller, 1999). Second, according to business leaders, the special abilities needed by the 21^{st} century's multi-dimensional and sophisticated workforce are knowledge and creativity (GEIA, 1996). Third, art education can potentially impact students' achievement by using multiple resources, thinking 'outside of the box,' looking for creative problem solving, and communicating ideas (National Endowment for the Arts (NEA), 1995; Rubin and Merrion, 2002). Creative drama is a multi-dimensional and improvisational form of art, designed especially for educational purposes. It emphasizes the thinking and creating processes rather than only the products. It combines all the arts, such as drama, music, dance, movement, rhythm, 'rap', communication, puppets, masks, drawings, role-plays and vignettes (Bailey, 1993; McCaslin, 1996). Teaching science through creative drama may be a viable solution.

In this study, the researcher explored the integration of creative drama into science teaching as an instructional strategy for enhancing elementary school students' learning of scientific concepts. The following sections provide the background for this study by providing a review of the reform movement in science education and the modern workplace, and an overview of the research study.

The Reform Movement in Science Education

Modern society is constantly looking for solutions to the problem of how to better prepare the next generation for the future. The American education system has experienced many changes aimed at improving schools so that learning will be useful and practical for life, for work, and for academic achievement (Shamos, 1995; Yager, 2000). As many as 40 major education reforms were implemented in the first 150 years of U.S. history (Hurd, 1991a). Over the past fifty years, science education underwent tremendous changes, gaining, losing, and regaining public attention, while receiving enormous budget increases (Roth, 1989; Shamos, 1995; Yager, 2000). Despite the reforms and changes, policymakers, scientists and science educators remain concerned with science achievement and course-taking patterns of American students, as well as with the lack of scientific literacy among the general public (Kuhn, 1996; Shamos, 1995; Yager, 2000). All are looking for feasible, practical solutions to this long-term problem.

The goals of science education are the most important component in scientific literacy, which by itself is the most important key in the outlook for success in the global economy and academic world of the 21st century (NRC, 1996; SCANS, 1991; USDOE, 2000a). These goals were the center of an on-going debate throughout the twentieth century between science teachers and scientists on one hand and science educators, historians and philosophers on the other hand (Kuhn, 1996; Shamos, 1995). Science teachers and scientists argued that the main reason for school science is to increase and maintain a pool of scientists and citizens who pursue science-related careers, while philosophers and educators asserted that science teaching should build a more scientifically literate society. Karl Pearson was the first to mention science education as a means of developing 'thinking habits,' as early as 1900 (Pearson, 1900, cited in Shamos, 1995, p. 79):

> The classification of facts, the recognition of their sequence and relative significance is the function of science, and the habit of forming a judgment upon these facts unbiased by personal feeling is characteristic of what may be termed the scientific frame of mind… The scientific habit of mind is one which may be acquired by all, and the readiest means of attaining to it ought to be placed within the reach of all.

John Dewey, a respected philosopher and educator, invoked the educational and scientific communities, discussing how to instill 'scientific methods' and measure 'scientific attitude' in students (Dewey, 1915, 1921, 1934). He argued that society needs graduates with a 'scientific frame of mind' or 'scientific habits of mind' and voiced the idea of 'social literacy' as a major purpose of science education (Dewey, 1909, cited in Shamos, 1995, pp. 77-78):

> The business of the high school is primarily a social business, not of creating a class of specialists. …[a] subject shall be so taught as to make individuals more intelligent and hence more competent in doing their share in social life. Contemporary civilization rests so largely upon applied science that no one can really understand it…; on the other hand, a consideration of scientific resources and achievements from the standpoint of their application to the control of industry, transportation, communication, not only increases the future social efficiency of those instructed, but augment the immediate vital appeal and interest of the subject.

Dewey wanted schools to promote a more intelligent population through science education, a population that could carry out the development of 'scientific habits of the mind' by exposing students to scientific methods.

> …The formation of scientific habits of the mind should be the primary aim of the science teacher in the high school. … The methods of experimental inquiry and testing which give intellectual integrity, sincerity and power in all fields, rather than those which are peculiar to his specialty are what the high school teacher should bear in mind. A new type of mind is gradually developing under the influence of scientific methods. (Dewey, 1909, cited in Shamos, 1995, pp. 78-79).

The most important outcome of general science education, according to Dewey, is having a scientific attitude. This attitude is expressed by instilling rational thought, reflective thinking, open mind, intellectual integrity, observation and interest in testing opinions. Dewey had enormous prestige in educational circles. Hence, his views on the social or 'good citizenship' purpose of science education were never tested. Many science educators in the 1920s and 1930s agreed that the value of scientific thinking expands towards every course in every subject, but most teachers' efforts to practice Dewey's theory in their classrooms have failed (Shamos, 1995). It is believed that Dewey's persistent ideas about the 'scientific attitude' triggered the scientific literacy movement (Shamos, 1995).

The horrifying results caused by the scientific/military invention of the atomic bomb in World War II ignited a deep concern among scientists and educators. They assumed that similar catastrophes would be prevented only if the U.S. had more scientists and a more educated public to back-up civilian control over nuclear energy sources (Shamos, 1995). In 1954, the National Science Foundation (NSF), whose primary function was supporting basic and applied research in science and engineering, began funding educational programs designed to increase the number of scientists and engineers. This trend intensified in 1957, after the Russians launched Sputnik to orbit earth, thereby besting the U.S. in the space-race. Policy makers' concerns that the Soviet Union not surpass the United States in scientific and technological achievements led to massive education reforms in the U.S. (Shamos, 1985; Yager, 2000). The NSF's annual education budget was increased from three and a half million dollars to sixty-one million dollars and its permission to support science, mathematics and engineering education at all levels was broadened (Shamos, 1995; Yager, 2000). In 1958, the U.S. Office of Education received a budget of several billion dollars for improvement in science and mathematics education. The money was used by local school systems for remodeling facilities and buying textbooks and teaching aids.

The science education reforms of the late 1950s and 1960s, influenced and led by scientists, shifted the fulcrum of science education by aiming to turn all students into future scientists, and by teaching science through inquiry (Roth, 1989; Shamos, 1995, Varrella, 2000; Yager, 2000). Education reformers considered curricular and instructional changes more important than any change on the part of the teachers. They focused teaching on specific knowledge, practice, and skills that professional scientists acquire. Scientists from various disciplines promoted only visions of their disciplines to be taught in schools and overlooked the broad interdisciplinary picture of science. In this mind-set, science teachers and new textbooks promoted new science courses, ignoring the subject of technology. Technical careers could be learned in vocational programs for non-college bound students (Yager, 2000). Inquiry was introduced as a major approach in science teaching, but students ended up doing textbook-directed 'cookbook' activities taught by teachers who believed that textbook content and direct instruction are the best ways to ensure the success of Post-Sputnik reforms (Varrella, 2000, Yager, 1991, 1993, 2000). Teachers followed instructions by implementing the new curricula but were not considered as partners for change. The terms "teacher-proof curricula" and "curriculum-proof teachers" were coined in this environment of reform (Shamos, 1995; Varrella, 2000; Yager, 2000).

Project Synthesis, a comprehensive study, was funded by the NSF in 1978 when science was blamed for the political, societal and environmental crises of the mid 1960s and 1970s, and public support of science stopped (Shamos, 1995). Project Synthesis identified four needs of modern science education: personal needs, societal needs, career awareness, and academic preparation (Yager, 2000) and concluded that science education goals needed to change focus, to step back from an emphasis on academic preparation (promoting science academic careers for a few students only) and turn toward an emphasis on preparing all students to cope with science and technology in their daily lives so they become knowledgeable and responsible in making decisions for science-related problems that might occur in the future. The new challenge for science education, according to Project Synthesis, was to increase students' understanding of the impact of science and technology on their individual lives as well as on national-scale issues (Yager, 2000).

In 1983, an economic instability caused by the perceived dominance of industrial nations, such as Japan and Germany, shook the political and educational establishments and appeared as a threat to the American democracy (Yager, 2000). The NSF reacted by funding studies about how humans learn. These studies, some of which still continue, provided useful information and guidance for teachers, educators and policymakers (NRC, 1999).

Project 2061: Science for All Americans, launched in 1985 by the American Association for the Advancement of Science (AAAS), envisioned "…a nation whose citizens are science literate....Voters that could make informed decisions, workers that could master new technology. And everyone could understand the great scientific and technological advances of the day." (AAAS, 1989, p. v). Science educators thought they should make an effort to provide students and the general public with a broader understanding of science and technology. Science/ Technology/ Society (STS) perspective became the new approach in school science teaching. The goal of science education shifted from creating scientists to creating scientifically literate citizens, who understand enough science to be able to solve problems and make smart decisions regarding social science and technology issues (AAAS, 1989). Curricula at all levels were revised and technology was put back in school science classes (Roth, 1989; Shamos, 1995). Summer programs and university fellowships were introduced to identify and support talented students in pursuing careers in science. Informal education, such as the promotion of science instruction through museums, popular lectures, and television, was introduced as a method for educating the general population in basic science.

The Goals 2000: Educate America Act, signed into law in 1994, constituted a framework for improving teaching and learning by the 21st century. Three National Goals in this program have special relevance to science education and to this study (USDOE,1994):

- By the year 2000, all students will leave grades 4, 8, and 12 having demonstrated competency over challenging subject matter including…science… and every school in America will ensure that all students learn to use their minds well, so they may be prepared for responsible citizenship, further learning, and productive employment in our Nation's modern economy.
- By the year 2000, United States' students will be first in the world in mathematics and science achievements.
- By the year 2000, every American adult will be literate and possess the knowledge and skills necessary to compete in a global economy and exercise the rights and responsibilities of citizenship (Goal 2000: Educate America Act (1994): Sec. 102. National Education Goals (6) (A)).

The publication of the National Science Education Standards (NSES) in 1996 added momentum, focus, and consensus to the effort to improve science education (NRC, 1996). The NSES promotes the use of inquiry and a constructivist approach to science teaching, while encouraging the use of real life contexts and current issues. Re-inclusion of technology in the science curriculum shows students that science and technology are interconnected and equally important (Yager, 2000). Students are expected to:

- Experience the richness and excitement of knowing about and understanding the natural world;
- Use appropriate scientific processes and principles in making personal decisions;

- Engage intelligently in public discourse and debate about matters of scientific and technological concern;
- Increase their economic productivity through the use of knowledge, understanding, and skills of the scientifically literate person in their careers (NRC, 1996, p. 13).
- Science should "reflect the intellectual and cultural traditions that characterize the practice of contemporary science" (NRC, 1996, p. 19).

The massive science education reforms of the 1960s, 1970s, and 1980s proved ineffective and eventually were judged failures (Goodnough, 2001; Ramsey, 1993; Roth, 1989; Shamos, 1995; Yager, 2000). Even Goals 2000 has not attained its aims. Although the public's awareness of and sensitivity to science-based societal issues (such as the atomic bomb, stem cells, cloning, genetic engineering, energy sources and environmental issues) has increased compared to fifty years ago, the adult population is still not scientifically literate and does not have a 'scientific way of mind' (Goodnough, 2001; Hodson, 1998; Shamos, 1995).

The academic performance of U.S. students in science and mathematics remains far from Goals 2000's aim that American students' achievements will be the first in the world in science and mathematics. The 1999 report of the Third International Mathematics and Science Study (TIMSS-R) ranks U.S. fourth-grade students above the international average for science and mathematics achievement in 1995, but U. S. students dropped to the international average in eighth grade. By Hight school graduation the American students were almost last among 41 nations whose students participated in this study (USDOE 2000a).

A national Commission on Mathematics and Science Teaching for the 21st century was announced by the Secretary of Education on July 1999. The mission of the committee was to investigate and report on the quality of mathematics and science teaching in the nation, and to consider ways of improving recruitment, preparation, retention and professional growth of mathematics and science teachers in K-12 classrooms nationwide. The committee, headed by former astronaut and Senator, John Glenn, completed its work and reported its findings to the Secretary of Education on September 2000. The report expressed concerns about the state of science and mathematics education, teachers' qualification and scientific literacy. The committee suggested three goals and action strategies to achieve these goals. John Glenn, in his letter to the Secretary said that if the goals "are ignored, our children and our nation will soon pay the high price that always accompanies apathy." The goals suggested were: 1) Establish an ongoing system to improve the quality of mathematics and science teaching in grades K-12; 2) increase significantly the number of mathematics and science teachers and improve the quality of their preparation; and 3) improve the working environment and make the teaching profession more attractive for K-12 mathematics and Sciences teachers (USDOE, 2000a).

In 2006, Project Kaleidoscope (PKAL) presented its first report. This report analyzed a selection of reports that were issued since the mid 1980s and had shaped the efforts to strengthen undergraduate learning environments in science, technology, engineering and mathematics (STEM) over a period of 17 years. The 2006 report reflects on an increasing concern at the national level and within academia about America's present and future capacity to be a world leader in innovating and applying scientific and technological advances to address critical societal problems. Many groups expressed concerns about the situation, including business and government groups, professional societies, foundations and academics and private-public partnerships operating at the national level. PKAL's goal is to strengthen undergraduate STEM. From the report it seems that what is urgently needed is fundamental change of the entire system of undergraduate education. Short-term, piece-meal, sector by sector, under funded and uncoordinated efforts will not move America confidently and creatively forward in the next decades of the 21st century (Project Kaleidoscope, 2006).

In contrast to the pessimistic Project Kaleidoscope, a more optimistic report concerning the state of teacher education, Turning The Tide, was released in 2006. The National Association of System Heads (NASH) was founded for the purpose of seeking improvement in the organization and governance of public higher education systems. It serves as the forum for the exchange of views and information among its members and with other higher education organizations. Five years ago, the National Commission on Mathematics and Science Teaching, led by Senator John Glenn, identified the pivot point for change and improvement in K-12 math and science education: the nation's teachers and the institutions that train them. Turning the Tide (NASH, 2006) describes the strategies that are being implemented: 1) Engaging arts and sciences faculty as leaders of reform; 2) developing new pathways and incentives to enter the teaching profession; and 3) establishing ambitious, widely shared and measurable goals with support and accountability for action. These initiatives are still growing and evolving, but there are already encouraging results, such as the nine higher education institutions of the Texas A&M University System that have collectively increased their annual production of teaches by 50%, are turning out nearly four times as many African American teachers, three times more math teachers and twice as many science teachers than in 1999. Another example is the NYC Teaching Fellow Program, which since 2000 has recruited and trained more than 7000 college graduates and mid-career professionals to teach in NYC public schools. About half of them are currently working in high-need subject areas and high-need schools. This report leaves the reader with the hope that something in the system of science teaching will change, at least in the number of qualified teachers, and hopefully in their quality, too.

A debate that started nearly a hundred years ago about the goals and the context of science education has been settled, at least for now. Nowadays science education is accepted as more than just information and concepts. It reflects “the intellectual and cultural traditions that characterize the practice of contemporary science” (NRC, 1996, p. 19). Science education is perceived as a broad approach that enhances students’ understanding of the nature of science. The context and processes of learning are at least as important as the concepts and processes of science that characterized science education for most of the 20^{th} century (Dass, 2000; Goodnough, 2001; Yager, 2000). Scientific literacy and the development of students’ higher order thinking skills are the keys to future success for our younger generations.

The Modern Workplace

The modern high-performance workplace is now the driving force for education reforms (NRC, 1996; Shamos, 1995). Science educators and reformers agree that higher order cognitive skills are their major goals because these are necessary to acquire scientific literacy, which is essential for the future workplace and responsible citizenship.

Overwhelming support for these goals has come recently from another direction: leaders in the U.S. business world. Their reaction would have been surprising more than a decade ago, but not today. In 1991, the Secretary of Labor and members of the Secretary’s Commission on Achieving Necessary Skills Committee (SCANS) published a letter to parents, employers, and educators reporting results of a12-month study done by the committee, which found the workplace was in a process of tremendous change. The committee examined the implications of these changes for learning, and wrote, “We understand that schools do more than simply prepare people to make a living. They prepare people to live full lives – to participate in their communities, to raise families, and to enjoy the fruit of their labor.” (SCANS, 1991, p. v).

Enormous changes have occurred in the workplace, causing a dramatic change in its attitudes and expectations of the modern workforce (GEIA, 1966; NRC, 1996; SCANS, 1991; USDOE, 2000a). GEIA (1996) describes it metaphorically: “The express train of the 21st century has left the station, and the typical workers of just a few years ago are standing on the platform – waving good bye from the rapidly receding 200-year history of industrialism.” (p. 1).

An information-based-systems era and the whole character of work are changing the workforce, the equipment and the attitudes towards expectations from employees, their knowledge, their skills and their responsibilities. High-paying but unskilled jobs are disappearing and traditional jobs are changing. Electronic and digital machines replace old fashioned, hand-operated ones. Computers are installed into almost any device and computerized systems leave almost no place for human errors in controlling operations. Communication devices connect multiple machines into multi-dimensional and multi-system units. Service has become the dominant sector of the American economy, replacing the manufacturing sector (GEIA, 1996; SCANS, 1991).

Management philosophies have changed to bridge the needs of the marketplace. Business leaders are more concerned with the lack of creative thinking and knowledge than with interest rates or inflation. The workers of tomorrow need multiple skills, knowledge in many dimensions, and flexibility. Knowledge is the new intellectual capital and ideas are the core of innovative business (Before It’s Too Late, 2000). In order to stay competitive in the world community, many companies are adding Chief Knowledge Officers (CKOs) to their staffs (GEIA, 1996). Workers in the information-age economy are the most important resource. They need to be sophisticated and intellectually compliant to possess a wide range of higher order thinking skills in order to use creative ideas and translate them into success (SCANS, 1991; Zoller, 1999).

Educated workers should be critical and analytical learners, confident decision-makers, problem posers and problem solvers, imaginative and creative thinkers. They need to think and work across traditional disciplines, analyze ideas and integrate knowledge. Not bound by conventional modes of thinking, they should be able to think “outside the box” (GEIA, 1996; NRC, 1996; SCANS, 1991). Modern workers need to possess and use excellent communication and interpersonal skills. They need to know how to work cooperatively, and how to work out conflicting points of view. They need to be persistent, high achievers.

The characteristics needed by the intellectual/modern worker point toward the ‘scientific frame of mind’ sought by science education. There is a strong connection between the goals of science education and the workplace. Here is how these connections are presented in an ad by GE (Business Week, 1996, April 28): “In schools across the country, tomorrow’s work force is being shaped today. Shaped by tools that teach children to use their imagination, that encourage them to create, to perform. And to dream. … Students who appreciate the conceptual as well as the analytical are the ones who’ll create the innovations of tomorrow.” (p. 4).

Changes in the workforce have important implications for school systems: the SCANS report indicates that more than half of our students leave school without the knowledge or the skills required to find and hold a good job. Low skills lead to low wages and low profits; unskilled youth will never be able to earn a decent living and, in the long run, will damage the quality of life of the whole American nation. The solutions suggested by SCANS call for the nation’s schools to “be transformed into high-performance organizations….All American high school students must develop a new set of competencies and foundation skills if they are to enjoy a productive, full, and satisfying life” (p. VI).

If the U.S. wants to compete and succeed in a technologically driven economy, its population and especially its younger generation need to be more scientifically literate (AAAS, 1989; GEIA, 1996; NRC, 1996; SCANS, 1991; Shamos, 1995; USDOE, 1994; USDOE, 2000a). Scientific literacy has become more complicated because of the increased ethnic diversity of the American population (Romjue & Collins, 1996). Demographics show that minority populations have been increasing at greater rates than those of the European-American majority (Duhon-Sells, 1994). Sometime before the year 2050 the United States will become a 'majority-minority' nation (GEIA, 1996). This trend will affect scientific literacy and the American workforce, mainly because the increased diversity occurs in populations that historically achieved and participated less in science. The document 'America 2000: An Education Strategy' (released in 1991 by the U.S. Department of Education) warns that by the year 2000, 68 % of the American workers will be minorities and women who are not adequately prepared for scientific, high-tech jobs. This situation threatens the quality of life and America's ability to compete in the world economy (Atwater, 1989; James, 1991; NRC, 1996; Shamos, 1995; USDOE, 2000a).

Gerstner et al. (1994) observed that even though schools should help all students acquire certain competencies (e.g., workplace skills, basic skills, and thinking skills) most students are apparently not mastering them. Learning to use the scientific way of critical thinking and problem solving will eventually help students acquire better personal and workplace skills (GEIA, 1996; Goodnouth, 2001, SCANS, 1991; Weld, 2000). By stimulating curiosity, enthusiasm, and eagerness to learning science in elementary school, and by using the right teaching methods (Goodnough, 2001; NASH, 2006; NRC, 2001; Penick, 2000), class atmosphere and teacher encouragement, more students will take science classes in high school and college, and will become scientifically literate citizens (Oakes, 1990).

Creative drama as a teaching tool has been shown to stimulate students' curiosity, reduce insecurity, support self esteem, contribute to positive class atmosphere and encourage participation in class activities (Bailey, 1993). Using creative drama for teaching science may be a successful way to achieve the goal of raising students' curiosity, interest in science, and helping them eventually to become scientifically literate citizens.

Summary of the Problem

The American education system failed to achieve its goals of American students leading the world in science and mathematics achievement and of all American adults achieving scientific literacy by the year 2000 (Goodnough, 2001; Shamos, 1995; USDOE, 2000a; Weld, 2000). Students have not acquired skills needed for the modern workplace, and the adult population does not have a 'scientific frame of mind' (GEIA, 1996; Shamos, 1995). Participation rates, especially of girls and minorities, are low in advanced science and mathematics classes (Baker, 1993; Monhardt, 2000; Sloat, 1992; Pollina, 1996).

Science is still taught in teacher-dominated classrooms by teaching methods that do not consider students' cognitive developmental stages, learning styles, or multiple intelligences (Goodnough, 2001; Weld, 2000). Many science teachers, especially in elementary school, still do not teach science through inquiry and discovery (Carin, 1997; Gega & Peters, 1998). Students are not challenged to engage in conceptual change, critical thinking, or problem solving. School science seems to have little relevance for students' lives.

Intervention

This researcher explored the integration of creative drama into science teaching as an instructional strategy for enhancing elementary school students' learning and understanding of scientific concepts.

Elementary school students' understanding of abstract scientific concepts is relevant to two functions addressed by creative drama. First, creative drama activities can help students bring abstract concepts into a concrete context through the use of imagination and play to explore and to construct an understanding of abstract ideas (Bailey, 1993, personal communication, 2001; McCaslin, 1996). Effective learning occurs when students construct their understanding by active learning and by building on their prior knowledge (Yager, 1993a). Second, creative drama can be a useful tool for all stages of the learning cycle, providing the science teacher an authentic assessment measure, as well as an excellent tool for engaging, explaining, exploring, elaborating and evaluating (BSCS, 1994; Llewellyn, 2004).

Elementary school teachers have often used creative drama to teach social studies and literature (Salisbury, 1986), but such methods are not commonly utilized by science teachers. A few reports, but no studies, exist on the use of creative drama activities in science teaching (Bolen, 1994; Kimbrough, Dyckes & Mlady, 1995; Rivera & Banbury, 1994; The Watercourse and Western Regional Environmental Education Council (WREEC), 1994).

Creative drama is a multi-dimensional art, designed especially for educational purposes (Bolton, 1985, 1986). It is a form of imaginative play, facilitated by a leader or a teacher. It is an improvisational group process, not scripted, created on the spot and not memorized (Bailey, 1993, personal communication, 2001; Booth & Lundy, 1985; McCaslin, 1981, 1996). The difference between creative drama and other forms of drama lies in its main goal, which is to "promote growth and educational development of the players, not to entertain an audience or train actors" (Heinig & Stillwell, 1981, p. 5). Creative drama emphasizes thinking and creating processes, rather than the products.

Creative drama may combine many arts, including drama, music, dance, movement, rhythm, 'rap', communication, puppets, masks, drawings, pantomime, role-plays and vignettes (Bailey, 1993, personal communication, 2001). Drama educators report that creative drama techniques are useful, helpful, and effective in many curriculum areas, including science (Bailey, 1993; Kase-Polisini & Spector, 1992; McCaslin, 1984, 1996; Cottrell, 1987). Science researchers and educators promote this idea as well (Butler, 1989; Duveen & Solomon, 1994; Kentish, 1995; Steinert, 1993; Stencel & Barkoff, 1993).

Similarities exist between science and creative drama processes. In both processes students are active, solve problems, ask questions, learn through inquiry and construct knowledge built on prior experience and information (Bailey, 1993; McCaslin, 1996; Kase-Polisini & Spector, 1992). When integrated into teaching science, creative drama can assist students in developing scientific skills as well as affective skills, such as cooperative work, empathy, communication, listening, and reasoning (Cristofi, 1997, Hodson & Reid, 1988; Kase-Polisini & Spector, 1992).

To date, few researchers have explored the potential of creative drama to contribute to learning science. In a library search, the researcher found few sources on creative drama in science teaching at the elementary, middle, secondary, and college levels. The majority of these sources reflect on activities done, but do not report data-based research. Only two documents were found that reported research in elementary school science (Kamen, 1991; Metcalfe, Abbott, Bray, Exley, & Wisnia, 1984). The facilitators dictated the activities and did not allow students to improvise and generate their own solutions to problems.

The intervention in this study was student-centered and used in all five stages of a guided inquiry instructional model developed by the Biological Sciences Curriculum Study (BSCS) (BSCS, 1994). A broad range of creative drama techniques was used, including the use of puppets, masks and scarves. The majority of the creative drama activities was designed, led, and executed by the students. These interventions were especially important because they allowed students to reflect on their understanding of the concepts learned and could be used as authentic, immediate assessments by the teachers and by the students. In the activities students used higher order thinking skills, incorporated creative solutions, 'out of the box' thinking, and integrated multi-dimensional skills to think through abstract concepts. Students became active participants rather than passive recipients of teachers' questions.

Goal of the Study

The goal of the study was to examine the effectiveness of creative drama in science teaching as an instructional strategy for enhancing elementary school students' learning and understanding of scientific concepts.

Research Questions

This researcher intended to answer the following questions:

1. Does the inclusion of creative drama activities in an activity-based science instruction enhance students' understanding of scientific concepts better than activity-based instruction without creative drama activities?
2. How do students and teachers react to creative drama in science?

Significance of the Study

The significance of this study is related to the fields of theater and science education in elementary schools. There is an abundant literature in arts education programs in schools. McCaslin (1984), for example, has written extensively on the use of creative drama in education, children's theater, creative drama, and theater in education practices in schools to increase children's learning. She describes the works of theater in education companies such as The Looking Glass Theatre of Providence in Rhode Island, and The Creative Arts Team (CAT) of New York University to address social and curricular issues.

The literature on creative drama in school science is very scarce. Documenting the benefits of using creative drama in science education may lead to a breakthrough for science teachers and educators to attract more students into science classes, not only in elementary school but also in the whole education system.

This study is useful:

A. For the body of knowledge about teaching;

B. For the science teacher as a practitioner;

C. For the researchers who want to study this subject later.

Research Design

This study was designed as an exploratory action research case study investigation. Both quantitative and qualitative strategies were used to collect and analyze all data. The quantitative aspect of this study involved a Separate Sample Pretest-Posttest Control Group Design (Campbell & Stanley, 1963). Two intermediate level elementary school classes were the treatment group and four other classes at the same level formed the control group. The qualitative aspect of the study involved observational and interview analysis to triangulate findings from the quantitative analysis.

The scientific concepts taught were from the Mixtures and Solutions unit from the Full Option Science System (FOSS), which is part of the adopted curriculum for the school district where the research took place. In order to examine the effectiveness of the use of creative drama, the treatment group was taught by science-through-creative-drama activities that were integrated into the activities of the FOSS unit.

The data were collected in three stages:

1. Some data were collected pre-intervention, based upon a written pretest. The pretest included questions of scientific factual knowledge and understanding of mixtures and solutions based on the FOSS unit of instruction.
2. Other data were collected during the instruction by:
    A. Researcher field notes, as well as discussion between the researcher and the regular class teachers, who attended class activities.
    B. Video taping of the activities.
    C. Consultation and review of the video tapes of intervention activities by the researcher.
3. Post-intervention data were collected by:
    A. Audio-taped interviews of students and the class teachers
    B. Posttest, which was identical to the pre-test.

Definition of Terms

The following terms are defined as they apply to this study:

<u>Creative drama</u> is defined by the Children's Theatre Association of America as "…an improvisational, nonexhibitional, process-centered form of drama in which participants are guided by a leader to imagine, enact, and reflect upon human experiences (McCaslin, 1981). Although creative drama traditionally has been thought of in relation to children and young people, the process is appropriate to all ages."(McCaslin, 1996, p. 7). It is always an improvised performance: lines are not written and not memorized. Each member of the group gets an opportunity to play various parts. Participants are guided by a teacher and not by a director. No decorations, costumes, or special equipment is needed, just time, space, and an enthusiastic leader.

<u>Dramatic play</u> is the free play of young children, in which they explore their surroundings and characters they meet. It is not facilitated by a teacher and lasts for a short time. Dramatic play is natural play, in which children create an authentic world. In this kind of play, they may imitate adults, play out real-life roles and try to solve real-life problems. Dramatic play is a way for children to express their most pressing needs and may be played repeatedly for the joy of doing it (Bailey, 1993, personal communication, 2002; McCaslin, 1984, 1996).

<u>Improvisation</u> refers to the spontaneous process of creating and acting a scene. It is participant-centered, and is not intended to be shared with others. Group members who are not playing are called observers (Bailey, 1993, personal communication, 2002; McCaslin, 1984, 1996).

<u>Role-play</u> is assuming a specific role (McCaslin, 1984, 1996).

Skit refers to a short scene improvised by a group to communicate how they understand, perceive, and feel about a relevant issue (Bailey, 1993, personal communication, 2002; McCaslin, 1984, 1996).

Vignette is a short story without an ending that presents an issue and serves as an entrance point for discussions to assist participants in finding possible solutions to the issue. Responding to vignettes individually or in small groups can be an effective way to experiment with ideas, build on the ideas of others, and work toward consensus in a non-threatening manner (Bailey, 1993, personal communication, 2002; McCaslin, 1984, 1996).

The introduction to this study is followed by a literature review, details of the methodology used to collect and analyze data for this research, the analysis of the data and the presentation of the results, and the final summary, conclusions and recommendations of this study.

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CHAPTER 2 - LITERATURE REVIEW

"Science is the belief in the ignorance of experts"

-Richard Feynman

Introduction

This chapter contains four parts. The first part focuses on science education. It begins with an explanation about science learning as an active process according to a constructivist view. Following this is an overview of the way science is currently taught, then suggestions by researchers, teachers and policy makers on how science should be taught.

The second part centers on the arts, play, and creative drama. It starts with an overview of the impact of arts education on students' learning and personal skills, and of the contribution that arts education makes toward the goals of education reform. The benefits of arts education for the acquisition of future workplace skills are then explained. Following this is a description of the importance of play in children's affective and cognitive development and the benefits of using play in school settings. Then comes an explanation of what creative drama is, how creative drama is facilitated in education, and how creative drama benefits students' learning.

The third part of this chapter discusses the use of play and creative drama in teaching science. It includes a review of research on the use of play and creative drama in science education, and a summary of the benefits of role-play in science education.

The fourth part includes a description and discussion of two studies in the use of creative drama in elementary science education.

Teaching and Learning Science

Many science educators and philosophers of science believe that learning science is an active process of building one's own models (Carin, 1997; Colburn, 2000; Shamos, 1995; Von Glaserfeld, 1996; Yager, 1993). The epistemological theory that knowledge is actively created within the learner is called constructivism. Conant (1947) suggested that science concepts are human constructs, not objective processes, and are therefore subjected to influence by interpretation (Novak, 1983). In the constructivist approach, science is viewed as a continuous process of inquiry, through which models of natural phenomena are developed in ways that will help explain our experiential world (Carin, 1997; Colburn, 2000; Von Glaserfeld, 1996; Yager, 1993). In these models, prior knowledge, experience, and information influence learning. Instead of talking about scientific "truth" in terms of how knowledge corresponds with reality, constructivists talk about the usefulness, viability, and coherence of scientific knowledge and consensus of the members of the scientific community. Constructivist views of science replaced the positivist perspective that the scientific method is an objective process for seeking truth of nature as it exists external to, separated from and independent of an observer. Positivist views had been accepted among philosophers of science and the scientific community until the 1950s (Kuhn, 1996).

Science educators have supported the constructivist view of the nature of science and the conceptual change model since the early 1960s (Schwab & Brandwein, 1962). Learning is regarded in the constructivist's view as "… genuine conceptual learning [that] occurs when learners make their own sense of such knowledge," (West & Pines, 1985, p. 6). The conceptual change model of learning (Posner, Strike, Hewson, & Gertzog, 1982) is a dynamic interactive process, which includes three stages:

- Being sure the students are clear in their understanding of their own ideas;
- Helping students understand the problems with their own ideas and misconceptions;
- Presenting alternate beliefs that work better for them personally (p. 211)

Students must first become aware that their conceptions need to be revised so that they will be ready to accept, adopt, and accommodate valid concepts. Vygotsky (1962) supported the notion that social interaction is crucial in the process of students gaining better understanding of concepts.

Many science teachers and researchers support the constructivist learning model (Carin, 1997; Carr & Flynn, 1993; Feldman, 2000; Goodnough, 2001; Llewellyn, 2004; Staver, 1998; Yaffe, 1989; Yager, 1993). They acknowledge the importance of prior knowledge and active experiences for learning science. Learning is constructivist in character if it is an active and interpretive process, if the learning experiences are purposeful, and if it considers prior knowledge and experience.

How Science is Currently Taught

Educators and researchers criticize the way in which science is currently being taught. Some critics (Before It's Too Late, 2000; GEIA, 1996; Butler, 1989; Goodnough, 2001; Dass, 2000; Hodson, 1998; Roth, 1989; Weirauch, 1997) claim that science teaching hasn't changed much in the last fifty years. James (1991) sees the schools trying to meet a standard they mistake as the one right way of doing and teaching science. Even the new National Science Education Standards (NRC, 1996) and the Goals 2000 education reform (U.S. Dept. of Education, 1994) have not yet made a real difference (Weld, 2000).

Science teaching is still mostly fact-oriented, and the majority of teachers focus on written examinations instead of looking for alternative assessments (Goodnough, 2001; Kamen, 1996; Penick, 2000). The typical science lesson uses the 'pencil-and-paper' method (Dass, 2000; Goodnough, 2001; Oakes, 1990; Veronesi, 2000). Students are required to read selected text and answer chapter questions (Cross & Ormiston, 1996; Goodnough, 2001; Roth, 1989; Weirauch, 1997). Dass (2000) compares current science instruction, which focuses on transmitting accepted scientific information and basic process skills to the taxonomy of the "domains of science", which includes six domains: concepts, processes, applications, attitudes, creativity, and the nature of science. Dass (2000) complains that students are currently presented only with two of these domains – concepts and processes, which severely narrow their view of science. Even though the National Science Education Standards (NRC, 1996) endorse the use of inquiry and 'learning by doing' as the best way to teach science, a constructivist approach to teaching has not yet taken over in most science classrooms (Leonard, 2000; Penick, 2000).

Teacher-dominated, teacher-centered classrooms are common (Goodnough, 2001; Kentish, 1995; Leonard, 2000). The setting of a teacher standing in front of a "rows and columns" classroom (Butler, 1989, p. 1) may be good for student-teacher interactions in a teacher-dominated classroom, but it does not allow direct student-student interactions (Johnson & Johnson, 1982, 1987; Penick, 2000). Students in these classes are too individualistic (Butler, 1989), do not have the opportunities to generate and evaluate their own knowledge, nor are they actively engaged in exchanging knowledge with each other. These are beneficial and even crucial elements in the learning process (Kentish, 1995; Johnson & Johnson, 1982; McNeil, 1987; Penick, 2000; Webb, 1980).

Teachers are concerned with coverage of the syllabus topics (Gallagher & Tobin, 1987; Roth, 1989; Goodnough, 2001) and take responsibility for the completion of tasks, but leave the responsibility for the learning to the students (Gallagher & Tobin, 1987; Kentish, 1995). In teacher-centered classes, students are passive learners and do not take responsibility and control over their own learning (Kentish, 1995). Leonard (2000) claims that "teaching by telling" is the most common pedagogy: teachers dominate classroom dialogues by asking all the questions, and if students do not know, the teachers also give the answers. If learning is found to be ineffective, teachers blame it on deficiencies in students' capabilities and not in flaws of the teaching strategies or of the educational system (Butler, 1989; Greenspan, 1997; Varrella, 2000; Weld, 2000).

Furthermore, science is usually presented in ways that don't seem relevant or interesting to the students (Penick, 2000). One purpose of science teaching is helping students gain a better conceptual understanding of the phenomena being taught, so students have a better understanding of their world and current events. Students should become scientifically literate and ready for their future workplace (Before It's Too Late, 2000; GEIA, 1996; SCANS, 1991; Kentish, 1995; Shamos, 1995). The way science is currently being taught, some students miss the excitement of new explorations and can't apply the lessons in school to their daily life and their surroundings (Before It's Too Late, 2000; GEIA, 1996; Goodnough, 2001; NRC, 1996; Weld, 2000).

Another major purpose of teaching science is helping students acquire problem solving and higher-order thinking skills that are important for their future workplace (GEIA, 1996; Carr & Flynn, 1993; Kentish, 1995; NRC, 1996; Resnick & Wilensky, 1998; SCANS, 1991; Varrella, 2000). When science lessons are not appealing and not challenging to students, they will not be able to achieve this goal.

The public school system is guilty, in part, for not making science appealing and relevant. Today's school curricula still reflect the 19th century German University system of academic "disciplines." In this system, 45 minute class periods are allotted to English, mathematics, science and civics and, as a result, students usually do not see their studies as a whole. Students are not taught how to breach subject area lines to enhance learning in more than one discipline, or how to create contexts for new knowledge that do not necessarily fit into the traditional disciplinary boxes (GEIA, 1996; Penick, 2000). The education system should afford opportunities for breaking down such barriers and challenging students (GEIA, 1996; NRC, 1996; Penick, 2000; Varrella, 2000).

Studies were conducted in order to understand the large drop out rate of students taking science classes in middle and high school. A major contributor seems to be tracking (Monhardt, 2000; Oakes, 1990). Students placed in low-ability groups in elementary school were very likely to continue in these tracks in middle school and junior high. These same students are placed in non-college preparatory tracks in senior high school (Rosenbaum, 1980; Oakes, 1990). Slavin (1986) found that elementary school students, who were not in the top tracks, appeared to learn less because of their tracking placements. Greenspan (1997) also opposes the grouping/tracking idea. He blames the American education system of ignoring the emotional basis of the intellectual development of children. He says that individual differences in the way children absorb information are not taken into account unless they are so large that children can be labeled as learning disabled, cognitively disabled, or emotionally disturbed. When schools sort children into academic-achievement tracks, a stigma is put on the students and it doesn't help them build their self-esteem. Lower track students believe they will never be able to move into a higher track (Monhardt, 2000; Oakes, 1990; Slavin, 1986; Yager, 2000).

Another example of a current mistake in the education system is the emphasis on testing (Veronesi, 2000; Yager, 2000). Criticism and testing are not necessarily negative if they are immediately followed-up by helping children figure out how to succeed in their future learning. If not, then testing can ruin students' self-confidence. Few schools are known to use special interventions as alternative assessments to find students' actual knowledge level (Veronesi, 2000; Weld, 2000, 2005). The public school system operates under the notion that children of the same age should be taught as a homogeneous group by standardized methods, and students who do not fit are regarded as exceptional (Veronesi, 2000; Yager, 2000). "Our educational system… assumes that twenty-five or thirty children born in the same year are sufficiently similar in developmental attainment, intellectual capacities, physical powers, and level of visual, verbal, and manual skill to be taught in the same way. We therefore put them together under a single teacher and in a single room to learn together, in public, at roughly the same rate." (Greenspan, 1997, p. 217). This notion is especially problematic in teaching science to elementary school students. Elementary students are expected to learn and understand the same abstract concepts at the same pace, even if their cognitive and affective developmental stages are very diverse (Carin, 1997; Wakefield, 1996). Recent research (Chronicle & MacGregor, 1998; Enger, 1997) supports the claim that standardized tests scores are inaccurate measures of real learning. Nevertheless, standardized tests scores are still accepted as learning measurements by far too many educators, policymakers, and citizens. Veronesi (2000) describes the current situation: "Unfortunately, there is still a huge effort to make the child fit the mittens rather than make the mittens to fit the child"

(p. 29). Yager (2000) argues that many testing experts are not well aware of the precise learning goals that characterize current visions of reform.

Insufficiency in the scientific knowledge of the science teachers themselves contributes to ineffective science teaching. Effective teachers believe in themselves, in what they teach, and in their ability to make a difference (Romjue & Collins, 1996; Varrella, 2000). The current reality is that many elementary school teachers lack scientific knowledge. They often feel uncomfortable and unconfident with their science knowledge and with their ability to teach it, which results in poor teaching (Goodlad, 1983, 1984; Lantz & Kass, 1987; Varrella, 2000; Weld, 2000). Regarding science teachers' professional development, nearly half of all science teachers belong to no professional organization, which could help them remain connected to the science education community (Weld, 2000). Teacher professional development is a basic component in current science reform (Dass, 2000; NASH, 2006; NRC, 1996; NRC, 2001; USDOE, 1994; USDOE 2000a; Varrella, 2000). Teachers must be involved in all aspects of change, including curriculum changes and textbook selection and use (Varrella, 2000; Yager, 2000).

Another reason for ineffective science teaching is that before 2007, science was not federally mandated to be included among the tests that measure young children's basic skills, and so it often received less attention than subjects that were being tested (Butler, 1989). National Science Education Standards are voluntary. Teachers or schools have the right to choose whether to teach science and how much. Because of these reasons, science teaching gets pushed back in priorities in elementary schools. Less than half of American science teachers use the National Science Education Standards for their teaching (Weld, 2000). The No Child Left Behind Act might change this picture. According to this act, schools across the country are held accountable to students' success and learning achievements. One way to attain this goal is professional development of teachers and paraprofessional school personnel. Teacher aids must meet criteria of associate's degree completion or obtain passing scores on tests measuring reading, writing, and mathematics competency (Cosentino de Cohen, 2006). Enhancement of the teaching force as mandated by NCLB through annual review of the effectiveness of school-wide programs; curriculum, instruction, and assessments aligned with state and national standards; and commitment to continuous review and improvement of schools (Pedallia et al., 2006) have the prospective of overall academic improvement, including science education.

Research-Based Science Instruction

Researchers, educators and policy makers agree that we need an effective way for teaching science. The 'scientific way of mind' that science education may provide to students and the scientific literacy that is expected from our citizens is in the core of every education reform (Before It's Too Late, 2000; Dass, 2000; NRC, 1996; Shamos, 1995). The Goals 2000: Educate America Act, initiated by President Clinton's administration in 1994, makes it clear that the way science is taught in the 21st century has to change. Some of the expectations regarding students' achievements in science according to national goals from 'Goals 2000' (Educate America Act: Goals 2000, 1994):

- By the year 2000, all students will leave grades 4, 8, and 12 having demonstrated competency over challenging subject matter including English, Mathematics, Science,…and every school in America will ensure that all students learn to use their minds well, so they may be prepared for responsible citizenship, further learning, and productive employment in our Nation's modern economy.
- By the year 2000, United States' students will be first in the world in mathematics and science achievement.

- By the year 2000, every adult American will be literate and will possess the knowledge and skills necessary to compete in a global economy and exercise the right and responsibilities of citizenship.
- By the year 2000, the nation's teaching force will have access to programs for the continued improvement of their professional skills and the opportunity to acquire the knowledge and skills needed to instruct and prepare all American students for the next century (p.3).

The National Science Educational Standards, published in 1996, emphasize the need to: teach science through inquiry; improve teaching and assessment; and enhance science teachers' professional development. To achieve the goals of the scientific way of mind and scientific literacy, science teaching must change so that students will be actively involved in creating their own understanding and knowledge (Dass, 2000; Varrella, 2000; Weld, 2000; Yager, 2000). Science must become meaningful for students' everyday life and natural environment (Goodnough, 2001; Kentish, 1995). Finally, science must enrich students with life skills, such as communication abilities, questioning, reasoning, problem solving and responsible decision-making. These skills will enable students to critically analyze scientific information and apply it to real-life situations, and help them become lifelong learners in science and in other matters, which are related to science or which use the scientific frame of mind (Goodnough, 2001; NRC, 1996; SCANS, 1991; Varrella, 2000; Weld, 2000; Zoller, 1999).

For effective learning, teaching needs to shift from traditional teacher-centered instructions to a student-centered curriculum, in which active students "do science" and take control over their own learning, based on student decision making and problem solving (GEIA, 1996; Butler, 1989; Kentish, 1995; Yager, 1991; NRC, 1996; Varrella, 2000). Any strategy that involves personal participation or commitment on the part of the students is more likely to be challenging and meaningful than a strategy that involves viewing the situation from the outside (Dass, 2000; James, 1991; Varrella, 2000). In a student-centered classroom the teacher must become a facilitator and help students build their own knowledge. The teacher needs to step back and give up some of her traditional teaching power, by letting students express and try out their ideas. For some science teachers this transition is difficult (Dass, 2000; Goodnough, 2001), but it is essential for the students' learning (Butler, 1989; Johnson & Johnson, 1982, Varrella, 2000).

Inquiry, discussion, and student-student communications should be an integral part of the learning process (Johnson & Johnson, 1982). Teachers need to initiate activities that will help students develop skills of asking questions and looking for answers as well as drawing responsible conclusions. Students need to learn that many times there is more than one correct answer, and that the scientific method involves inquiry (GEIA, 1996; Goodnough, 2001; Kentish, 1995; Shamos, 1995). The way teachers assess their students should change into alternative ways of assessment that will be given in a non-threatening environment and will portray students' knowledge and abilities (Kamen, 1996; NRC, 1996; Reichel, 1994).

Koballa (1995) found that science learning for young students involves all the domains of human learning: cognitive, affective and psychomotor. He stated that "the feelings and emotions that one has about the natural world" (p. 59) are the heart of affective learning in science, and it is important to consider them because "it has implications far beyond the immediate classroom experience" (p. 60). When students experience personal involvement in their studies and when they use their curiosity and imagination, the affective domain is involved and a sense of responsibility may be initiated. It was suggested, therefore, that teachers incorporate affective domain elements into science teaching and learning, so that students will be motivated and see themselves as responsible for their studies (Bailey, 1993; Kentish, 1995; Hildebrand, 1989).

Many studies have recommended that teachers provide enjoyable and non-threatening opportunities, where students can develop their understanding about abstract science concepts. By understanding those concepts students might learn and know more about their world (Chester & Fox, 1966; Cobern, 1993; Educating for the workplace through the arts, 1996; James, 1991; Tobin & Fraser, 1987; Yager, 1989; Yager & Lutz, 1994). Students should be involved in peer teaching, which was found to be a highly valuable way of learning (Duch, 1996; Johnson & Johnson, 1982).

As mature citizens, students will have to deal with complex scientific/social issues (Shamos, 1995). Therefore, schools need to provide students with experiences that encourage responsibility, personal involvement, empowerment, and active participation in society (Zoller, 1999). By becoming aware of their own personal values as well as societal values, students will become more critical of decisions made by industry and the government (Bailey, 1993; SCANS, 1991). For this reason it is important that problem-solving skills be taught as part of the science curriculum. Science should be presented as it is integrated in life: integrated with social studies, politics, mathematics, economics, journalism and health (GEIA, 1996; Kentish, 1995; Jung, 1986; Rivera & Banbury, 1994).

As for the teachers' competencies in teaching science, professional development programs should be offered extensively, as recommended by the NSES, the Educate America Act and others (NASH, 2006; NRC 2005; Penick, 2000; USDOE, 2000a; Weld, 2000) educate America Act, and funded by the government through this program (Weld, 2000). It is recommended that teachers be involved in action research as an effective, feasible and systematic form of inquiry, to get immediate results and practical applications for classroom-based problems and for their own professional development (Goodnough, 2000; Tillotson, 2000).

Arts in Education

The arts have long been present in the public school system, especially in the elementary schools. Music and fine arts classes are commonly taught in schools as enrichment or entertainment by music and art teachers. Drama or plays are usually used only for special events (Day, 1998; McCaslin, 1996; Rubin & Merrion, 1996). The arts are not integrated into the curriculum and are not used by teachers as teaching tools in the majority of schools.

Over the past decade a new way of thinking about arts education has emerged. It differs significantly from the limited art activities that most adults remember from their own schooling. Enhanced support for the use of the arts in the learning process has come from two major sources. One is the Federal government through the Goals 2000: Educate America Act (1994), and the other is state and local mutual forums of industrial leaders, art organizations and educators (GEIA, 1996). The arts are now receiving recognition as a fundamental, integral, visible and viable component, which is a part of the national strategy for improving the nation's schools. With the help of these two sources, the arts are being accepted as having value on their own, as well as in integration into other disciplines.

In the new arts education, children learn to express ideas, feelings, and emotions by creating their own images and performing dance, music, and drama. They learn to understand historical and cultural messages that are conveyed in works of art. They also learn to analyze, critique, and draw reasoned conclusions from what they see and hear, and to reflect on the meaning of their perceptions and experiences. Based on substantive and rigorous content, the new arts education develops the capacities that business leaders, educators, and parents want the schools to provide: creativity; problem solving; analytical thinking; collaborative skills; and responsible judgments (GEIA, 1996; Rubin & Merrion, 1996).

Lauren Resnick of the University of Pittsburgh has developed a list of the thinking skills nurtured by the arts curriculum. She says that arts education trains students in complex thinking and encourages a path of thinking that often leads to innovative solutions or even multiple solutions, as when an actor tries different ways of portraying a character. In creating a work of art, students use multiple criteria and involve "outside of the box" thinking. Students' work is sometimes accompanied by uncertainty about the results. Arts education requires self-regulation of the thinking process itself, such as when students have to assess their own work, self-correct, or apply external standards. Students learn how to impose meaning and find structure in apparent disorder. Arts education also involves nuanced interpretations, as when playwrights work to find exactly the right words to establish a character, signal a turn of plot, or achieve an emotional effect (Resnick, 1987).

Other research suggests that the arts can be a valuable tool for integrating knowledge across other academic disciplines and that the arts can be effectively used to create cross-disciplinary curricula. An education in the arts can make this contribution because it develops the ability of students to see and think in 'wholes' and see the big picture (GEIA, 1996). Peter Senge, one of America's foremost experts on the "learning organization," (cited in GEIA, 1996, p. 8) says: "From a very early age, we are taught to break problems apart, to fragment the world. This apparently makes complex tasks and subjects more manageable, but we pay an enormous price. We can no longer see the consequences of our actions; we lose our intrinsic sense of connection to a larger whole…After a while, we give up trying to see the whole altogether."

Creative drama, one aspect of the arts, involves play, movement, music, dance, puppets, masks, speech, pantomime and even drawings (Bailey, 1993; McCaslin, 1984, 1996). Students analyze, synthesize and criticize ideas. They produce and perform. Being such a multi-dimensional art, the use of creative drama for teaching, in general, and for the teaching of science, in particular, may be beneficial.

Play in Education

Children learn through play. It helps them make sense of their experiences. Drama, in its simplest form, is structured play. For centuries play has been seen as liberating the potential of children (Cohen, 1987). As we get older, we tend to forget how to play, and the imagination is often associated with "kids' stuff." It becomes more difficult for adults to imagine. But the child still lives in all of us, and if reinforced with time, it will again emerge (Bailey, 1993).

Early childhood teachers consider play as a vital component of young children's learning. Play is seen as freeing children's potential (McCaslin, 1984). As children engage in imaginative play, they learn how to move between an imaginative world and reality. They learn and develop wisdom about the concepts of pretend and real, and at the same time they engage in a repertoire of play scenarios that are usually focused on acting out their real world (Smilansky, 1990; Smilansky & Shefatya, 1990; Bailey, 1993; McCaslin, 1996).

The literature on play and early childhood education concentrates on the diversity and value of play for the cognitive, social and emotional development of young children (Bailey, 1993; Bateson, 1976; Bretherton, 1984; King, 1992; Smilansky & Shefatya, 1990). Teachers know that learning can be maximized and optimized when children are interested in what they do or in the topic, when they have some control over the direction of the play, and when they have opportunities to interact with others. Thus, learning can be facilitated when social and emotional needs are also being developed through play (McCaslin, 1996; Heathcote, 1971; Smilansky & Shefatya, 1990; Greenspan, 1997).

In our fast-paced world, most industrial societies become more competitive and complex. Even children's spontaneous play turns into structured activities, both at home and at school (Smilansky, 1968; Smilansky & Shefatya, 1990). Play is considered to be the main feature of childhood, but almost no consideration is given to play's relevance for the development of children or their learning (Educating for the Workplace through the Arts, 1996; Newman & Holzman, 1993). This is an outcome of parents' and teachers' aspirations to help children compete in society. Traditional means of childhood play are being replaced with adult-directed structured activities, such as worksheets and rote learning. This workplace-oriented approach is based on assumptions such as: play has little value; success and winning are more important than effort; teacher-directed work is the best and most efficient way for students to learn; children are interested in learning only when they are rewarded; and the earlier you start training children, the better (Greenspan, 1997; (GEIA, 1996; Newman & Holzman, 1993; Smilansky & Shefatya, 1990).

Examining the social and emotional foundations of human development, Greenspan (1997) worries about the current modern-world-industrial-society strategy that is presented by our educational system. He warns that it endangers the healthy growth of children. He asks educators to be attentive to the early stages of the emotional development of children in order to help them become more thoughtful and sensitive human beings. He complains that programs that boost self-esteem are limited to preschool, kindergarten and to the very early primary grades in most American schools. As soon as students get to first or (at the latest) second grade, their teachers are only concerned with academic achievements. Children are then grouped into fast and slow tracks for math, reading and other subjects, and the classroom atmosphere changes into achievement-based competition. Teachers measure children's success by how quickly they learn with the same methods that everybody else does. Greenspan would like to see every child taught in a manner that suits her/his needs and teachers focusing on creating learning experiences for each child, instead of focusing on children's achievements. Play is a good learning experience because it helps students to absorb and analyze ideas (Reinsmith, 1993).

An educational program that is based on play may benefit students as well as teachers by providing the context and the means to promote learning and teaching at the individual level (Bailey, 1993; McCaslin, 1996; Reinsmith, 1993). Children engage in play at levels that are comfortable for them. They reflect upon their level of learning and demonstrate their level of understanding (Smilansky, 1990). Play can help children overcome cultural differences (Smilansky, 1968). When children play, they mimic and represent behaviors of themselves and others. It is important for children to consider the perspectives of others in order to understand why someone might act in a particular way. These skills provide students with the basis to learn about themselves and about other people: actions; reactions and interactions; roles and responsibilities in specific contexts (Bailey, 1993).

Teachers may gain a lot by implementing programs that are based on play. Play provides teachers with opportunities for observation, data collection and documentation as well as assessment of children's learning. Through observation of children's play, teachers may identify specific needs of individual children or they may note particular strengths or weaknesses. Examples of information that may be collected through observations of children's play are: details of the language children use; strategies for problem-solving and for negotiations; their level of understanding; and their perceptions (Smilansky, 1990; Dockett, 1995; Dockett &

Lambert, 1996). In play situations teachers may become aware of individual children's actions and interactions, interactions of groups of children and the nature and directions of the play. Through play settings one can observe if a child prefers to interact only with a few other children or if a child is often excluded from the play (Smilansky, 1990). The observations and data may provide a basis for planning future learning experiences and also for reporting details to parents, to faculty, and to the children themselves about their learning (Dockett & Lambert, 1996).

Teachers play an essential role in facilitating, supporting and promoting play (Bailey, 1993). As they create learning environments in early childhood classes, teachers are responsible to provide opportunities for play. These opportunities will determine the degree to which children demonstrate specific outcomes in their play. In planning for play, teachers may choose to focus on an area that presents problems for one child or may plan experiences that are relevant to the whole class (Dockett, 1995; Dockett & Lambert, 1996; McCaslin, 1996). Teachers may supply relevant props to add complexity and enrichment to children's play. Teachers may match children's interests with challenging, meaningful experiences. Complex play is more likely to result when play is supported for substantial periods of time rather than just a few minutes before lunch or recess, and when students realize that the teacher has a positive attitude and encourages it (McCaslin, 1996). Teachers can make a difference to the play of children, both by their direct and indirect actions. Teachers who support and encourage play, or act to complicate, extend and enrich it, are likely to observe a wide range of outcomes that relate to children's actual competencies. Then they can reflect from those observations on issues, which are valuable and important to those children.

Play, like science, provides the context for further expanding children's thinking in ways that build upon their previous knowledge, experience and interest (Kase-Polisini & Spector, 1992). The arts, drama among them, are recognized as an "integral way of looking at life and at education and understanding the complexities of the world and our challenges in it." (Jim Kelly, The Role of the Arts in National Education. Cited in: Rubin and Merrion, 1996, p. 8).

Creative Drama

In the late 1800s Francis Parker challenged rote learning, which was the main method of instruction used in the 19th century and before (Schwartz, 1979). He argued that sensory observations are important for imaginative thoughts. Although Parker never incorporated creative drama into his own work, he set the stage for the Progressive Education Movement, from which creative drama emerged. As this movement grew, John Dewey and Marietta Piece became leaders for the new thinking about education. Dewey was clear in his recommendations for the use of drama in teaching content in the classroom (Bolton, 1985), and argued for a shift from knowledge-centered to child-centered education:

> The old education may be summed up by stating that the center of gravity is outside the child. It is in the teacher, the textbook, anywhere and everywhere you please except in the immediate instincts and activities of the child himself…Now the change which is coming into our education is shifting the center of gravity…The child becomes the sun about which the appliances of education revolve; he is the center about which they are organized. (Dewey, 1921, p. 35, cited in Bolton, 1984, p. 4)

Winifred Ward, who was influenced by Dewey and the Progressive Education Movement, is considered the pioneer in American educational drama (Bolton, 1984, 1985). She made major contributions to creative drama through her writing (Ward, 1930) and the establishment of the Evanston Program, an experimental program that introduced creative drama into the elementary schools of Evanston, Illinois. She founded the Children's Theatre Association of America, which is now called the American Alliance for Theatre and Education

(McCaslin, 1981). Winifred Ward was followed by Brian Way and Dorothy Heathcote, who were well known for preparing drama educators in the 1960s and the 1970s (Bolton, 1985). Creative drama has continued to evolve and gain acceptance in the education community. Cottrell (1987) has defined creative drama as:

> …an art form for children in which they involve their whole selves in experiential learning that requires imaginative thinking and creative expression. Through movement and pantomime, improvisation, role-playing and characterization, and more, children explore what it means to be a human being. (p. 1)

Creative drama is a form of imaginative play. There is a leader or teacher who facilitates it by structuring the play into a defined form that often consists of a beginning, a middle and a conclusion. It is a group process; it works from the strength of the group and enriches the lives of everyone concerned (Booth & Lundy, 1985). Creative drama is improvisational, not scripted; it is created on the spot, not memorized. The result is a spontaneous self-expression of the participants (Bailey, 1993; McCaslin, 1996). The students act out a story or a concept they are learning or had learned before. This improvisational process allows children to analyze and synthesize information and to translate educational concepts into a personally meaningful form.

The results of using creative drama in the classroom can be beneficial. Students who are usually shy, quiet, self- conscious or seem troubled, “wake up” or “come to life” when they are free to use their imagination. Teachers are often surprised at the knowledge and the vocabulary that students have internalized but had not shared through traditional forms of learning and assessment. Creative drama brings out strong oral composing skills, which are very important for language development and written composition (Salisbury, 1986; O’Hara, 1984, 1985). Therefore, creative drama may give teachers an excellent perspective of their students’ abilities, while also preparing students for writing (McCaslin, 1996).

Creative drama is a process-centered activity rather than a product-centered one. The success of an activity is measured by the ideas, the expressions, the skills, the abilities, the imagination, and the creativity it sparks, not by the students' theatrical skills or by the beauty of the outcome as in a professional theater production. The outcome is not meant to be seen by an audience; the process is only for the experience of the participants. No prior theater or creative drama training or experience is needed in order to use creative drama activities effectively. The activities are not complicated, and when explained step by step to the students, teachers can implement them quite easily (McCaslin, 1996).

Focusing on the process of learning rather than on the outcome may be quite different from most regular educational practices (Bailey, 1993; McCaslin, 1996; Reinsmith, 1993). Educators often are interested only in the products of education, such as: Does the student know how to read? How fast does s/he read? Can s/he spell? Does s/he know the multiplication tables? These questions concentrate on the product of the learning process, not on the process itself. Teachers know that not all students learn in the same way or at the same pace (Goodnough, 2001; Yager, 2000). Students have a variety of learning styles (Kolb, 1984), and therefore they respond differently to various teaching methods (Gardner, 1983). The Theory of Multiple Intelligences, introduced by Gardner (1983, 1995), stresses the importance of "the how" and shifts the focus of learning. According to this view, learning is primarily affected by how a teacher presents information, because the process might make all the difference as to whether or not a student understands and succeeds (Yager & Lutz, 1994).

Benefits of Creative Drama for Education

The most important facet of creative drama is stimulating imagination. Imagination has been recognized recently as "the magic force that goes beyond the mastery of facts and techniques in the search for new ideas." (McCaslin,1996, p. 22). The power of imagination is accepted and appreciated as essential and indispensable in all frontiers. It is used in daily life as well as in business and management, in medical work, in military maneuvers, and in school domains. Imagination is used by scientists as well as by military leaders and actors. A GE ad in BusinessNews magazine (October 28, 1996) says: "In schools across the country, tomorrow's work force is being shaped today. Shaped by tools that teach children to use their imagination and encourage them to create, to perform. And to dream" (GEIA, 1996). Imagination is a mental trait that young children use freely when they play. Creating mental images helps to associate ideas and visualize new visions and situations (Bailey, 1993; Gardner, 1991; O'Neill, 1985; Piaget, 1962).

Creative thinking and critical thinking skills are promoted by a stimulated imagination, and are also a benefit of creative drama (Bailey, 1993). Critical thinking activities are important because by their nature they are open-ended, and they provide opportunities to define a problem, to develop solutions to the problem, to try out new behaviors and to receive feedback (Yaffe, 1989; Steinert, 1993). Through play, children are motivated to associate ideas, to conceptualize and to solve problems that are relevant and meaningful for them (Dockett, 1995).

All learning involves the senses, which bring information into the brain. Creative drama has the capacity to strengthen comprehension and retention because it is experiential-based and multi-sensory (Bailey, 1993; McCaslin, 1996). Using creative drama strategies in the classroom may enable teachers to help meet the needs of students with varying learning styles or special needs (Dockett, 1995; McCaslin, 1996; Smilansky, 1968; Smilansky, 1990; Yaffe, 1989).

Creative drama utilizes the power of group work to promote learning. It has been argued (Bailey, 1993; Edwards & Mercer, 1987; Johnson & Johnson, 1984) that optimum learning occurs when common knowledge is developed across a group of children. A meaningful group play can be easily initiated, sustained, and developed after common knowledge has been established. The power and advantage of a group assists, first, to form a common understanding across the whole group and then to help the children engage in imaginative play, particularly in sociodramatic play (Bailey, 1993; Smilansky, 1990; Smilansky, 1996).

Creative drama can reinforces positive self-concept. A fundamental concept of creative drama is self-expression. Students are allowed to create their own reality and are encouraged to bring their personal experiences into the classroom. Individual perceptions and interpretations are promoted, approved, supported, and sincerely valued (Bailey, 1993; McCaslin, 1984). The experience leads students to receive positive reinforcement for their contributions, enabling them to feel successful. Success leads to success, just as failure leads to failure (Greenspan, 1997). Providing students with an opportunity and support for success can help them build self-esteem and enhance affective development that they may transfer to other domains of learning (Butler, 1989; Greenspan, 1997; McCaslin, 1996; O'Neill, 1985; Smilansky 1968; Yaffe, 1989). Studies in which adults have actively participated in assisting kindergarten children to engage in make-believe play at school report gains in cognitive-creative and socio-emotional activities of these children (Smilansky, 1990).

Creative drama activities are done in a non-threatening class atmosphere. This allows students an opportunity to participate without being ashamed or afraid. Everyone is encouraged to be him/herself (Bailey, 1993; McCaslin, 1996). Mearns (1958) explains, "You have something to say, something no one in the world has ever said in just your way of saying it – but the thing itself is not half so important to you as what the saying will be to you." (p. 259).

Creative drama creates self-discipline among participants. Its strategies help support, encourage and protect the rights of each individual. This means that all students have to obey, accept and hold to the group's rules. When self-discipline is achieved, each group member has the right to pursue her/his goals and interests, while respecting the rights of others (McCaslin, 1996). According to Charles (cited in McCaslin, 1996) "order in the classroom 'facilitates learning, fosters socialization, permits democracy, fills a psychological need and promotes a sense of joy" (p. 31).

Creative drama increases understanding, compassion, awareness and respect for others. It is a vehicle for exploring values and feelings by reenacting various characters and their behaviors. It also allows students to explore and experience the consequences of behavior. The process of creative drama involves repetitions of role-play scenarios, which can be used again and again with other participants. The result is a variety of attitudes, approaches and perceptions that the participants have for the same basic scenario. Students learn that they see and understand things differently, that they should not expect everybody to produce the same play, because they come from different backgrounds and have had different experiences.

A recommended pattern for the use of creative drama activities is developed in three stages (1) play; (2) evaluate; (3) replay, while original cast members switch roles (Bailey, 1993; Rubin & Merrion, 1996). Because students look at occurrences from a different perspective (Dawson, 1994), this procedure allows players to view the conflict or the issue learned from more than one character's point of view. It helps identify misunderstandings and is important to show students that sometimes there is no absolutely wrong answer, there might be more than one perspective to study a problem, or more than one possible solution. Another benefit for both teachers and students is that they may assess the extent of students' understanding (McCaslin, 1996; Rubin & Merrion, 1996).

Creative drama activities increase students' motivation to learn by capturing their attention and by physically involving them in learning. These activities are simultaneously educational, entertaining, and something students enjoy doing. Students are actively involved in reinterpreting information while they seem to be playing. For shy students, these activities are especially powerful experiences because of the nature of the interventions: hiding behind another identity or a puppet allows them greater participation (Ladrousse, 1989). For all these reasons, creative drama can be a valuable addition to classroom instruction. "…[It] aids, rather than interferes, with other study and achievement." (Way, 1972 p. 7)

Many (Bailey, 1993; Dockett, 1995; Erickson, 1988; Ladrousse, 1989; McCaslin, 1996; and others) recommend the use of creative drama activities in education for:

- Review and reinforcement.
- Teaching spelling and grammar.
- Deepening comprehension.
- Visualizations.
- Promoting writing skills.
- Promoting language and thinking skills.
- Literature enrichment by story dramatization.
- Creative thinking development.
- Promoting problem solving skills.

- Teaching decision-making skills.
- Enhancing communication skills.
- Promoting cooperation and responsibility.

Play and Creative Drama in Science

Science aims to make sense of the world in an empirical, systematic way through observation and experimentation. From these observations and experiments, scientists develop and test theories and propose possible solutions to problems, which can then be tested. From the results, scientists try to clarify their understanding, based on previous experiences and knowledge, and communicate their understanding in a coherent and logical way (Cristofi & Davis, 1991; Harlen, 1985; Hodson & Reid, 1988; Shamos, 1995).

Young children explore their world in a similar way. Young learners use all their senses to find out about their world (Bailey, 1993; McCaslin, 1996). Children acquire information and make meaning from their observations. They are always exploring and investigating (Elstgeest, 1985). Once curiosity is aroused, children will repeat the experience over and over again (James, 1991). Children are learning that every time a particular event occurs in similar circumstances, it is likely that the same thing will happen again. This helps them to establish knowledge, which is continually being tested. Young learners are like active scientists who have acquired a lot of scientific knowledge just waiting to be tested, tried, elaborated upon and changed, if necessary (Bailey, 1993; Elstgeest, 1985; Karvonen-Lee, 1997). According to this view, children are already proficient learners of science, and we must take into account all the prior knowledge and experience that children bring with them into the classroom (Colburn, 2000; Kentish, 1995).

Much of children's science learning takes place before entering school through informal play situations. Play provides a medium through which children are free to explore and engage with ideas without outside direction (Moyles, 1993). Children have opportunities to try out their ideas, solve problems and develop further understanding and knowledge (Smilansky, 1968). The value of using play in the classroom to facilitate the learning of science cannot be underestimated (King, 1992). It makes sense that if play has provided opportunities to experience and to explore different events and enable valuable learning to take place before coming to school, it is an important component for learning science when children enter the classroom (Koballa, 1995; Ladrousse, 1989; McCaslin, 1984: Yaffe, 1989).

An effective learning environment for school science requires the provision of a variety of experiences that allow children to explore, question, investigate and draw conclusions. These experiences should be learner-centered. In early childhood classrooms, structured and unstructured play experiences are already a part of the daily routine (Smilansky, 1990). Activities are planned to stimulate free exploration and play, to confront challenging problems, to communicate and clarify ideas in a variety of ways, to value each other's opinions and contributions. The children are encouraged to work in groups in order to develop social interaction skills such as trust and respect for others' opinions and abilities.

Learning science through play in the classroom should be a mixture of free explorations and planned investigations of events and materials that are done by children even without the teacher's guidance. Play activities, whether planned or undirected, provide a variety of opportunities for children's explorations.

> Through free, exploratory play, children learn something about situation, people, attitudes and responses, materials, properties, textures, structures, visual, auditory, and kinesthetic attributes dependent upon the play activity. Through directed play, they are proposed another dimension

> and a further range of possibilities extending to a relative mastery within that area or activity. (Moyles, 1993, p. 20).

There is a general agreement about the need for play as a principal pedagogical tool for learning in the early childhood years (Bateson, 1976; Bretherton, 1984; Elstgeest, 1985; King, 1992; Moyles, 1993; Smilansky, 1990). Play is recommended in teaching school age children about science concepts, since sociodramatic play was found to be a way for children to make meaning of their experiences (Hildebrand, 1989; Smilansky, 1968). The value of play in learning science cannot be ignored, nor can educators dismiss what children bring with them to any situation. Elstgeest (1985) says:

> It may be the clouds in the sky, or the birds in the undergrowth; it may be a bumblebee on the clover, or a spider in a web, the pollen of a flower, or the ripples in a pond. It may be the softness of a fleece, the 'bang' in a drum or the rainbow in a soap film. From all around comes the invitation; all around sounds the challenge. The question is there, the answer lies hidden, and the child has the key. (p. 10)

Play provides the context for expanding children's thinking in ways that build upon their previous knowledge, experience and interest (Kase-Polisini & Spector, 1992).

Creative drama is already successfully implemented in the language arts curriculum and is recommended as an effective teaching strategy for science teaching (Bailey, 1993; Butler, 1989; Carr & Flynn, 1993; Duveen, & Solomon, 1994; Erickson, 1988; Gardner, 1991; Hurd, 1991; Hildebrand, 1989; Kentish, 1995; Ladrousse, 1989; Riding, 1995; and Steinert, 1993). Kelly, Carlson, and Cunningham (1993) strongly recommend that the sociological aspects of a genuine scientific culture should be included in school science curricula. Early childhood science education seems as an ideal place to begin this incorporation through sociodramatic play. It is evident that the children utilize play to clarify their scientific thinking (Bailey, 1993; McCaslin, 1996; Smilansky, 1968, Smilansky, 1990).

They mentally play with the concepts they are dealing with, incorporating them into an imaginary setting. They use play in order to try and make sense of ideas that are puzzling and stimulating to them and of ideas that emerge from contexts that are familiar to them.

Kentish (1995) argues that a strategy that involves any level of personal involvement or commitment on the part of students is more likely to be meaningful to them than a strategy that involves viewing the situation impersonally from the outside. Once students have experienced personal involvement in their studies through a form of play, the affective domain has been involved and a sense of responsibility may have been initiated. Therefore, science teachers may need to employ activities in which the ideas of children are drawn out in a non-threatening manner. While involved in these activities, students may develop shared meanings, which reflect more closely on accepted science concepts. Teachers also should incorporate the affective domain elements into science teaching and learning, so that the students will see themselves responsible for their studies. Erickson (1988), too, mentions the importance of active involvement in the process of learning. He sees students' involvement as the key to becoming experts on subjects, and explains this point: that people become good at what they do only when they become totally immersed in it. He sees drama as an activity that immediately draws people in, engages the senses and awakens the entire physical being as well as all the functions of the mind.

Creative drama is also suggested to help students make sense of the science they learn at school by connecting it with their own understanding of the world, and to create deeper understanding (Bailey, 1993; Butler, 1989; Cristofi & Davis, 1991; Dockett & Lambert, 1996; Eisenberg, 1992). According to this view, role-play may allow students to demonstrate their understanding, explore their views and develop deeper understanding of phenomena by combining new facts with background knowledge and applying it to solving real-life problems (Butler, 1989). Role-play may help students verbalize abstract science ideas in terms that they can understand. Role-play has the potential to assist students to develop and create their own mental models. Gardner (1991) suggested that "in trying to understand science, students draw on available mental models" (p. 157). Often in science these mental models create images of a microscopic world, which is inferred from observations of theories while trying to explain phenomena (Aubusson et al., 1997).

Creative drama is recommended by teachers and by researchers as an effective strategy to teach abstract concepts. According to Stencel and Barkoff (1993), drama is very useful in teaching abstract concepts, especially those at the molecular level, that are often difficult for students to understand. Although lectures, films, problem solving, models and computer programs are helpful techniques, Stencel and Barkoff found that role playing can be most educational and an enjoyable teaching method. Another example for the use of drama to teach difficult concepts is discussed by Bachelis et al., (1994). They believe that students can best understand an algorithm if they can see the process tangibly at work, and creative drama activities are suggested as a means of accomplishing this goal. Regarding environmental science education programs, Kentish (1995) suggests the use of action-based participatory learning strategies. When students use creative drama strategies, they develop greater ownership of their learning, which may be reflected not only by developing professional skills but also by problem solving and decision-making skills and abilities. Resnick and Wilensky (1998) claim role-play activities provide an effective way for students to get involved, and this is a particularly powerful role in helping students learn about complex systems, such as chaos or artificial life. Research about complex systems, such as order versus chaos, randomness versus determinacy, analysis versus synthesis, deals with some of the deepest issues in science and philosophy. The study of complexity is a new way of thinking about all sciences. The authors' belief is that role-play activities can help students build intuitions about systems and complexity, just as playing with the Logo turtle helps them build intuitions about geometry. Role-play activities, according to this view, may also serve as a good start for computer modeling activities.

Butler (1989) and Webb (1980) see a major benefit of using creative drama in science classrooms because it enables students to learn openly from and with each other. According to this view, drama is a stimulating alternative to class discussions, lectures or question-and-answer sessions. Science must become more than learning a collection of isolated facts, and when drama processes are involved, application and synthesis of facts and knowledge occur naturally.

Moore (1992) introduced drama as a teaching technique for motivating students and for showing students' talents – from acting to writing – in science class, where it would generally go unnoticed. Shy students, who usually do not participate in scientific discussions, might find themselves writing a script, or even acting in a skit. Drama is highly rated by British students who were found to learn concepts more effectively than if they listened to a lecture or were given a handout describing the new subject matter. The results are evident in students' examination work (Cristofi & Davis 1991).

What affective benefits do the students get while doing creative drama activities in science class? Role-play offers the method of learning through the process of teaching others, where able students learn by teaching the concepts to others. Research by Webb (1980) found this way of teaching and learning very valuable. While doing the role-play, students profit from exercising their newly acquired knowledge. Role-play allows students to rehearse material that can be encoded into long-term memory and leads to a deeper understanding of the concepts.

After participating in creative drama activities, students remembered the exercises vividly and could quote details of the text they used. They also could illustrate their understanding of the scientific concepts learned (Duveen & Solomon, 1994; Steinert, 1993).

Creative drama activities could fit in science classrooms where the teachers are able and willing to use them. The role of the teacher is to enhance the learning process by providing direction, motivating and challenging the learner. Only teachers who are confident that their status in the classroom will not be ruined by their flexibility in letting the students take responsibility on class communications, discussions and decisions will be able to use this teaching method (Lantz & Kass, 1987). In order to engage the class successfully in creative drama, the teacher has to "… be prepared to embrace a wide range of status roles" (Heathcote, 1971, 1985, p. 51). Dorothy Heathcote suggests that the teacher should also be in role, which means that the whole concept of the teacher is challenged: the teacher may vary his/her relationship with the students and her/his status in the classroom (Bolton, 1979, 1985, 1986).

Comparison of creative drama and science shows clearly that both require the same processes. In both, students are actively engaged in analyzing, expressing and sharing their own ideas, attitudes, perceptions and feelings (Bailey, 1993; Butler, 1989; Kase-Polisini & Spector, 1992; McCaslin, 1996). These activities require students' involvement in doing and in problem solving and use student-teacher communication as well as peer communications. Students' personal experiences, knowledge and values might be challenged and considered (Cooper & Byrne, 1983). In both processes students are encouraged to learn through inquiry. Both processes intend to encourage personal investment, empowerment and active participation in society. Science classes should engage students in dialogues about citizens' social and political responsibilities towards their environment, and drama processes are exactly the right tool to encourage students to role play members of the community that examine different perspectives toward environment-concerned issues (Rivera & Banbury, 1994). In both processes teachers have a major role. They use open-ended questions to guide the group, help students construct knowledge, and build on the information and the experience students already have.

A partial list of the benefits of role-play in science teaching is:

- Effective learning strategy for both content and process. Students better understand the process and the content (Kentish, 1995; Steinert, 1993);
- It is a form of active learning. The students are involved in "doing science," inquiry, making sense of the content, and discussing it (Steinert, 1993; Duveen & Solomon, 1994; Kentish, 1995);
- Students find role-play memorable. Students that learned science through creative drama remembered the activities as well as the content (Duveen & Solomon, 1994; Steinert, 1993);
- Creative drama can be used to construct knowledge. Students are actively involved in searching for explanations of abstract concepts and processes, while constructing their own knowledge (Bailey, 1993; Duveen & Solomon, 1994);
- Presenting scientific knowledge by creative drama means, lead to a deeper and a concrete understanding of the subject matter (Bailey, 1993; Duveen & Solomon, 1994);
- Students have to show a greater degree of responsibility for their own learning. Groups of students are involved in the creative drama activities. Each member is responsible and accountable for the whole team (Duveen & Solomon, 1994; Kentish, 1995);
- The students need to reflect on the experiences they gained by participating in the activities and contributing to the development of general skills - such as posing

questions, building ideas, flexibility, creativity, communication, and team work that are valued in the workplace (GEIA, 1996; Hurd, 1991; Kentish, 1995; SCANS, 1991; Steinert, 1993);

- Role-plays are generally more spontaneous and more flexible than end-of-the- chapter questions or discussion led by the teacher. (Steinert, 1993);
- It is a powerful teaching technique. Students like creative activities and are more attentive (Bailey, 1993; McCaslin, 1996; Steinert, 1993);
- It helps develop writing skills as well as oral skills (Bailey, 1993; Kelner, 1993; McCaslin, 1996);
- Role plays enable students to define a problem, to develop solutions to a problem, to try out new solutions and new behaviors and to receive feedback (Hurd, 1991; Steinert, 1993);
- Role-plays generally provoke less anxiety in students than real life situations, because they generally represent a simplified version of reality (Hennings, Hennings & Banich, 1980; Steinert, 1993);
- Designing role-plays helps students learn through the process of peer-teaching the concepts (Duveen & Solomon, 1994). The power of peer-teaching is well known by now (Johnson & Johnson, 1982), and role play activities use it to benefit the learning process;
- Within the role-play, the students profit from exercising their newly acquired knowledge. Discussing, rehearsing and performing the concept taught is a enjoyable and unthreatening experience (Duveen & Solomon, 1994);

Prior Research

The available literature for using creative drama in science education is very limited. A library search by this researcher found a few articles and other sources, which include mostly examples of using creative drama in different science teaching settings. Some creative drama activities were done in elementary schools, in secondary schools, or even in college. However, the majority of these articles include only examples of activities done, but not any research or statistical data. Only two reports, in which research was done in elementary school settings were found and only one also presented statistical data.

The first study (Metcalfe, Abbott, Bray et al., 1984), investigated the effectiveness of teaching one element of a science syllabus, using drama instead of a traditional-conventional practical work. The research question was: How and why does drama experience affect learning? This study compared two fifth-grade groups of students. The control group was taught traditional science, and the treatment group was taught science through teacher-dominated creative drama activities. Both groups were taught the same topic and for the same length of time by different science teachers. The researchers hypothesized that the treatment group would do better explaining and interpreting questions on the posttest.

A posttest was given to the students two weeks after the last lessons, and the results were compared in a two-way ANOVA, which showed a significant difference ($p<.05$) in the performance of the two groups and also significant interaction effects ($p<.001$). There were no significant differences between the classes in mean scores of factual recall questions, but on explanation and interpretation the performance of treatment group was significantly better than that of the control group ($p<0.001$). The researchers concluded that even though drama didn't seem to affect memorization of facts, it was a valuable alternative approach to teaching a difficult topic, especially among lower achieving and less able students, whose ability to analyze, synthesize and apply learned concepts is limited. They also concluded that drama activities could be carried out effectively where laboratory space was restricted.

The second study (Kamen, 1991) tested the effectiveness of creative drama as an instructional strategy in the elementary science classroom. This naturalistic research involved two teachers, each teaching a different topic of science to their own classes, through teacher-directed creative drama activities. The ages of the students of each teacher varied, and the length of time spent on the study was not the same. The data gathered included open ended pretests and posttests, pre and post interviews of the two teachers and some of the students, some of whom were interviewed in a group. Results showed improved students' achievement. Students and teachers both reported better understanding of the science concepts as an outcome of the creative drama. The students also reported their enjoyment of the creative drama activities.

These cases cannot represent samples from which we can draw conclusions about the effectiveness of creative drama as an instructional strategy in the elementary science classroom. Such research should include creative drama activities for at least five meetings per class; creative drama activities should be designed by the students; more techniques of creative drama activities (such as puppets and script writing) should be used. It is also important to interview students and teachers to reach triangulation.

This chapter discussed the way science is being taught and how science should be taught. Educational reforms that were supposed to help students acquire scientific knowledge and skills did not achieve their goals. Play, which is the natural way for children to learn about their world, was considered to be an effective in promoting thinking, problems-solving and learning skills. Creative drama, which incorporates various forms of play, has many benefits for education and is suggested as a tool for helping students learn and understand scientific concepts. Literature review shows few studies reported that involved creative drama in science education. Chapter three will describe the methods and procedures used in conducting this study.

CHAPTER 3 - METHODOLOGY

"Play is the greatest form of research"

- Albert Einstein

Introduction

Conducting this study, the researcher's goal was to examine the effectiveness of using creative drama as an instructional strategy for enhancing elementary school students' learning of scientific concepts. The following questions guided all data collection and analysis decisions:

1. Does the inclusion of creative drama activities in an activity-based science instruction enhance students' understanding of scientific concepts better than activity-based instruction without creative drama activities?
2. How do students and teachers react to creative drama in science?

Two groups participated in this study. The treatment group received activity-based science instruction integrated with creative drama, and the control group received activity-based science instructions without creative drama activities.

This chapter includes descriptions of the pilot study, timeline, setting, population, validity issues, methodological assumptions, general procedures, and data collection and analysis strategies. Copies of the pretest, posttest and protocols for interviews and class observations are in Appendix A. Examples of creative drama activities are in Appendix C.

Pilot Study

In January of 1999 the researcher and two elementary school teachers were awarded an NSTA - Toyota Tapestry Award for the innovation of teaching science through creative drama. In fulfillment of the requirements for this award, the researcher and these teachers conducted a study in which two combination classes of fifth and sixth grade students (45 students in total) were taught the concepts of matter and electricity through creative drama for about two months. The two class teachers team-taught all subjects, including science in both classes. For this study, the class teachers taught matter and electricity first using primarily hands-on activities from the Full Option Science System (FOSS) (The Regents of the University of California, 2000). After the students had learned the foundations of matter and electricity, the researcher conducted creative drama activities with the students. These activities included mostly warm-ups, teacher-led explanations of the concepts by creative drama methods, and student-designed assessments.

Students answered questionnaires in which they were asked to show their knowledge and understanding of the scientific concepts taught, and also what they liked and disliked about the creative drama activities. Forty-three out of the 45 students (96.2%) who were taught science through creative drama were very excited about this method of learning. Just two students (twelve year-old boys) said that they did not like these activities, although these two students eagerly participated in the creative drama activities, and repeatedly volunteered to take a part in these activities. The researcher did not investigate further to understand the discrepancy between their questionnaire responses and their behavior in class. Many students mentioned that these activities helped them better understand the abstract concepts and learn new facts, and some wrote that the audio-visual activities helped them memorize names and processes taught.

At the end of that year, a group of nine students from these two classes assembled a "science theater." With the facilitation of the researcher, these nine students wrote an eight-minute script, including the melody, rhythm, and movements about matter, and presented it to an audience of the whole school: students, teachers, and administrators. All of the science-theater students were excited to participate, and in later interviews all had only positive comments about this form of learning. After the science-theater performance, students from several classes were observed walking in the halls singing the song about H_2O, CO_2, atoms, molecules and polymers, which they heard in the play. The class teachers mentioned in researcher-conducted interviews how impressed they were with the students' abilities to express their knowledge through the creative drama activities. Moreover, they pointed out that creative drama was an excellent authentic assessment and an effective teaching method. In summary, the pilot study was deemed successful and provided the impetus and direction for further research.

Timeline

The current study took place over a period of eight months from October 2006 until the end of May 2007. The Full Option Science System Mixtures and Solution unit was selected as the science topic of study. This unit is to be taught in 15 class meetings, and it is the science teachers' decision how many times per week to teach the unit. The average time for teaching this unit is nine weeks, but schedule constrains affect this time. Actual teaching time for this study ranged from four to nine weeks. The study was conducted in six sixth-grade classes, and it was the science teachers' decision when to teach the unit through the school year. In four of the classes the unit was taught during the fall semester, and in two classes the unit was taught at the end of the spring semester.

Setting

The research took place in a Midwestern community with a population of 50,000. The economy of the community is dominated by two major sources. One is a public university, which is located in the center of town and is attended by about 22,000 students. Housing, restaurants, stores, gas stations, banks, entertainment places and other businesses benefit from the large population of college students.

The second major source of income and influence is a military base located approximately 20 miles southwest of the city. Some military families live inside the city limits; their children attend local public schools, and their family members are employed in the city. Soldiers and military family members enjoy coming to places of entertainment and stores in the city.

The public school system consists of eight elementary schools, two middle schools and one high school. In addition, there are two private schools with religious affiliations, one of which has students in grades K-8 and the other has students in grades K-12. The public elementary schools are considered neighborhood schools, which means that most students attend their school because it is in their neighborhood. The public schools are Professional Development Schools in collaboration with the university. Students from the college of education come to observe, participate in extensive field experiences prior to student teaching, and serve as student-teachers in the public schools as part of their teacher education program. Many partnership activities have been implemented by the district and the university to collaboratively enhance K-12 teaching and learning while improving the teacher education programs. Professional development programs are an on-going feature of this partnership, and researchers from the university use this school district as a setting for their research and frequently participate with teachers on action research.

Population

Six classes of sixth-grade students from three elementary schools participated in this study. All classes belong to the same school district and use the FOSS curriculum for science. The treatment group was composed of 50 students from two sixth-grade classes that received the creative drama treatment. The control group included 80 students from four sixth-grade classes.

Research Design

An exploratory action research case-study with a Separate Sample Pretest-Posttest Control Group Design was used for this study. This research is exploratory because very few studies have examined the use of creative drama for teaching and learning science. This is action research because the teachers in the classrooms were active participants in the research, and its goal was to improve science learning through improved teaching. Action research is typically designed and conducted by practitioners who want to improve their own practice. Action research can be done by individuals or by teams of colleagues. Action research has become popular among educators because it has the potential to generate genuine and sustained improvements in schools. It gives educators new opportunities to reflect on and assess their teaching; to explore and test new ideas, methods, and materials; to assess how effective the new approaches were; to share feedback with fellow team members; and to make decisions about which new approaches to include in the team's curriculum, instruction, and assessment plans. Action research has been used in many areas where an understanding of complex social situations has been sought in order to improve the quality of life. Among these are industrial, health and community work settings (Riding, Fowell & Levy, 1995; Zuber-Skerritt, 1982). The collaboration between the researcher and the two class teachers represents an action research project designed to enhance science teaching through creative drama.

This is a case study due to the small population size, lack of the researcher's control over events, and the study's focus on a contemporary phenomenon within a real life situation (Yin, 1994). Yin (1994) claims that a case study is the preferred research strategy that has the ability not only to deal with large amounts of data gathered from diverse sources but also to capture its authenticity. The researcher used multiple sources of data to capture students' achievements, and students' and teachers' reactions to creative drama in science. A quantitative science assessment, part of the FOSS curriculum, and a quantitative Oral Assessment of Conceptual Understanding as well as qualitative observations, interviews and videotapes were used for data collection and to triangulate data for more robust interpretation.

The Separate Sample Pretest-Posttest Control Group Design (Campbell & Stanley, 1963) is a quasi-experimental design that establishes needed experimental control. Quasi-experimental designs were developed to deal with field research, where it is not always practical or even possible to randomly assign persons to treatment and control groups.

This research design allows division of a relatively small population into two groups; one is the treatment group, and the other is the control group. This design fits this study because the groups (six elementary school classes) were not randomly selected, but were randomly assigned to participate in the pretest or the posttest. The Separate-Sample Pretest-Posttest Control Group Design can be represented as follows:

Figure 3.1 Separate-Sample Pretest-Posttest Control Group Design

Treatment	R	0	(X)	
Group	R		X	0
Control	R	0		
Group	R			0

"X" represents the exposure of a group to the intervention (treatment), "O" refers to observations or measurements, and "R" represents random assignment (Campbell & Stanley, 1963, p. 56).

In this design the same students are not retested and the possible interaction of testing and the intervention is thereby avoided.

Validity issues

Validity of Quantitative Strategies

According to Campbell and Stanley there are eight sources of threat to internal validity in any research design and four sources of threat to external validity (see Table 3.1 below). The threats to internal validity are: history, maturation, testing, instrumentation, regression, selection, mortality, and interaction of selection and maturation. The threats to external validity are: interaction effects of testing, interaction of selection and treatment, reactive arrangements, and multiple-treatment interference. As table 3.1 indicates, only one of these threats, selection-maturation interaction, is of concern in the Separate Sample Pretest Posttest Control group design (Campbell & Stanley, 1963) and it was controlled, as will be explained below.

Table 3.1 Separate-Sample Pretest-Posttest Control Group Design

Sources of Invalidity		
Internal	+	History
	+	Maturation
	+	Testing
	+	Instrumentation
	+	Regression
	+	Selection
	+	Mortality
	-	Selection-Maturation Interaction
External	+	Interaction Effects of Testing
	+	Interaction of Selection and Treatment
	+	Reactive Arrangements (Artificiality)
		Multiple-Treatment Interference

Note: A minus sign (-) indicates a definite weakness

A plus sign (+) indicates that the factor is controlled

A blank indicates that the factor is not relevant

Source: Campbell & Stanley (1963, p.56)

In terms of internal validity, selection refers to the special traits and characteristics that the subjects bring with them to the experiment, such as gender, height, weight, color, personality, motor ability, mental ability, and so forth. If subjects are assigned to comparison groups in a way that these unique characteristics are not equally distributed among the groups, there may be a threat to internal validity. History refers to any outside events that may have happened in the time between repeated measurements of the dependent variables and could influence the subjects' reactions. Examples of such events are illness, war, political issues, natural disasters, and so forth. Maturation represents changes, such as biological growth, that occur in subjects during the course of the experiment between repeated measures of the dependent variables due to natural passage of time. Repeated Testing refers to the effect of one test on a second test. For example, exposure of subjects to pretests may lead subjects to give special attention to the test questions, resulting in attitude change and/or new knowledge learned in the test-connected subject matter.

Instrumentation refers to changes in the reliability of the instruments used for measurements of the dependent variable. These could occur due to changes in the calibration of measuring/taping devices or due to changes of the proficiency of a human observer. Regression to the Mean can occur where subjects are selected on the basis of extreme scores and the extreme scores tend to move toward the average on a second testing occasion without anything being done to the subjects in the meantime due to a regression artifact. According to Campbell (1969), "Take any dependent measure that is repeatedly sampled, move along it as in a time dimension, and pick a point that is the highest (lowest) so far. On the average, the next point will be lower (higher), nearer the general trend" (p.414). Mortality refers to drop out of subjects during the course of the experiment before it is completed. In such cases, unique characteristics of a group's subjects that contributed to the group's measurements of the dependent variable will now change, causing discrepancies in the results. The Selection-Maturation Interaction threat to internal validity refers to interactions of subject-related variables (such as age or gender) and time-related variables. The same maturation factor may affect different persons differently (for example, time since the last meal affects diabetic patients more than non-diabetic persons).

As mentioned earlier, the first seven threats to internal validity mentioned by Campbell and Stanley (1963) are controlled by the design of this study. The only weakness and a possible threat in this design occurs if a specific local trend in the treatment group is mistaken for an effect of the treatment, while it is actually not related at all. Campbell and Stanley suggest that increasing the number of units, such as classes, that are involved in the study and are assigned with randomization to the treatment and to the control group, will "remove the one source of invalidity, and a true experiment can be achieved" (p. 55). Such a design is illustrated in Figure 3.2 (model 13a in Campbell & Stanley, 1963, p.56). This study involved two classes as treatment and four classes as control, thereby controlling the threat of mistaking a local development to an effect of the treatment. Also, data from each class were collected over a limited time frame (four to nine weeks) and the subjects (students) were all approximately the same age, so this threat was controlled.

Figure 3.2 Multiple Units of Separate-Sample Pretest-Posttest Control Group Design

Treatment	R	0	(X)	
Group	R		X	0
Treatment	R	0	(X)	
Group	R		X	0
Treatment	R	0	(X)	
Group	R		X	0
Control	R	0		
Group	R			0
Control	R	0		
Group	R			0
Control	R	0		
Group	R			0

"X" represents the exposure of a group to the intervention (treatment), "O" refers to observations or measurements, and "R" represents random assignment (Campbell & Stanley, 1963, p. 56).

In terms of external validity, Interaction of Testing and Treatment refers to effects resulting from subjects' exposure to pretest or to multiple tests during the course of the research. This exposure might increase or decrease the respondent's sensitivity to the treatment variable and prevent the results of the pre-tested group from being representative of the real effect of the treatment variable. This threat is especially valid in longitudinal studies during which the participants are required to take numerous tests. The Interaction Effects of Selection Biases and the Treatment Variable concerns the special characteristics of the selected population and their reaction to the treatment. Reactive Effects of Experimental Arrangements assumes that people in an experimental setting react differently than people who are not in an experimental setting when exposed to the same experimental variable(s). Multiple-Treatment Interference is a concern if the members of the treatment group had been exposed to prior treatments. Such treatments, even if they happened in the past, are likely to affect the participants' reaction to the treatment. As indicated in table 3.1, all four of these sources of threat to external validity are controlled or not relevant when using the Separate Sample Pretest Posttest design. Since this is a case study, action research project, the researcher is not interested in generalization.

Validity of Qualitative Strategies

The major threat to validity for qualitative studies is researcher bias. When the same person is the researcher and the creative drama teacher, bias may be unavoidable. Several measures were taken to hold bias to a minimum: The researcher collected a large amount of observational and interview data from multiple sources to enable triangulation of the data. She attempted to not overlook any behaviors that occurred and could have jeopardized the research validity. The treatment class teachers were in the class (for the most part) when the researcher taught science through creative drama, so their observations and comments helped identify bias. To prevent researcher bias while scoring the Oral Assessment of Conceptual Understanding, a specific grading key was developed and the assessments were scored by two additional teachers, and their scores were compared to the researcher's scores. In addition, student names were not included to reduce researcher bias.

As in any research, the teacher personality, enthusiasm, skill, and passion could affect the outcome of the research; therefore, teacher effect is a potential limitation to the study.

Methodological Assumptions

Several assumptions and decisions were made in choosing the participants for this research. One important decision was to choose classes that use the same science curriculum. Because the science curricula in neighboring school districts are different than in the community where the research took place, the researcher decided that only classes from the local school district could participate in this research. All teachers who participated in this study were experienced FOSS teachers, had participated in FOSS training when the curriculum was adopted and were participants in the FOSS Assessing Science Knowledge (ASK) Project. The researcher assumed that these experienced FOSS teachers would teach the same science unit in a similar way. This assumption contributed to the decision to let the teachers teach the science unit as they normally do, allowing the researcher to teach the science through creative drama. A second assumption was that since all district students are taught the same FOSS curriculum, all elementary schools have almost the same academic level, and therefore it is possible to compare classes from different schools for this study. In addition, the researcher assumed that students' academic level is almost the same between schools, thereby permitting her to merge all control classes into one control group and both treatment classes into one treatment group. The two classes that formed the treatment group were in the same school.

General Procedures

Six sixth-grade classes were divided in this study as followed: two classes were the treatment group and four other classes were the control group. One teacher taught two of the control classes, from the same school, and the remaining two control classes, as well as the two treatment classes, were taught science by the individual classroom teacher who taught all other basic subjects in that room. Having the class teacher teaching the science unit the same way as it should be taught was essential for maintaining regular and peaceful atmosphere in the classroom and for reducing any researcher bias. The school district's sixth grade science curriculum includes a unit entitled Mixtures and Solutions. This unit is part of the Full Option Science System (FOSS) (The Regents of the University of California, 2000), and was used in this study. The primary concepts in the Mixtures and Solutions unit are: making and separating mixtures, crystals, saturation, concentration, solubility, and chemical reactions.

The Mixtures and Solutions unit is divided into 15 class periods. All six classes completed the entire Mixtures and Solutions unit. The researcher added creative drama activities to the two treatment classes, while the class teachers stayed in the classroom, which helped minimize changes in class atmosphere. All students were asked to take either a pretest or a posttest (part of the FOSS curriculum) in accordance with the research design. The class teachers, as participants in this action research, randomly selected the students who answered either the pretest or the posttest. For this research design it was important that each student saw the test just one time, either at beginning of the unit or at the end of it. The class teachers, all experienced in teaching science in general, and in teaching Mixtures and Solution in particular, taught the science the exact way that they taught it regularly, including many hands-on activities that students usually enjoy.

The Teachers

Both the treatment and the control groups were taught the Mixtures and Solutions unit by their assigned teachers as part of the FOSS curriculum. Three teachers taught the four control classes. One teacher, who taught science to two control classes, has taught for 12 years. She considers herself to be a "hands-on teacher" and believes that students learn by doing better than by book work. She looks for creative activities to supplement her teaching while she uses the science standards as a guide. She adds songs and dress-up to her teaching, because she thinks that learning should be fun. Another control group teacher has taught for 40 years. She uses many experiments, response sheets and reading materials in her teaching. She has been teaching the FOSS science curriculum for a number of years. With some topics she likes to have students research materials that support the topic they are studying. This teacher likes to do hands-on activities as much as possible, because she believes that such activities get the students actively involved and motivated. The third control class teacher, who holds a MS degree in Curriculum & Instruction and in Elementary Education, is currently in his 25th year of teaching elementary school, most of them as a sixth grade teacher, and all these years he has taught science. His method of teaching is a mixture of the best of all he has seen and done throughout his teaching career. Experimentation is done in his class on a regular basis, combined with the necessary content to make the students knowledgeable about the topics covered. As with all that he teaches, he loves the teaching of science, too.

Two teachers taught the two treatment classes. One of these teachers taught for 31 years, 28 of them in sixth grade. Science was always a part of his teaching assignments. His belief is that "if a child cannot learn from the way I am teaching, then I must learn to teach in a new way that he or she can learn". He enjoyed teaching math and science. Early in his teaching career he became frustrated with how science was being taught, because students used to read about science. He attended workshops and conferences to figure out how he could do hands-on science activities. This teacher helped pilot the FOSS curriculum in the school district and continued to work with the FOSS curriculum until he retired last year. This teacher is known to be a creative teacher and a magician, and he performs magic with chemicals for students in the local community. The other treatment class teacher has taught sixth grade for several years, and has 20 years of experience. This teacher is known as a more traditional teacher. He likes to demonstrate experiments to his students, and they complete worksheets, activities and hands-on experiments from the teachers' guide.

The treatment group (two classrooms) experienced additional activities of science through creative drama, following the class activities. The creative drama activities were taught by the researcher. The researcher has experienced teaching science at the elementary, middle, and university levels and she also is familiar with the techniques and the strategies of creative drama. She has already taught science through creative drama to several classes at the elementary and the college levels prior to conducting this study. These teaching experiences did not contain a research component.

Facilitating Creative Drama

The researcher facilitated creative drama activities in each treatment class for 45 minutes at a time. The number of creative drama activities depended on the availability of class time. The researcher taught one class sixteen times and the other class only twelve times, and the creative drama interventions were interspersed throughout the unit. In both treatment classes the researcher related the creative drama activities to the science content that had already been taught by the class teacher. Because of the busy sixth-grade schedule (e.g., D.A.R.E., university field experience students, library time) and other time limitations, the researcher could not come in immediately following the regular science lesson and could not come as often as she desired. When possible, the researcher taught using creative drama on the same day as the FOSS science lesson, and sometimes a day or two after, depending on the availability of class time. In one class, the researcher was asked to come two additional times when the class teacher was absent for medical reasons. This teacher wanted his students to be actively engaged in science and therefore asked the researcher to teach science rather than directing the substitute teacher to lead the science lesson.

Creative drama activities included games and the use of props of any kind. Hats, scarves, noise-makers, balloons, masks, puppets and any item that students wanted to use – without harming other students - were allowed. In creative drama students are constantly engaged and active. They move, jump, dance, rap, write scripts, improvise, act out skits, sing songs, perform pantomimes or play musical instruments. The atmosphere in creative drama class is very relaxed, positive and friendly, with no pressure. Participation was always the students' choice. In the first creative drama session, when creative drama is introduced to the class there may be one or two students who are shy and are not sure that they want to participate. These students will watch the activities from the side, and join the group when they feel comfortable to do so. This happened in one of the treatment classes only during the first creative drama lesson.

Creative drama activities were not designed as solitary lesson plans because they were not intended as lessons by themselves, just additions to the FOSS science lessons that had already been taught by the science teacher. The goal of the researcher in facilitating the creative drama activities was to enhance students' understanding of scientific concepts, as well as to help them recall and comprehend the science vocabulary.

Creative drama is a student-centered activity; thus, the creative drama teacher acts more as a facilitator. When creative drama is integrated in science, the facilitator/teacher has two roles: one role is to explain the activities and make sure that the students know the scientific concept that the activities are connected to, and the other role is to give the students general directions and let them design their own skits, improvisations and performances.

Before starting the creative drama activities, the facilitator/teacher needs to establish some ground rules to make sure that the students know how to behave toward each other, how to talk (not to use foul language), to respect each other's ideas and to respect each other's space. The fact that creative drama activities are done while moving around and not sitting at the desks, might require the teacher to remind students that they are still in school and need to maintain proper behavior. Before starting a creative drama activity, the desks and chairs must be moved aside, leaving the center of the classroom empty and ready as a stage on which the creative drama activities can be performed. The creative drama teacher/facilitator brought different props to class, including scarves, puppets, hats, bandana, noisemakers, elastics, aprons, decorative pins, markers and white sheets of paper. Use of any props was the students' choice. At the end of each class, the facilitator made sure that the desks and chairs were moved back, and that all props were gathered and put where they belonged.

All creative drama activities were done with student volunteers, and in groups. Not once was a student forced to participate in the activities. The facilitator explained and demonstrated scientific concepts through creative drama activities and the students designed their own skits and performances. The performers included a certain number of vocabulary words in their skits. At the end of each group performance, the class students (the audience) and the facilitator/teacher asked questions about the performance. The performers were expected to answer audience questions at the end of the performance. All group members needed to show their conceptual understanding of the scientific content and were responsible for all group members' scientific knowledge.

All students were very excited to participate in the creative drama activities. Examples of creative drama activities are presented in Appendix D.

Data Collection and Analysis

The use of multiple sources for collection of data is essential for achieving reliable and valid data as well as triangulation of measurement. The means for data collection are described below (and summarized in Table 3.2).

Table 3.2 Means of Data Collection for the Research Questions

Question	Question Content	Method of Data Collection*
1	Students' science knowledge	1, 2a
2	Students' and teachers' reaction to creative drama activities	2b, 3, 4

* Data collection

1. Pretest and post-test
2. Student interviews
    a. Oral Assessment of Conceptual Understanding
    b. Open-ended questions
3. Videotaped students' activities
4. Observations of students' activities

Quantitative Strategies

Pretest and Posttest

The pretest and posttest, which are identical, are part of the Mixtures and Solutions module in Full Option Science System (FOSS) curriculum. FOSS curriculum developers at the Lawrence Hall of Science and measurement researchers at the Berkeley Evaluation and Assessment Research Center of the University of California at Berkeley have been working to revise current assessment materials and develop new assessment materials for the next edition of FOSS. The content test used in this study (see Appendix A) was a revised version of the end-of-module test currently available in the FOSS Mixtures and Solutions module. Using item response theory (e.g., Thorndike, 1999) working groups of Lawrence Hall of Science staff, teachers, measurement researchers, and scientists made initial revisions, field tested, and further revised all FOSS end-of-module tests in grades 3 – 6, including the Mixtures and Solutions module. Final indicators of the reliability and validity of the content tests are not yet available because the final analyses of revision work will not be completed until 2008. Some preliminary findings, however, are available. Regarding the FOSS Mixtures and Solutions test, unweighted (MLE), weighted (WLE), and expected a posteriori estimation based upon plausible values (EAP/PV) reliabilities are 0. 895, 0.982, and 0.829, respectively. Whereas the work of the revision committees established the initial content validity of the test, statistical analyses that will provide sophisticated indicators of validity will not be completed until 2008 (K. Long, personal communication, December 11, 2007).

The pretest and the posttest included four types of questions: recall knowledge, interpretation, explanation and analysis. The pretest and the posttest provide data for answering the first research question. Students from the treatment group and the control group took these tests. As the research design indicates, only half of the students in each class answered the pretest, while the other half answered the posttest. The class teachers randomly assigned the students to the pretest and to the posttest. Participants' names, genders and identities were kept unknown to the researcher to encourage unbiased grading. A t-test and a two-way ANOVA with nested factors were used to compare the test results between and within the control group and the treatment group on the null hypothesis: there will be no significant ($p<.05$) difference between the control and the treatment group. The results are presented in chapter 4.

Student Interviews: Oral Assessment of Conceptual Understanding

Interviews were held with students from the six sixth-grade classes that took part in this research. Six students from each class were interviewed: 12 treatment group students and 24 control group students, thirty-six students altogether. These students were chosen by their teachers to participate in the interview according to their achievement levels: two high-achievers, two middle-achievers and two low-achievers. The interviews averaged 10-15 minutes, as per the teachers' requests. The sixth grade classes have many activities, and the teachers who participated in the research did not want their students to lose too much instructional time. All interviews were conducted after the completion of the Mixtures and Solutions unit, and after submitting the posttests. The interviewees' identities remained anonymous. The researcher knew only the students from the treatment group. Regarding the interviewees from the control group, she knew only their first names. Their achievement categories were given to her after the interviews. Nevertheless, the students' identities were not unveiled, and their answers were not revealed.

All interviews took place in the comfortable environment of the conference room of each school, where the students felt at ease, relaxed and undistracted. The researcher started all interviews by explaining to the students that the interview was not a test, that their answers would not affect their grade, and that only the researcher would know their responses. The students were asked to give their answers to the best of their knowledge, and to be honest in their responses. All students answered nine predetermined questions about the science concepts taught in the unit they had completed. Students from the treatment group were asked five more questions regarding their experience with the creative drama activities. The interview protocols are included in Appendix A. The researcher recorded students' answers on audiotape and by hand. Researcher footnotes are especially important when reporting students' body language and when there may be technical problems with the tape recorder. The taped interviews were later transcribed.

The first part of the interview, which focused on Oral Assessment of Conceptual Understanding, included nine questions on recall knowledge, explanation, interpretation and analysis. The second part of the interview was analyzed qualitatively and will be discussed later. The first part was graded for accuracy with a specific key. To increase validity and reliability of the interview as a measurement tool for student understanding of science, and to minimize researcher bias, the students' answers were scored by the researcher and by two additional reviewers. The results were compared at 98% level of agreement. A t-test was administered on the first part of the interview, the Oral Assessment of Conceptual Understanding, to compare the interview results between the treatment group and the control groups, and to triangulate with the pre- and posttest data to provide an answer to the first research question. The null hypothesis for this analysis was that there would be no significant difference ($p>.05$) between the treatment and the control groups. The results of the t-test are presented in chapter four.

Qualitative Strategies

Student Interviews: Open-Ended Questions

As previously mentioned, the student interviews were separated into two sections. The first section was analyzed quantitatively and was described previously. The second section included five open-ended questions, which were analyzed qualitatively. These five questions with students' responses to the creative drama activities were given only to the twelve students from the treatment group. Data gathered gave information about whether students liked and enjoyed the creative drama activities, what they felt while participating in the creative drama activities, whether it helped them to understand science and what kind of activities they preferred. Data collected from these five questions were analyzed through content analysis and are presented in chapter four. A more detailed description of content analysis is presented in chapter four.

Teacher Interviews

Interviews were conducted with the teachers from both treatment classes after the completion of the unit. The teachers were asked for their opinions, impressions and thoughts about creative drama as a tool for teaching science. They were also asked to express any changes in their own perceptions regarding the use of creative drama for teaching science and any trends in their students' social behavior and attitude. The teacher interview protocol consisted of nine questions (see Appendix A), but the researcher was not limited by an interview length or time, so she had more flexibility for follow-up questions. The data from these interviews were analyzed using pattern analysis, to identify common patterns or themes. Pattern analysis will be described in more detail in chapter four. The results also are presented in chapter four.

Video-taped Creative Drama Activities

Some of the creative drama activities were videotaped to allow the researcher to see and listen to patterns and content of verbal and non-verbal communication within groups of students, and to learn how the students agreed, disagreed, and persuaded each other while preparing their group activities. The researcher's intention was to tape all creative drama activities, but she could not do it by herself while she facilitated the activities. To overcome this problem, the researcher took notes after the activities. The classroom teachers were able to videotape the lessons six times when they were not involved in the activities. Videotapes were analyzed using pattern analysis to identify common patterns or themes in the data. Observations from these videotapes are included in chapter four together with classroom observations.

Classroom Observations

Observations of the creative drama activities were made by the researcher and by the teachers of the treatment classes, who stayed in the classroom for the duration of most activities as observers. Since these teachers knew the students better than the researcher, their observations possessed an added and significant value. The researcher and the class teacher discussed their observations frequently, in order to change and improve the creative drama teaching tool and also to enhance students' understanding when they showed a lack understanding. Observational data were analyzed using pattern analysis to identify common patterns or themes. The results are presented in chapter four.

This chapter presented the research design, the setting, the population, the content and the tools that were used for data collection by the researcher. The data was analyzed both quantitatively and qualitatively. The results are presented in chapter 4.

CHAPTER 4 - ANALYSIS OF DATA AND PRESENTATION OF FINDINGS

"When it comes to atoms, language can be used only as in poetry. The poet, too, is not nearly so concerned with describing facts as with creating images"

- Niels Bohr

Introduction

The researcher's goal was to examine the effectiveness of using creative drama as an instructional strategy for enhancing elementary school students' learning of scientific concepts. The following questions guided all data collection and analysis decisions:

1. Does the inclusion of creative drama activities in activity-based science instruction enhance students' understanding of scientific concepts better than activity-based instruction without creative drama activities?
2. How do students and teachers react to creative drama in science?

This chapter provides the description of the setting in which the research took place, a summary of data collection and analysis strategies, and the results of this investigation.

Setting and Population

The research took place in a midwestern university town, with a population of about 50,000, in addition to 22,000 students who attend the university. According to Census 2000, the racial make up of the city is about 87% Caucasian, 5% African American, 0.5% Native

American, 4% Asian, and 3.5% Hispanic. The average household size was 2.30 in 2000. The median age was 24 years and the general age distribution is typical of a university town. The median income for a household in the city was about $30,500. About 8.7% of the families and more than 24% of the population were below the poverty line. The city has a regional airport located 4 miles west of town, but has no bus or train transportation systems.

This town is home to several secondary educational institutions. The largest is a public university, located in the center of town and attended by 22,000 students. There is also a religious college, a technical college, and a school for young adults who dropped out of high school and returned to complete their GED. These colleges, especially the public university, are major entities that influence and dominate the economy of the community. Students rent houses and apartments, shop in the local stores, use banking facilities, gas stations, and go to restaurants and to other entertainment places, benefiting the local businesses and the community's economy. Another important source of influence is a military base, located approximately 20 miles southwest of the city. Some of the military families live within the city limits, send their children to the local schools, represent part of the city work force, and contribute to the city economics by using the local businesses for their needs. The number of the military families changes quite drastically at times, according to soldiers' deployment and other military needs. These changes pose general challenges for the city's economics and exert a great impact on the education system. Needs such as closing or opening an elementary school when students leave or come to town are discussed frequently when the students' numbers decline or grow. The city is also home to eleven public schools, all organized under one school district, and two religious affiliated private schools.

The public school district includes one 9-12 grade high school with two campuses, two 7-8-grade middle schools, and eight K-6 grade elementary schools. About 5,200 students attended public schools at the time of the research; 1,900 of them were 9-12 grade students; 860 were 7-8 grade students; the rest were K-6 elementary school students. Out of the total student population, 47.6% were female, 15.6% were special education and 31.7% of the students were eligible for free/reduced school meals. Almost 77% percent of students were Caucasian, 9.2% were African American, 0.7% were American Indian, 5.3% were Asian/ Pacific Islander, 4.5% were Hispanic, and 3.6% were Multi-Ethnic.

The school district received 54 Standard of Excellence Awards for students' performance on the 2006-2007 State assessments. Students took the State assessments in three subject areas – reading, math and writing. To receive a Standard of Excellence Award at the elementary level, the school must have at least 25% of its students score exemplary on the state assessment and no more than five percent of its students on academic warning. The six classrooms that took part in this study came from three elementary schools.

The school that hosted the treatment group classes had an enrollment of 336 students. Within the total number of students 46.7% were female, 17.6% were special education and 22.0% were eligible for free/reduced meals. Regarding categories of ethnicity, 84.8% were Caucasian, 7.1% were Multi Ethnic, 3.3% were Asian/ Pacific Islander, 2.4% were African American, 2.1% were Hispanic, and 0.3% American Indian. A more specific examination of sixth grade students in this school revealed that 43.64% were female, 23.64% were special education, 27.3% were eligible for free/reduced meals. Regarding categories of ethnicity, 92.7% of the sixth-graders were Caucasian, 10.9% were Multi-Ethnic, 3.64% were African American, 3.64% were Hispanic, and 3.64% were Asian.

The second elementary school whose students were part of the control group was attended by 309 students. Within the total student population, 43.7% were female; 31.4% were special education and 32.4% were eligible for free/reduced meals. Regarding categories of ethnicity, 67.0% were Caucasian, 15.5% were African American, 6.8% were Hispanic, 5.8% were Multi-Ethnicity, and 1.0% were American Indian. A more specific examination of sixth grade students in this school revealed that 55.56% were female, 13.9% were special education, and 41.67% were eligible for free/reduced meals. Regarding categories of ethnicity, 80.56% of the sixth-graders were Caucasian, 8.33% were African American, 5.56% were Hispanic, 2.8% were Multi-Ethnic, and 2.8% were Asian.

The third school whose students participated as part of the control group was attended by 437 students. Within the total number 48.8% were female, 16.48% were special education, and16.48% were eligible for free/reduced meals. Regarding categories of ethnicity, 73.7% were Caucasian, 7.8% were Asian, 6.9% were Multi-Ethnic, 5.7% were African American, 5.3% were Hispanic, and 0.6% American Indian. A more specific examination of sixth grade students in this school revealed that 45.1% were female, 13.73% were special education, and 19.61% were eligible for free/reduced meals. Regarding categories of ethnicity, 70.59% of the sixth-graders were Caucasian, 13.73% were Asian, 7.85% were Multi-Ethnic, 5.88% were Hispanic, and 1.96% were African American.

The population for this research was selected with the help of the school district education center. The Director of Teaching and Learning met with the researcher and her major advisors. The Director was asked to identify sixth grade teachers who were experienced using the FOSS curriculum. The Director then contacted potential sixth grade teachers in the district and gave the researcher a list of ten potential, experienced teacher participants. The researcher contacted these sixth grade teachers, and asked if they were willing to participate in this research. Five teachers responded and were willing to participate as control classes only, having their students answer the pretest and the posttest and be interviewed. Two of these teachers later cancelled their participation due to various reasons. Only one classroom teacher was willing to have his students participate as a treatment group. When the researcher met with this teacher and explained to him how creative drama would be taught, another sixth-grade teacher from the same building overheard the conversation and decided, on the spot, to join with his students and be another treatment group. Both classes were taught the FOSS Mixtures and Solutions unit approximately at the same time period of the school year, but at different hours of the school day. The researcher had to have a flexible schedule so that she would be able to facilitate creative drama activities whenever the treatment group teachers could have her in their classrooms.

The researcher wanted to maintain unity in choosing the same science curriculum; therefore, all classes involved in the research were from the same school district. All sixth-grade students in the district are taught the same FOSS units, so the researcher assumed the same average level of knowledge for all sixth-grade classes across the district. The teachers who teach science in this school district attend continuous teacher development programs and attended FOSS training when the curriculum was first adopted, which led the researcher to assume that teachers would teach the same science unit in a similar way. In addition, all teachers were participants in the FOSS Assessing Science Knowledge (ASK) Project, providing them with additional knowledge of and experience with the curriculum. With these assumptions, two teachers agreed and were assigned as the treatment classes and four other teachers agreed to serve as control classes for the research. Fifty students from the two treatment classes and 80 students from the four control classes participated in the research. Because the sample size was small, data from both treatment classes were consolidated into one treatment group, and the data from all four control classes were merged and presented as one control group.

Summary of Data Collection and Strategies

As described in chapter 3, the researcher used multiple sources to collect data in order to answer the research questions. The pretest was administered to half of the students from all participating classes before they began the FOSS unit on Mixture and Solutions. At the end of the unit the same test, now called "Posttest," was given to all the students who did not take the pretest. An interview was held with six students from each participating class, thirty-six students altogether. The teachers of both treatment classes were interviewed at the end of the unit as well.

Two kinds of analysis were used to analyze the data. Quantitative analysis was used to analyze the pretest and posttest data, and the data from the first part of the student interviews, the Oral Assessment of Conceptual Understanding. Qualitative analysis was used to analyze the second part of the student interviews, the teacher interviews and the classroom observations.

The quantitative data were used to answer the first research question: Does the inclusion of creative drama activities in an activity-based science instruction enhance students' understanding of scientific concepts better than activity-based instruction without creative drama activities?

The qualitative data were used to provide additional insights into the first question and to answer the second research question: How do students and teachers react to creative drama in science?

Quantitative Results

Quantitative data included the pretest, posttest, and Oral Assessment of Conceptual Understanding. Although the Oral Assessment of Conceptual Understanding was conducted as an interview, it was an assessment with points assigned for correct scientific explanations. It was, therefore, analyzed as quantitative data. Points were assigned to all assessment responses and mean scores were calculated. Comparisons were made between treatment and control groups and probability levels were determined. The results are presented in the following sections. Table 4.1 shows the participating classes, nested in the groups, and the number of students in each as they participated in the pretest and posttest (designated as Time 1 and Time 2).

Table 4.1 Sample Size for Levels of Between-Subjects Factors

Factor	Value	Label	N
Group	1	Treatment	50
	2	Control	80
Time	1	Pretest	66
	2	Posttest	64
Class	1	Control – 1	23
	2	Control – 2	22
	3	Control – 3	18
	4	Control – 4	17
	5	Treatment - 1	25
	6	Treatment - 2	25

Pretest-posttest

Pretest and posttest scores of the treatment group and the control group were compared using a Two-Way ANOVA and a t-test. A Two-Way ANOVA was administered to evaluate any interactions between the two groups (treatment and control) and the two times the students were assessed (pretest and posttest). This was done in order to answer the first research question stated as a null hypotheses: there will be no significant difference ($p<.05$) between the control and the treatment group. Results of the Two-Way ANOVA are presented in Table 4.2.

Table 3.2 Two-Way-ANOVA: Tests of Between-Subjects Effects

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Time	61540.641	1	61540.641	302.845	.000*	.706
Group	5739.024	1	5739.024	28.242	.000*	.183
Time * Group	7517.396	1	7517.396	36.994	.000*	.227
Error	25604.219	126	203.208			
Total	339326.000	130				

* $p < 0.001$

The Two-Way Analysis of Variance reveals three important effects:

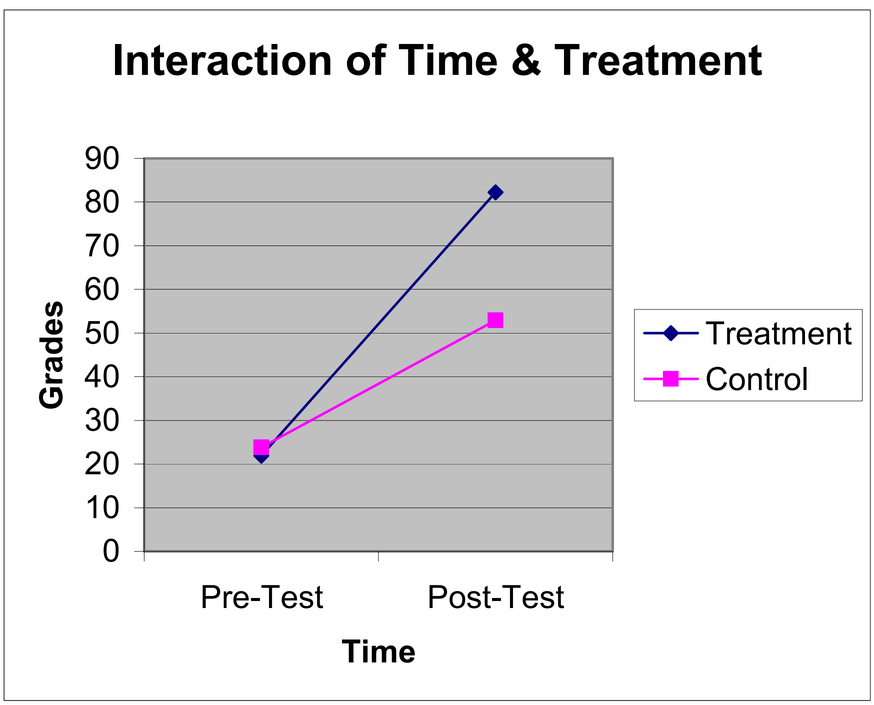
1. The Time effect: Both groups of students enhanced their knowledge of Mixtures and Solutions between the pretest and the posttest. The knowledge the students demonstrated after completing the unit is significantly higher ($p< 0.001$) than their knowledge before the unit began.
2. The group (treatment) effect: Comparison of the posttest means shows that there was a significant difference ($p < 0.001$) between the treatment group and the control group with respect to their knowledge of mixtures and solutions. The treatment group scored significantly higher than the control group on the posttest.

3. The Time * Group effect: The interaction of time and group shows that the treatment group gained overall significantly ($p < 0.001$) more regarding their knowledge of mixtures and solutions.

Knowing these statistical results, the researcher rejected the null hypothesis.

The effects of Time, Group and Time*Group are demonstrated graphically in Figure 4.1 below. Both groups started at similar levels, both groups learned, and the treatment group learned more than did the control group. In other words, the rate of acquiring knowledge was greater for the treatment group.

Figure 4.1 Effect of Time * Group on Scientific Knowledge



Comparisons of the mean scores and the standard deviations of both groups for the pretest and for the posttest are presented in Table 4.3 below.

Table 4.3 Pre/Post Test Results

	Treatment		Control		P
	Pre-Test	Post Test	Pre-Test	Post Test	
	(n = 25)	(n = 25)	(n = 41)	(n = 39)	
Mean	21.88	82.24*	23.85	52.95*	< .001
S.D.	(11.22)	(15.16)	(13.09)	(16.41)	

* Results were significantly different

The researcher administered a t-test (see table 4.4) to compare the pretest and the posttest mean scores of the treatment and control groups to determine whether these means were significantly different. Table 4.4 shows no significant difference (p>.05) between the pretest means of the groups. Both groups started the study with a similar level of knowledge of mixtures and solutions. The posttest mean score of the treatment group was significantly (p< 0.001) different than the posttest mean score for the control group, once again supporting the rejection of the null hypothesis.

Table 4.4 T-Test comparing mean scores of pretest

		Lavene's Test for Equality of Variances		t-test for Equality of Means			
			Sig.	t	df	Sig. (2-tailed)	Mean Difference
Test	Equal variances assumed	315	.577	.626	64	.533	-1.974
	Equal Variances not assumed			.650	56.846	.518	-1.974

Whereas the various effects of the treatment and the time on each group as a whole are clear, the researcher also examined the effects on individual classes. A nested two way ANOVA was performed, and the results are presented in Table 4.5.

Table 4.5 Test between-subjects effects; Classes nested within groups

Source		Type III Sum of Squares	df	Mean Square	F
Time	Hypothesis	54804.617	1	54804.617	207.288*
	Error	32255.459	122	264.389	
Group	Hypothesis	5786.012	1	5739.024	28.603*
	Error	650.257	3.214		
Class (Nested)**	Hypothesis	829.297	4	207.324	.784
	Error	32255.459	122	264.389	

* $p < 0.001$

** classes nested within groups

The results in Table 4.5 reveal no significant differences among the classes that made up the groups. This validates the grouping of 6 individual classes into 1 control group and 1 treatment group, and it also supports the researcher's assumptions that all classes were generally at the same knowledge level, and that the teachers taught Mixtures and Solutions in a similar way.

Oral Assessment of Conceptual Understanding

The researcher interviewed six students from each class that participated in the research - twelve treatment group students and twenty-four control group students - after they had completed the study of the unit and the posttest. The interviewees were selected by their class teachers. The guideline was to select two students from the high achieving tier, two students from the medium achieving tier, and two students from the low-achieving tier of each class. The interview questions were divided into two parts. The first part, including the first nine questions, was the Oral Assessment for Conceptual Understanding. These responses were treated as quantitative data. Each response was scored using a specific grading key and scores were compared using a t-test. The second part, consisting of five open-ended questions, related to the students' reactions to creative drama activities. Since only the treatment group received the creative drama activities, these questions were administered only to the twelve interviewees from the treatment group. The responses to these open-ended items were treated as qualitative data and will be described later under qualitative data.

Responses from the first part of the interview - Oral Assessment of Conceptual Understanding – were scored using the grading key. The researcher and two additional reviewers scored each response at 98% level of agreement. Scores from the treatment group were compared to scores from the control group using a t-test. Results are presented in table 4.6.

Table 4.6 Oral Assessment of Conceptual Understanding

	Experimental (n = 12)	Control (n = 24)	P
Mean	50.18	37.96	< .003
S.D.	(11.03)	(11.82)	

Thirty-six students were interviewed using the Oral Assessment of Conceptual Understanding. The t-test results reveal that the mean scores of the treatment group and the control group were significantly ($p< 0.003$) different. The null hypothesis was that there will be no significant difference between the means of the groups at a probability level of less than .05; therefore, the null hypothesis was rejected. The treatment group interviewees demonstrated a greater conceptual understanding of mixtures and solutions.

Qualitative Results

Data from the second part of the student interviews, from teacher interviews and from class observations were analyzed through qualitative analysis. The researcher used content analysis to analyze students' responses to the open-ended interview questions and pattern analysis for interpretation of the teacher interviews and the class observations.

Content analysis

Content analysis is a research methodology that examines ideas, words and phrases within a given text in order to build categories and determine the presence of certain concepts in that text (Berg, 1998). Texts can be defined broadly as books, book chapters, essays, interviews, discussions, newspaper headlines and articles, historical documents, speeches, conversations, advertising, theater, informal conversation, or any occurrence of communicative language. To conduct a content analysis, the text should be divided into categories on a variety of levels -word, word sense, phrase, sentence, or theme - and the researcher needs to identify objectively the characteristics of the text (Carley, 1990). The researcher looks for words, phrases, sentences or themes in the text, examining whether there is a certain relationship between the words and concepts, in order to make inferences, quantify and analyze their meaning. According to the variety of the words found, the researcher can add thoughts into categories and build more substantial data that support a certain concept.

Pattern Analysis

Pattern analysis, also known as 'Thematic Analysis', is the way researchers are coding data (text) to find hidden themes or patterns. Pattern analysis is the main way for researchers trying to look for patterns in qualitative "raw data." (Shank, 2006). The researcher is looking through the data for patterns and similarities that are concealed in the data (Shank, 2006). When the patterns become organizational they can be called "themes". Morse (1994) sees the data analysis as a process that requires active observation, intelligent questioning, persistent search for answers, and precise recall. The researcher looks at all the pieces of data, link them together so that themes become clear, obvious and significant (Miles & Huberman, 1984).

Open-Ended Interview Questions about Creative Drama

The second part of the student interviews, questions ten to fourteen, dealt with students' reactions to and experiences with the creative drama activities. This part of the interview was administered only to the twelve treatment group students to capture their reactions to creative drama in science. These questions were analyzed through content analysis and the results are presented in the following paragraphs.

Question 10: Did you like the creative drama activities? Why?

The first part of the question was answered "Yes" by all twelve students from the treatment group. Answering the "Why" part of the question, the students had many ideas and reasons for liking creative drama. Using content analysis, the researcher developed categories for these answers. The categories are presented in table 4.7 below. The numbers in the table represent frequency of each reason, not the number of students who answered. The answers were divided into three main categories: "Enjoyment" of doing creative drama (20 responses), "Working with Friends" (10 responses), and "Understanding Science" (7 responses).

The category "Enjoyment" included students comments, such as, "It was fun", "I liked acting out", "I liked using costumes, masks", "It put a lesson into a fun way and a fun way into a lesson", "It kind of excites things a little, making them more interesting", "It was fun to create plays", "I enjoyed saying what I wanted to say."

The category "Working with friends" included comments, such as: "We all had a chance to participate", "We got to share ideas", "I could say what I wanted and my group listened to me", "It felt good. It was good to do the activity with my friends", "It was fun to be included", "It was really fun to work in groups with kids that I usually don't talk to or sit by them."

The category "Understanding science" included students responses, such as, "Creative drama created a new way of looking and learning the materials that we studied in class", "Creative drama made me understand more about science", "It made me think more."

Table 4.7 Why did you like creative drama activities?

Response Categories	Frequency of Responses
Enjoyment	20
Working with friends	10
Understanding science	7

Student responses indicated that they enjoyed the creative drama activities from a social perspective as well as from a learning perspective.

Question 11: Do you prefer science with or without creative drama?

The researcher elaborated on this question, explaining that hypothetically the students could choose between "science with creative drama", which means that drama activities would be integrated into the regular science teaching, and "science without creative drama", which would be studying science as their teacher was teaching them, including the hands-on activities, according to the FOSS curriculum. All twelve students answered that they would like to learn "science with creative drama."

Question 12: What creative drama activities did you like the most?

Students listed such a variety of activities they liked while doing science through creative drama that categories were difficult to find. The use of the human body and balloons to explain concepts such as saturation, concentration, and molecular interactions were identified by ten of the students (83.3%) as important and beneficial to their learning. In their responses to a follow up question, "Why did you like it?" eight students (66.7%) explained that while doing these activities they had to “use the science vocabulary” and it helped them learn and remember these words.

Question 13: Was there anything you learned better because of creative drama?

The researcher made sure the students understood that this question asked them about activities that helped them understand a concept that they did not fully understand before the creative drama activities. All twelve students replied that the creative drama activities helped them better understand some of the scientific concepts. Two students (16.6%) said that they understood things that their teacher taught in science, but creative drama helped them understand it better. Table 4.8 shows a list of the subjects/concepts that were better explained through creative drama and the number of responses that were given.

Table 4.8 What Subjects/Concepts Were Better Explained Through Creative Drama

Response Categories	# of responses
Saturation	10
Vocabulary	10
Concentration	8
Molecular interactions	8
Evaporation	7
Physical reactions	5
Solubility	2
Creating crystals	2

The concepts mentioned in table 4.8 are abstract, hard to grasp and difficult to understand. Students' responses to this question led the researcher to conclude that the creative drama activities indeed had a positive impact on students' understanding of hard-to-understand concepts.

Question 14: Do you like science more after studying science with creative drama?

Eleven out of the twelve students (91.6%) who were asked this question responded with "Yes" to the question. These students thought that they liked science more because they had a good experience studying science with creative drama.

Teacher Interviews

Only the two teachers who taught the treatment classes were interviewed to capture their reactions to creative drama in science (see interview protocol in Appendix B). The teacher interviews were analyzed using Pattern Analysis. These two teachers have different teaching philosophies and teaching methods, and these differences are expressed through their responses to the interview questions; however, four common patterns were identified that represented both teachers: overall positive impressions, creative drama helps build conceptual understanding, creative drama improves students' social behavior, and creative drama requires more time.

Overall Positive Impressions

The overall impression of both teachers is that creative drama is a good tool for teaching science. The following comments represent their overall positive impressions: "I was very pleasantly surprised at how they did, how much they did remember and how creative they got with it.", "Overall it was a very positive experience. I saw students grow and I was impressed with their creativity", "I think that all the students benefited from the creative drama". Both teachers said that the students were looked forward to doing the creative drama. As one teacher expressed, “I had students asking me everyday ‘Are we doing science today?’ ‘Are we going to do the creative drama activities today?’” and, the teacher continues, “They did not mean the traditional science teaching.”

Creative Drama Helps Build Conceptual Understanding

Both teachers agreed that creative drama helped with conceptual understanding. One teacher thought that it was especially beneficial for weak students, because the activities helped them use their imaginations and “see” abstract concepts. The other teacher thought that one important benefit was “using the vocabulary, using the concepts and putting them into the storage (of knowledge) in their mind.”, “Some concepts, like reaching saturation, were taught very well with creative drama”.

Creative Drama Improves Students’ Social Behavior

Both teachers praised the social impact of creative drama on some students. A few students from each class “transformed” from shy and quiet people, and became much more open, talkative and friendly, not only in science, but in class in general. The teachers stated, “Creative drama gave students the opportunity to express themselves.”, “One student, a new student in school, started to branch out and make friends thanks to creative drama. The kids started to realize that he is a real talent”.

Both teachers said that they would like to incorporate creative drama into their science teaching. They realize that there are many benefits to the use of creative drama in the teaching of science.

Creative Drama Needs More Time.

Both teachers responded that creative drama takes time, but they still appreciated the value of the creative drama for the increased understanding of the scientific content and the improvement of the students' social skills, in general. One teacher mentioned creative drama is a time consuming activity, but, "It's worth it". The other teacher suggested that creative drama activities should be done immediately following the science activities or even be integrated into them and not done a few hours or a few days after. In this manner, he would not have to remind the students of what they had learned and they would immediately be able to practice the scientific concept through creative drama.

Observations

The researcher videotaped 6 activities, wrote field notes after each class period, and discussed the activities with the class teachers. The researcher also completed forms for assessment of individual student and group performances. The goal of these forms was to evaluate how accurately students were able to explain and demonstrate the scientific concepts through role playing and using the correct vocabulary. The researcher used pattern analysis and identified the following major patterns from the observational data: Creative drama class is like no other class; students enjoy creative drama; creative drama creates a positive classroom environment; creative drama improves social interaction and self-esteem; and the teacher's teaching style influences students' use of creative drama activities.

Creative drama class is like no other class

Two kinds of activities were used in creative drama sessions: 1) the activities designed and instructed by the facilitator; and 2) activities designed by the students according to the facilitator's general instructions. All activities took place in the center of the classroom, while all desks and chairs were moved aside. The students sat on the carpet, sometimes in a circle, and sometimes in a U-shape while leaving one side as a stage for the performers. The process of preparing the performance is the most difficult for the students and took up most of the time.

If a spectator who was not familiar with creative drama would have observed a session of creative drama class, the events in the classroom would appear very unusual and even chaotic: higher noise levels than in a regular class; students moving around in the classroom; groups of students talking, laughing and brainstorming; students wearing funny outfits, including hats, headbands, scarves, masks; students singing and dancing; students using musical instruments or noise makers; students writing scripts or lyrics for songs, or attempting to perform skits. This description is quite different from regular class activities but it is accurate portrayal of a creative drama class session. Looking and listening closely to what was happening would reveal groups of students trying to choose the topic for their performance, deciding how to present their chosen topic, writing the script (or lyrics) for the performance, deciding which vocabulary words they were going to include in the performance, assigning parts to the group members, determining what props they were going to use, rehearsing the story/scene and preparing the performance. Students were vocally brainstorming and making decisions regarding the content of their performances. They were actively engaged, and therefore their voice levels were higher than expected in a regular class session. The researcher listened to the groups at these stages of preparation, answered questions or gave advice if needed.

Students enjoy creative drama

All student were eager to participate in the creative drama activities and expressed that they were having fun learning and working together. All students showed enthusiasm while doing activities and participated as often as they could. In fact, some activities had to be done more than once because so many students wanted a chance to participate. There were lots of laughter and smiling faces during the creative drama sessions. Students looked happy and expressed their enjoyment to the teacher, to the facilitator and to their friends. Class time seemed to pass quickly, and students were disappointed when it was time to wrap things up.

Creative drama creates a positive classroom environment

All students in both classes participated in the creative drama activities. Even though even though these activities were done in the center of the classroom or outside the classroom, not in "rows of tables", there were no instances of a discipline issue. The students exhibited high levels of responsibility, and did not misuse the freedom they had to move, run, jump, and so forth in class. Students showed respect to each other, to the teachers, and to the researcher. At one instance, when the class teacher was missing and only the researcher was in class, the students were divided into two groups and were given an assignment. It was interesting and commendable that while still enjoying themselves, the students managed to keep their voices down, did not disturb the other group, and did their activity very responsibly. The students were responsible about the games, about the activities and about making sure that all the props were stored back were they belonged. The students took responsibility for their own studies and shared responsibility for their peers' scientific knowledge. After every performance the students “watching” asked questions of the “actors” and, according to cooperative group strategies, the actors helped each other and took responsibility for the whole group’s scientific knowledge. Five students mentioned that if they did not know the answer, the peers from their performance team helped them find the right answer and they felt very comfortable being supported by their team members.

Creative drama improves social interaction

All students felt very comfortable in the class atmosphere created by the creative drama activities. They were willing to work with all members of the class, not just their friends. They were not afraid to talk, nor were they afraid of making mistakes. Students volunteered often to answer questions connected to the scientific content, and they volunteered to help friends who had difficulty answering questions as part of the activities. They did not hesitate to participate in role-plays, sometimes in very humorous situations. All students demonstrated that they trusted their peers not to ridicule them for a certain role they played. Even shy students in both classes, who usually were quiet or did not like answering questions in class, changed during the course of creative drama and started to participate in the creative drama activities and volunteered to answer science related questions.

Classroom teacher’s teaching style influence students’ use of creative drama

Observational data demonstrated that the teacher’s teaching style might affect his ability to accept his students’ attitudes and use of creative drama activities. Both teachers liked the creative drama activities, but their different personalities impacted their attitude towards the creative drama activities, and their students, too. The first teacher, who agreed from the beginning to have his class participate as a treatment group, is a hands-on teacher and a magician. He would dress up funny (e.g., "crazy scientist") and he allowed his students to move around the classroom when he was conducting science experiments. He had a very positive attitude towards the creative drama activities, and he expressed it openly when he welcomed the researcher into the classroom. The students in his class were very cooperative and positive about creative drama. They very skillfully designed very creative performances. They took the challenge and used any props they wanted if the props helped them to explain the scientific concepts. The students from this class prepared beautiful masks, and they used them again and again for class activities.

The other class teacher is a more traditional teacher and his students were not used to moving around in class. Even though this teacher welcomed the researcher to his classroom, he did not demonstrate the same comfort when the students moved so much during class time. This teacher thought that making the masks was a waste of time, and most of his students did not use the masks they made and decorated. The researcher's observations provided evidence that the students in the second class were more active, more creative and showed their full potential when the class teacher was absent or when he commented positively about the activities.

The students in both classes showed positive attitudes towards creative drama; they all liked the activities and demonstrated their ability to design high-quality performances. However, students from one class were always open to do all kinds of performances while students in the other class were more active, positive and cooperative when their teacher showed more cooperation and acceptance of the activities or when he was not in the classroom.

Summary

The data collected in this study were analyzed and presented in chapter 4. Results of the Two-Way ANOVA and t-test show that students in both groups made significant gains in their scientific knowledge. The treatment group students, however, scored significantly higher than the control group students on the posttest. The most meaningful results were obtained by looking at the interaction between time and group. The statistical t-test comparison of the content pretest means between the treatment group and the control group revealed no significant difference. However, the students who received the creative drama treatment, performed significantly better ($p< 0.001$) on the content posttest.

The t-test comparison of data from the Oral Assessment of Conceptual Understanding also revealed significant differences between the two groups. The treatment group demonstrated greater understanding of scientific concepts related to mixtures and solutions.

Interviews with the treatment group indicated that all 12 students liked creative drama activities from a social as well as learning perspective and would like to study science with creative drama. Students suggested a variety of creative drama activities that they liked “most” and all 12 students believed that creative drama activities helped them to better understand difficult science concepts. Eleven of the 12 students (91.6%) stated they liked science more after doing creative drama with science. Interviews with the treatment class teachers indicated that both teachers agreed that creative drama is a good tool for teaching science, that it helps students to understand science conceptually, and that it has a positive impact on students’ social behavior. Both teachers also mentioned that creative drama activities are time consuming. Observational data indicated that a creative drama class is like no other class; that students enjoyed creative drama activities; that creative drama creates a positive classroom environment; that creative drama improves social interactions; and that the teaching style of the class teacher affects his students' use of creative drama.

CHAPTER 5 - SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

"No amount of experimentation can ever prove me right; a single experiment can prove me wrong"

- Albert Einstein

Introduction

Chapter 5 includes a summary of this study, conclusions, discussion of the limitations of the study, recommendations for future research and the researcher's final thoughts.

In this study, the researcher explored whether the inclusion of creative drama activities in activity-based science instruction enhanced students' understanding of scientific concepts better than activity-based instruction without creative drama activities. The researcher also investigated students' and teachers' reactions to creative drama in science. Two groups participated in this study. The treatment group, 50 sixth-grade students, received activity-based science instructions integrated with creative drama, and the control group, 80 sixth-grade students, received activity-based science instruction without creative drama activities. The activity-based science instruction for both groups was based on the Full Option Science System (FOSS) (University of California, Berkeley) unit on Mixtures and Solutions. An exploratory action research case-study with a Separate Sample Pretest-Posttest Control Group Design was used for this study. Both quantitative and qualitative data collection and analysis strategies were used.

Summary

As part of the quantitative analysis, half of the students from both groups answered the pretest questions at the beginning of the Mixtures and Solution unit, and the other half of the students answered the posttest questions after they had finished studying the unit. A Two-Way ANOVA was performed on the pretest and posttest data and revealed a significant difference between the two groups, at a probability level of less than 0.001. The students from the treatment group demonstrated a better understanding of the scientific concepts related to mixtures and solutions. Since the pretest mean scores were similar for both groups, a t-test was administered to determine if there was significant difference. No significant difference was found. The nested ANOVA test found no significant difference between the mean scores of all four control classes and between the two treatment classes.

In addition, 12 students from the treatment group and 24 students from the control group were interviewed. The interview questions were divided into two parts. The first part, the Oral Assessment for Conceptual Understanding, included nine questions. Responses to these nine questions were graded using a specific key and scores from both groups were compared by t-test. Results show a significant difference at a probability of less than .003, where the 12 treatment group students demonstrated a greater understanding of mixtures and solutions concepts than the 24 control group students.

As part of the qualitative analysis, the 12 students from the treatment group responded to five open-ended questions during the second part of the interview process. This second part of the interview related to the students' experience of creative drama activities. The second part of the interview was analyzed using content analysis. These interviews indicated that all twelve students appreciated the social as well as the learning benefits of creative drama. All twelve students believed these activities helped them better understand difficult science concepts. Eleven students said they liked science more after doing creative drama with science.

In addition, the two teachers of the treatment classes were interviewed about their own observations and experiences with the creative drama activities. These teacher responses were analyzed through pattern analysis. Both teachers demonstrated positive reactions to creative drama. They believed it helped build conceptual understanding of science and had a positive impact on students' social behavior. Both teachers also mentioned the extra time required of creative drama.

Classroom observations made by the researcher found the following patterns: creative drama class is like no other class; students enjoyed creative drama activities; creative drama created a positive classroom environment; creative drama enhanced social interactions; and the class teachers' teaching style influenced his students' creativity and use of creative drama activities.

Conclusions

The first research question was "Does the inclusion of creative drama activities in an activity-based science instruction enhance students' understanding of scientific concepts better than activity-based instruction without creative drama activities?" The first conclusion is: Creative drama activities do enhance scientific knowledge and understanding. Although both groups demonstrated significant gains, students in the treatment group showed greater gains than their control group counterparts. Both students and teachers who were interviewed believed that creative drama activities helped students to better understand difficult scientific concepts.

The second research question, “How do students and teachers react to creative drama in science?” was answered through observations and student and teacher interviews about their experiences with creative drama. The second conclusion from this study is: Both teachers and students reacted positively to creative drama in science. Students liked the creative drama activities and expressed a preference for studying science this way. Students thought these activities were fun and enjoyable and believed that they had an impact on social interaction in the science class and beyond; 91.7% of the students interviewed claimed that they like science more after being involved in the creative drama activities. This was supported by researcher observations. The researcher observed five patterns: creative drama class is like no other class, students enjoyed creative drama activities, creative drama contributed to a positive classroom environment, creative drama enhanced social interactions, and the classroom teacher’s teaching style affected students’ use of the creative drama activities. It is important to report that during all research time, there was no incident of discipline problems among the treatment groups, even when the classroom teachers were not present in the classroom.

The treatment classes’ teachers appreciated the value of using creative drama, particularly the benefits of creative drama for learning difficult scientific concepts, and its positive impact on students’ social behavior. These teachers also expressed concern over the amount of time that was required for creative drama. This leads to the third and final conclusion: Creative drama requires more time. This final conclusion will be elaborated on in the discussion section.

Limitations of the Study

Three limitations have been identified:

1. All classes, the treatment classes and the control classes, were taught by their assigned teacher. Thus, teacher differences were not controlled. The researcher added creative drama activities after the class experienced their FOSS science lesson. Teacher effect was, therefore, a limitation.
2. The objectivity of the researcher is an issue. It is difficult to maintain objectivity when the researcher wants to document the advantage of creative drama as a tool for teaching science. The researcher conducted this study as an action research investigation (as explained in chapter 3), which has become a legitimate, acceptable strategy for improving teaching. This research explored the effect of a certain teaching strategy and researcher bias was constantly assessed by the researcher and the science teachers of the two classes.
3. This study included two separate groups of students (two treatment classrooms and four control classrooms). Consistent with action research principles, the researcher did not intend to generalize the results beyond the students in this study.

Discussion

The idea of incorporating creative drama into the teaching of science came up while looking for a teaching tool that would stimulate students' curiosity, reduce insecurity, support self esteem, contribute to positive class atmosphere and encourage participation in class activities (Bailey, 1993). Letting students use their imagination to design skits, plays and improvisations and write narratives about scientific concepts proved to be an interesting and challenging endeavor. In prior research, which is described in chapter 2, students did not design their own performances: they performed activities that were either taken from science activity books, such as Project Wet and Project Wild, or performed activities that were suggested by the teacher. The students in these studies still demonstrated greater levels of scientific understanding. The current study supports these earlier findings (Kamen, 1991; Metcalfe, Abbott, Bray et al., 1984).

Creative drama activities, as implemented in this study, did not supply the students with "cookie cutter" or "recipe book" (created and packaged, ready to use) activities. Students had to use their imagination, their higher-thinking skills, and sharpen their problem solving skills. They were required to be creative, to communicate with others and to think 'outside of the box'. Students were given the freedom to build their own understanding of the scientific concepts, while being actively engaged in using their imagination and their communication and thinking skills, as is suggested by the constructivist learning model (Carin, 1997; Carr & Flynn, 1993; Feldman, 2003; Goodnough, 2001; Llewellyn, 2004; Staver, 1998; Yaffe, 1989; Yager, 1993). Building scientific concepts through social interaction is also supported by Vigotsky (1962). Using creative drama in the current research, the students attempted to make sense of their world by designing their own performance.

Some educational psychologists (e.g., Kirschner et al, 2006) criticize the constructivist approach and related teaching methods such as discovery, problem-based, experiential and inquiry-based, claiming that these teaching approaches use minimally directed instruction, which is less effective and less efficient in students' learning processes. This researcher believes these teaching approaches are not minimally directed. This investigation is an example of constructivist, experiential, and inquiry-based teaching that is student-centered, also facilitated by the teacher in a very direct manner. The process of creative drama helps students internalize and understand better the science processes and abstract concepts. Even though students get the sense of independence and freedom to choose the explanation for scientific learning process, the creative drama facilitator stays in class through the entire experience and guides the experience in a direct fashion.

The beauty of creative drama is that students are constantly involved in the processes of thinking, brain-storming and creating. When they perform their role-play, the facilitator treats it as an authentic assessment, as suggested by Wiggins (1990) and Kamen (1996). Creative drama might be the only educational activity in which the teacher gets an immediate and authentic assessment of students' understanding and misconceptions of the material. All of it is done in a non-threatening atmosphere, while the students do not suspect they are being assessed, and they do not develop test anxiety symptoms. The researcher believes that creative drama supplies the teacher with a unique tool for assessment which is immediate, authentic and non-threatening.

The treatment group students admitted that it was harder to act and use the vocabulary at the same time. Students' comments such as: "You didn't have to only put things together; you had to think and to act at the same time. It's a challenge", "Creative drama created a new way of looking and learning the materials that we studied in class before" and "I had to think more" show that students realized they were thinking more and were challenged, but it still was fun and therefore they would like to have more of it. Another student said "Creative drama excites things a little", and that's exactly what a teacher should try to do in order to make science interesting and appealing to the students (USDOE, 2000a).

The researcher argues that creative drama is an effective tool to promote learning, and would like to compare the benefits of creative drama to what researchers have found about how people learn. Major research has been done in the past 30 years in the field of leaning (Kirschner et al., 2006; NRC, 1999; NRC, 2000; NRC, 2005; Perry, 2003; Ratey, 2001; Salomon, 1993).

Children are born with some biological capacity, not as an empty slate (tabula rasa). They can recognize human sounds and distinguish animate objects from inanimate objects. The human infant is born with an inherent sense of space, motion, number and causality. Learning is promoted and regulated by the child's biology and the environment, which includes the parents, caregivers and all interpersonal supports. As the child develops, there are cognitive changes due to processes that involve conceptual reorganization. Researchers found that young children actively engage in making sense of their worlds. They lack knowledge but have the abilities to reason with the knowledge that they understand. Young children are problem solvers who generate questions and attempt to solve problems that are presented to them; children develop metacognition at a very early stage and this capacity contributes to their ability to plan and monitor their success, and to correct error whenever needed. Children require assistance for learning. They depend on others to mediate their learning capacities which makes the role of the adults in their life critical to: promote curiosity, direct attention, structure experiences, support learning attempts and regulate the levels of the information given to them (NRC, 1999; 2000).

Research on the brain has shown that the brain is a dynamic organ, that both developing and mature brains' structures are altered during the process of learning and that learning specific tasks appears to alter the specific regions of the brain that are appropriate to the task (NRC, 2000; Kirschner et al., 2006; Ratey, 2001). The learning process includes the ability to adapt and apply acquired knowledge to new problems and settings. The most important factor in people's ability to transfer existing knowledge to new situations is the effectiveness of their learning. "Deliberate practice" emphasizes the importance of helping students monitor their learning by getting feedback and actively evaluate their current levels of understanding (Ericsson et al, 1993). Creative drama seems to be an excellent tool for that because it gives the learners immediate feedback of their level of understanding. Researchers mention that learning with understanding is more likely to promote transfer of knowledge than just memorizing information from a test or a lecture (Kirshner et al, 2006; Ratey, 2001). Creative drama is a tool that promotes understanding and does not empphsize 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.

Teachers, according to researchers, have a critical role in assisting learners to engage their understanding, building on learners' understanding, correcting misconceptions and observing and engaging with learners during the processes of learning ((Kirshner et al, 2006; NRC, 2005; Ratey, 2001). Researchers also view the interactions of learners with one another and with the teacher as most important condition for promoting understanding (NRC, 2000; Ratey, 2001). Creative drama activities give teachers and students a tool for alternative assessment, for identifying misconceptions, and for encouraging students to work with each other and with the teacher.

Rresearchers (NRC, 2000; Ratey, 2001) note that when material is taught in multiple contexts, people are more likely to develop a flexible representation of the knowledge. Learning in multiple contexts is what the process of creative drama involves. Creative drama is an active process, as is the transfer of learning. The committee who researched how people learn (NRC, 1999; NRC, 2000) says that teachers need to consider an alternative assessment approach, and that effective teachers should attempt to support positive transfer of knowledge by actively identifying students' strengths. Creative drama addresses both.

In chapter 2, the Multiple Intelligences Theory is mentioned as a way for effective and improved teaching (Gardner, 1983, 1991, 1995). Creative drama is a teaching tool that fits well with the Multiple Intelligences Theory. Creative drama has the capacity to approach each of the multiple intelligences separately and all of them together. All the techniques that are used in creative drama work with all eight of the multiple intelligences: verbal-linguistic; logical-mathematical; visual-spatial; kinesthetic; musical; naturalist; interpersonal; and intrapersonal. Because creative drama is a multi-dimensional form of art, a creative drama facilitator can apply many activities to work with the different intelligences. In creative drama, students move, use their voices and their bodies, communicate, and observe.

Treatment group students mentioned their positive experience from interacting with others while doing the creative drama activities. Comments such as: “It was fun because we all got a chance to participate and share ideas”, “I liked working in groups with kids that usually I don’t talk to or sit by.”, “I enjoyed saying what I wanted to say”, “I felt happy because it was fun to be included”, “it was nice to work with different students every time in new groups” and “I made new friends” show what an impact creative drama might have on students’ self esteem, social skills and general feelings about learning (Bailey, 1993; Hildebrand, 1989; Kentish, 1995; Koballa, 1995; McCaslin, 1996; Rubin & Merrion, 1996).

A student in one of the treatment classes had been shy and quiet. He did not have many friends, did not interact with others, and did not talk or participate in class. This student liked participating in the creative drama activates. He was brave when he chose to take-on a female part in a skit (Mama Bear). He put on an apron, a bandana to cover his head, and talked in a feminine voice. The part he played was very funny and this was a point of metamorphosis for this student. The class teacher and the researcher talked about this student, as they discussed the activities done in class on a regular basis. The class teacher said that this one student really “Popped up. He learned much better with creative drama. He is a kind of a guy that is shy and quiet. You couldn't get him to talk much. I just saw him blossom with the creative drama activities, and that really opened him up in the class in general. He is more willing to discuss things; he is lighter; he is more pleasant as an individual". This is another example of the potential impact of creative drama on students' self[esteem.

Both teachers from the treatment classes mentioned that creative drama takes more time, and that is considered a disadvantage. Creative drama does take time, but if it is possible to integrate creative drama into the science lesson, not just as an addition at a later time, then the time will be managed more efficiently. Although the teachers saw the time factor as a disadvantage, it may have positively impacted students' learning. Student and teacher interview responses indicated that creative drama helped students understand complex and abstract concepts. The researcher does not believe that the extra time spent on science was solely responsible for improved student understanding, but it may have provided an additional positive impact. It is interesting to note, therefore, that both teachers mentioned the extra time these activities took. In an era where science is often neglected in elementary schools (Goodnough, 2001; Penick, 2000) and reading and math become the focus of the curriculum, we need to ask ourselves if scientific literacy will ever be possible in such an environment (Shamos, 1996; USDOE, 2000a).

In this study, the researcher facilitated the creative drama after the science content had already been taught, sometimes a day or two later, even after another science class lesson was taught. Therefore, the researcher was doing activities on a subject that the students had already learned about and moved beyond. Even if there are ways this research could have been done differently, it is still considered a success, looking at the treatment students' level of understanding and the student and teacher comments.

Looking at the limitations of the study, the "teacher effect" becomes an issue. Although a variety of teachers were involved in the teaching the FOSS unit to control the effect of the teacher, only one teacher, the researcher, taught the creative drama lessons. The results show no significant difference between the pretest means of the control and the treatment groups. Also, the nested two-way ANOVA test shows no significant difference among the control classes and between the treatment classes (classes nested within groups). These results justify the researcher's initial assumptions that all participating teachers were teaching science in a similar way.

However, the effect of the researcher teaching creative drama remains a limitation of this study. The researcher is both a science teacher and a creative drama facilitator. The researcher knows the theories about creative drama and believes that creative drama is an effective tool for teaching. The researcher is passionate about teaching science in general and believes in the power and benefits of creative drama for teaching. While conducting this study, the researcher taught only the creative drama and not the science. The research design did not control for the "teacher effect" on the creative drama lessons. If such an effect did exist, the way to avoid it is to have the researcher supervise the research, and let another person, perhaps the class teacher who is trained in creative drama, facilitate the creative drama. This strategy, however, reveals another problem, which originates in the nature of creative drama. Teachers need to be trained to be effective creative drama facilitators. The researcher participated in several courses of creative drama, taught by different instructors. The researcher's personal impression is that the atmosphere in these classes is very open, happy, warm, friendly, positive and energetic with lots of laughter. The participants in creative drama classes appear to be positive and happy people, just like the atmosphere in the treatment classes. The researcher thinks that even if she would choose another facilitator for the creative drama activities the results would have been the same, since most creative drama people will be happy, energetic and positive. On the other hand, the creative drama would not be successful if it was led by someone who had no background in how to facilitate it correctly. The researcher hypothesizes that it is the nature of creative drama that benefits the students and the facilitators, and therefore the results of a similar research, using a different but equally trained creative drama facilitator, would still be similar to this study.

Recommendations for Future Research

There are nine suggestions for future research:

1. Compare two treatment classes, one taught by the researcher and one taught by a different creative drama facilitator who is also a science teacher. In such a design, the "teacher effect" might be minimized.
2. Explore gender and racial ethnic connections in the creative drama activities to determine if girls or minorities perceive creative drama differently.
3. Examine changes in students' attitudes towards science as a result of teaching science through creative drama.
4. Use a larger sample, to be able to generalize the results and the conclusions to a larger population.
5. Repeat this investigation using a different science unit in FOSS to determine if the same conclusions are found for other science topics.
6. Repeat this investigation using a science unit from another curriculum to determine if the same conclusions are found for a different curriculum

7. Repeat this investigation using different grade levels to determine if the same conclusions are found regardless of student age.
8. Incorporate creative drama into the science lesson so that it will be taught at the same time and not after a day or more. This way it will be easier for the students to make connections between the science lesson and the creative drama activities. It may also be possible to determine how much additional time is needed to incorporate creative drama into the science lessons when the topic is still fresh on students' minds.
9. Compare the implementation of creative drama in place of some of the hands-on science lesson with the implementation of creative drama in addition to the hands-on science lesson to determine the relationship between time spent in science and the use of creative drama in science.

Final Thoughts

The American educational system faces problems of ineffective science teaching and low academic performance in science and mathematics. Many factors contribute synergistically to the current situation in science education. In teacher-centered classrooms, lectures and reliance on textbooks and worksheets dominate. Students are neither challenged to use inquiry and think critically nor are they encouraged to use creative ways to solve problems. Students' different learning styles (Kolb, 1984) and multiple intelligences (Gardner, 1983, 1993, 1999; Goodnough, 2001) are not addressed. A synthesis of the literature indicates that three major components should be considered in the search for a solution to ineffective science teaching. First, the major goal of science education is scientific literacy that leads to scientific knowledge and the acquiring of higher-level thinking and problem solving skills (Shamos, 1995; Zoller, 1999). Second, according to business leaders, the special abilities needed by the 21st century's multi-dimensional and sophisticated workforce are knowledge and creativity (GEIA, 1996). Third, art education can potentially impact students' achievement by using multiple resources, thinking 'outside of the box,' looking for creative problem solving, and communicating ideas (SCANS, 1991).

Creative drama is a multi-dimensional and improvisational form of art, designed especially for educational purposes. It emphasizes the thinking and creating processes rather than only the products. It combines all the arts, such as drama, music, dance, movement, rhythm, 'rap', communication, puppets, masks, drawings, role-plays and vignettes (Bailey, 1993; McCaslin, 1996). Creative drama as a teaching tool has been shown to stimulate students' curiosity, reduce insecurity, support self esteem, contribute to positive class atmosphere and encourage participation in class activities (Bailey, 1993). This study indicates using creative drama for teaching science may be a successful way to achieve the goal of raising students' curiosity, interest in science, and helping them eventually to become scientifically literate citizens.

Creative drama is not a magic bullet, and it might not work for every teacher. This researcher looks at creative drama as one more tool for teaching science, not the ultimate or only tool Teachers who would like to use creative drama in their teaching need to take a creative drama course so they will be able to use it wisely and in the right way. Creative drama has a theoretical base, and no one should think that creative drama is just playing games with students.

The researcher also suggests that colleges of education incorporate creative drama into their curriculum to add to the repertoire of strategies available to new teachers. Creative drama was designed especially for educational purposes and it is important that future teachers learn to use it.

And the final thought: Creative drama activities do enhance scientific knowledge and understanding and contribute to better social interactions in the classrooms. Adding creative drama to science teaching as another teaching tool might be the solution we are looking for in science education.

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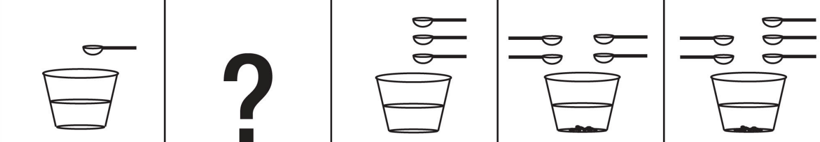
Appendix A - Research Tools

Pretest-Posttest

Mixtures and Solutions
Posttest

ASK ID Number
Date

mx11. Jim used a solid and water to make Mixtures 1, 3, 4, and 5 as shown below. He stirred each one and observed the results.

Mixture 1	Mixture 2	Mixture 3	Mixture 4	Mixture 5
1 spoon solid 100 mL water		3 spoons solid 100 mL water	4 spoons solid 100 mL water	5 spoons solid 100 mL water
	?			
Clear Nothing on bottom		Clear Nothing on bottom	Clear Material on bottom	Clear Material on bottom

a. What evidence does Jim have that the solid and water make a solution?

____

b. Which solution(s) is saturated? What is the evidence of saturation?

____

c. Is the **concentration** of Mixture 5 less than, greater than, or the same as the **concentration** of Mixture 4? Explain your answer.

____

d. If one spoon of solid has a mass of 5 g, what is the mass of Mixture 3?

____

e. Describe how Jim could separate the dissolved solid from the water in Mixture 1. What happens to the solid and to the water?

____

____

____

f. If Jim made Mixture 2 with two spoons of solid in 100 mL of water, what would he observe? What evidence do you have to support this?

____

____

ASK ID Number

mx51. Which one of the following statements about solubility is true?

(Circle the one best answer.)

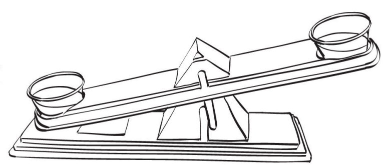
A. Solubility is the amount of solvent that can dissolve in a given solute.

B. Solubility cannot be changed by stirring more.

C. Solubility does not change with temperature.

D. Solubility is the same for different materials.

mx49. Beth made two solutions of different concentrations of water and citric acid. She put 50 mL of the first solution in cup X and 50 mL of the second solution in cup Y. When she put the cups on the balance, the balance looked as shown below.



- Which solution, X or Y, is **more** concentrated? ____

- Explain how you know which is more concentrated.

____

____

____

____

Mixtures and Solutions

ASK ID Number

Posttest

mx12. When you mix two clear liquids, what kinds of observations would tell you that a chemical reaction occurred? Mark an X next to each statement that indicates a chemical reaction has occurred.

______ The mixture bubbles or fizzes.

______ The solid dissolves.

______ A precipitate is formed in the mixture.

______ You can see through the mixture.

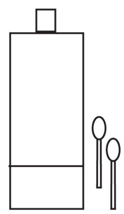
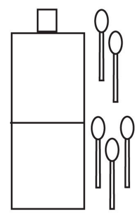
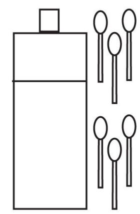
mx14. Jace's teacher asked him to design an experiment to find out if temperature affects the number of grams of salt it takes to saturate 50 mL of water. He wrote the first step below, but he's not sure what to do next. Write out the steps that Jace should take to conduct the investigation.

1. Set up three cups with 50 mL of water, (1) hot water, (2) cold water, (3) room-temperature water.
2. ______________________________

Mixtures and Solutions
Posttest

ASK ID Number

mx50. Barb made three solutions.

Solution 1	Solution 2	Solution 3
		
100 mL of water 2 spoons of solute	200 mL of water 5 spoons of solute	300 mL of water 6 spoons of solute

Which solution is the most concentrated and how do you know?

mx53. Adam's friend gave him a cup filled with a water solution. Adam did not know what solid material was used to make it. He evaporated the solution and found crystals in the dish after all of the water was gone.

How will the crystals help him decide what solid material was used to make the solution?

Oral Assessment for Conceptual Understanding

1. What do you think a mixture is? Can you give two examples?
2. Do you think that tea is a mixture? Please explain your answer
3. Can you name two solids? Two gases? Two liquids?
4. True or False:
    a. Every mixture is a solution
    b. Every solution is a mixture
5. Do you think that gases can make mixtures? Solutions?
6. What happens when we mix salt with water? Where does the salt disappear? What would happen if we add much more salt?
7. True or False:
    a. A saturated solution is always more concentrated
    b. A concentrated solution is always saturated
8. How will you turn a concentrated solution into a diluted solution? A diluted solution into a concentrated solution?
9. What is the difference between a physical reaction and a chemical reaction? Please give examples to both.

Key for Oral Assessment for Conceptual Understanding

1. What do you think a mixture is? Can you give two examples?

- Two (1)

  or

- Two or more (2)
- chemicals/ substances/ materials/ items/ things (2)
- Combined/ put/ mixed together (2)
- Can be made of solids, liquids, gases (2)

  or

- Solute and solvent (3)
- Materials retain their properties (4)
- Can take it apart/ separate (2)
- It can be a solution (2)
- Examples (1 per each)

2. Do you think that tea is a mixture? Please explain your answer

- Yes (1)
- Tea is a mixture (2)
- Tea is made of water and tea bag (2)
- Tea is made of water and tea leaves (2)

- Elaboration (2)

3. Can you name two solids? Two gases? Two liquids?

    Any substances will count (up to 6 points).

4. True or False:

    a. Every mixture is a solution - False (2).

        Every solution is a mixture, but not all mixtures are solutions

        * elaborated answer (2)

    b. Every solution is a mixture – True (2)

        * elaborated answer (2)

5. Do you think that gases can make mixtures? Solutions?

    - Yes (2)

        * elaborated answer (2)

    - Examples (2) per each right example

6. What happens when we mix salt with water? Where does the salt disappear? What would happen if we add much more salt?

    - The salt dissolves/ disperses in the water (2)
    - We get salt solution (2)

        Or

- Transparent liquid/ solution/ can see through (2)
- Salt doesn't disappear: Water is salty to taste – (4)
- Salt breaks down to tiny particles/ molecules (4)
- Salt stays in the water. Doesn't disappear (1)
- Adding more salt ➔ a saturated solution (3)
- Saturation happens when water molecules can't bond anymore with salt molecules (4)
- Mass of salt stays the same (2)
- Excess of salt stays on bottom of container (1)

7. True or False:

   a A saturated solution is always more concentrated - True (2)

   Saturation happens after the solution gets to its maximum concentration

   * elaborated answer (2)

   b A concentrated solution is always saturated - False (2)

   Concentrated solution is not necessarily saturated.

   * elaborated answer (2)

8. a. How will you turn a concentrated solution into a diluted solution?

- Add more solvent (3)

  Or

- Add more water (2)

b. How will you turn a concentrated solution into a diluted solution?

- Add more solute(3)

  Or

- Add more powder/ solid (2)

9. What is the difference between a physical reaction and a chemical reaction? Please give examples to both

- chemical reaction can't be taken apart/ can't be separated (2)
- physical reaction can be separated to original ingredients/ chemicals (2)
- ingredients in physical reaction don't change (2)
- Ingredients in physical reaction change their shape, size and appearance (2)
- chemical reaction creates new substances (2)
- Chemical reactions fizz/ smoke/ heat/ bubble/ change color (1)
- correct examples (2) for each

Student Interview about Creative Drama

10. Did you like the creative drama activities? Why?

11. Do you prefer science with or without creative drama?

12. What creative drama activities did you like the most? The least?

13. Was there anything you learned better because of creative drama?

14. Do you like science more after studying science with creative drama?

Teacher Interview

1. Can you recall of what you thought before I started implementing the creative drama in your class? What did you really think about it?
2. Now that we are done, what do you think about the integration of creative drama into science teaching?
3. Can you name students that seem to have learned better in the traditional way rather than in creative drama?
4. Can you mention students that creative drama didn't do anything for?
5. You talked in changes in general behavior, like J and M. How about changes in patterns in communication, self-esteem, team work, responsibility?
6. What about D.? Did it improve in anyway his class behavior?
7. Do your students use creative drama or other means of creativity in your class in other subjects? You are known to be a very creative person and teacher.
8. Did you hear any comments about the creative drama from the students, from parents, or from other teachers?
9. Would you adopt some of the creative drama techniques if you could?
10. I was really impressed by them one session when you were not here. I divided them into two groups and they were supposed to tell a science story, sitting in a circle, when each student adds one word at a time. They took it very seriously. They were laughing a lot, there were many jokes, but they created a good science story. They really created story while having fun. I didn't have to tell them to be quiet.

11. Your students also mentioned that they enjoyed working in groups (in creative drama), getting to work and to know new people they never knew before and seeing them in different ways.

12. If you had to conduct this research yourself or give me advice of how to conduct this research, what would you say or do differently? Knowing all the advantages and disadvantages of creative drama in science that you know now, how would you do it?

Overall, what are the minuses that you mentioned earlier besides the fact that they didn't take with them all the attention we expected?

Individual Student's Performance Observation

Date of performance: ________ Date of review: ________

Reviewed by: ______________ Class observation/Videotape review

This form will be used for performances' reviews both – in class performances review and videotape review.

A separate form should be completed for each student.

Questions specifying videotaped performances should not be answered when observing in-class performances.

1. Student's name ______________________________________
2. Other group members

   ____

   ____

3. What role did the student have in the group (script writing, acting, singing, dancing, etc.)?

   ____

   ____

4. Was the student able to answer questions at the end of the performance?

   ____

   ____

5. What audience or teachers' questions was the student unable to answer?

   ____

   ____

   ____

6. Grade the student's performance on a scale from 1 (lowest) to 5 (highest) for:

   a. Scientific knowledge __________________

   b. Student's confidence __________________

   c. Student's body language __________________

d. Student's self-esteem __________________

e. Student's communication skills __________________

f. Student's leadership skills __________________

g. Student's integration in the group __________________

h. Student's responsibility __________________

7. Do you observe any changes in the student's behavior and/or self esteem in comparison to pervious performances?

8. Knowing the student on a daily basis, would you say that her/his behavior and communication skills are different when participating in the science through creative dramatics activities?

9. Other comments

Group Performance Review Form

Date of performance: ________ Date of review: ________

Reviewed by: ______________ Videotape review Y/N

This form will be used for performance critique, both – in class performances review and videotape review.

Questions specifying videotaped performance should not be answered when critiquing in-class performances.

1. Group members: ____
2. Group leader(s) (if there was any):

   ____
3. Script writer(s): ____
4. Did all members participate in the role-play? Y/N
   - If not – who didn't participate?

     ____

     ____
   - Did these students have other roles? What?

     ____

     ____
5. In the table below write the vocabulary words that were used by the group on the left column. On the right column write if the words were used in the right scientific context.

	Word	Used correctly
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

6. Were the group members able to answer questions?

____

____

7. Did the students sound confident in their scientific understanding?

____

____

8. Did the group use any props? Give examples.

____

____

9. Did the group use special performance elements (Rap, songs, dance, etc.?

____

____

10. Grade this performance on a scale of 1-10 for:

- Scientific knowledge ________,
- Creative performance _______,

- Cooperative group work ______,
- Clarity of ideas _______.

11. If the group needed to improve and re-do their role-play, how would you grade their scientific understanding on the re-play on a scale of 1-10?

    ____

    ____

12. While watching the videotape, did you observed things that you didn't observed while watching the role-play in class?

    ____

    ____

    ____

13. Other comments

    ____

    ____

    ____

Appendix B - Pilot Study

Scientific Minds Want to Know…

Name: ______________ Date: ______________

In the frame below draw a picture of your idea of what a scientist looks like.

Rate the following statements with the following scale:

1	2		4	5
Strongly agree			Strongly disagree	

1. Science is a subject I like to study. _________
2. Much of what I have learned about science has been from a textbook. _________
3. I enjoy doing science experiments. _________
4. I enjoy completing science lab sheets. _________
5. I am confused about what I am supposed to learn when I complete a science experiment. _________
6. I only like learning about nature in science. _________
7. I only like learning about space in science. _________
8. I know a lot about electricity, sound, light, motion and matter. _________
9. I have participated in a science fair in past years. (yes/no)

Science and Creative Drama Questionnaire

Date: _____________ girl/boy (please circle)

Dear students,

You opinion about the science and drama activities is really important to me. I would like to hear from you if – and how – you would like to continue with these activities.

Please be honest and let me know what you think.

The activities we did since the beginning of the year were:

- The molecules game (molecules in gases, liquids and solids)
- How do molecules combine to make different materials?
- Magnets
- Electricity

1. We started every drama-science activity with a "warm-up".
   a. Did you like it?
   b. If you liked it, can you tell why?
   ____
   ____
   c. What "warm-up" activity did you like the most?
   ____
   ____
   d. If you didn't like the "warm-up" activities, can you explain why?
   ____
   ____

2. This week we did an activity about "electricity".
   a. Do you think you learned something new about electricity from this activity? Y/N
   b. If you answer is YES – please write what you have learned.
   ____
   ____

3. What was the most fun creative dramatics activity that we have done since the beginning of the year?
   ____
   ____

Thanks for your answers!

Bari Arieli

Appendix C - Permission Letters

Permission for Interview – Treatment Group

October, 2006

Dear parent/ guardian,

My name is Bari Arieli, I am a doctoral student in the Center of science education at xxxxx and I am researching new and effective ways of teaching science, so that the students will be active learners and enjoy doing science. In the next few weeks I will join Mr. G. in teaching your 6th grade student science through creative drama. Students will be doing theater games, role-play, improvisation, rap, skits, songs, dance and any other performing arts they choose. The students will be working in groups to design and act-out their own scientific performances. They will be able to use puppets, masks and other props to explain and express the science they learned. The creative drama activities will compliment the regular science experiments, tests and journals. While all students have to do the regular science assignments, participating in the creative drama activities will be on a voluntary basis.

Since teaching science with creative drama is unique, new and is in its research stage, I would like to interview the students and to videotape their group activities. I would like to get your written permission for videotaping and/or for audio-recording your student. Videotaped information will be used by the researcher to assess students' understanding and their attitude towards science. Some illustrations of the creative drama techniques might be used only in professional documentations and gatherings.

I am very excited to be teaching your student and hope that this will be a fun learning experience for all of us.

Please, send back the attached permission form by _________, 2006.

Sincerely,
Bari Arieli

Any questions about creative drama? e-mail me @ barieli@xxxxxx

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Permission Form

I _______________give my approval for my student _________ to be
___ videotaped and interviewed
___ videotaped only
___ interviewed only
in science class at _________________ Elementary school.
Parent/guardian's signature:__________ Date: ________________

Permission for Interview – Control Group

Dear parents/ guardians,

My name is Bari Arieli, and I am a graduate student at xxx. I am currently conducting a research on the use of creative drama in the teaching of science. Your student's class was chosen to be a control group for this research. With your permission, I would like to interview your student about the unit Mixtures & Solutions that was taught in class by the class teacher. The interview is short, and your student's name will not be revealed. The interview will not be a part of the science grade.

I will greatly appreciate your written permission for your student to be interviewed. The interview will be tape-recorded, but the tapes will be used only by me in order to transcribe them as part of the research. If you have any questions regarding this research or the interview you may reach me at ------. I will also be happy to provide you with the results of the research as of your request.

Thanks,

Bari Arieli

Permission for a tape-recorded interview

I ___________________, parent/ guardian of ______________________, give my permission for my student to be interviewed by Bari Arieli as a part of researching the teaching of science through creative drama.

___________________________ _________________________

signature date

Appendix D - Creative Drama Activities

Activity for enhancing understanding the concepts of Concentration

The teacher brought three Hula-Hoops, two of the same size and one bigger (could also be smaller, as long as it was different from the other two.)

The teacher put one of the two same-diameter hula-hoops on the floor, and told the students to imagine that the hula-hoop symbolize a cup with 220ml water. She then asked students (volunteers) to enter, one by one, into the center of one hula-hoop, explaining that each student is one tea spoon of salt (or a drop of food coloring).

When four students stood in the center of one hula-hoop, the facilitator will discuss with all the students what they have made so far (a solution of 100ml of water and four teaspoons of salt). Students that work with the FOSS curriculum should know how many grams each tea spoon of salt weighs and how much the water weighs, so students can calculate the weight or the solution. Then the facilitator will ask the class if they can prepare the exact same solution. The facilitator will show the students the two other hula-hoops she had, and ask for volunteers that would like to create another solution with the same concentration as the first one. Students will probably have different ideas how to prepare the new solution. If the idea is correct, the facilitator should allow one student (the one that came up with the idea) to "prepare the solution". This student will have to invite volunteers and let them into the hula-hoop. After one student enters the second hula-hoop, the facilitator should ask one of the students if both solutions have the same concentration. A discussion about concentration should take place then, and if there is a student that seem to not be sure of what concentration is – the teacher should ask this student how she would know that the concentration is the same or not.

When the second solution is ready, the facilitator should talk about the concentration of the solution, making sure all students know what concentration is. She can take out one “tea spoon” (student) and ask if now the concentration changed and how it changed, etc. this is the time to talk about “concentrated” and “diluted” solutions.

When all is done well, the students (tea spoons) should return to their seats. The facilitator should ask the class what she should do with the extra hula-hoop she has. According to students’ answers, she should mention and show that the third hula-hoop has a bigger (or smaller) diameter, and ask the students for advise of how to create a solution of the same concentration as the first and second one. The class should agree of how many ml are there in the third hula-hoop. If it has a bigger diameter than the first and the second ones, students might agree that the third one has 200ml or 300ml of water, and if it has a smaller diameter, they might decide that the third one has only 50 ml of water.

At this point, the facilitator has two options. One option is that the facilitator will prepare the third solution herself according to students’ suggestions, showing when the concentration is the same as before or more concentrated or diluted. Another option is that the facilitator will divide the class into groups of 4-5 students (not more than five groups) and ask each group to prepare a short presentation / skit about concentration.

The facilitator should write 8 vocabulary words on the board (solution, concentration, solvent, solute, dilute, molecules, atoms, ml) and ask that each group will include in their presentation at least five of the words. Each group gets five minutes to prepare the performance, and are aloud to use any props they want.

When all the groups are ready to perform, each one of them will show their performace to the whole class and at the end of each performance students from the audience have to ask the performers questions about their topic.

Connecting atoms and molecules

1. Ask for three volunteers.
2. Attach to each one a note (with a safety pin) with a letter on it. Explain to the students that each letter represents a chemical. For example: the letter “O” stands for Oxygen, and the letter “H” represents Hydrogen.
3. Ask the students to imagine that each one of the three students is one atom. In front of the class we have three students, two of them are “H” and one is an “O”.
4. Repeat it to the students, and have some students repeat it back to you, to make sure they know what “O” and “H” represents.
5. Have the three students hold hands while the “O” is in the middle, and the two “H” are on both sides.
6. Explain to the class that you had just created a molecule of water, H_2O.
7. Show the students that one molecule of water is made of three atoms.
8. Show the students why water is called in Chemistry H_2O.
9. you may invite other volunteers to do the same, creating more molecules of water, so you’ll have “lots of water” in the center of the classroom.
10. Do the same activity with another molecule, such as CO_2 or CO.

It will be best if the facilitator chooses atoms and molecules that the students have heard about and familiar with.

11. To elaborate, divide the class into groups and ask them to create their own molecules. They are allowed to use their imagination and create an imaginary molecule.

12. Each group will present their molecules to the whole class, and explain how they chose the name (the name has to make sense, according to the atoms that make up the molecule).
13. Discuss how atoms make up molecules, and why there is such a huge variety of molecules and chemicals in nature.

Activity to explain the water molecules' movement and energy

1.ask for 6-8 volunteers and have them stand in the (emptied) center of the class

2. Explain that each one of the student is a molecule of water (you may remind them that each water molecule is made of three atoms)

3. Explain that each molecule needs to move according to the tempo of the racilitator hand clapping. When you clap slow, the molecules move in place, slow movement and when you clap faster, the molecules start to move faster and in a bigger diameter.

4. Discuss what happens when water freezes: the molecules create a solid structure, ice. Have the students stand close in a group, to represent an ice cube. You clap your hands very slow, and each molecule in the ice cube moves in place, very slowly.

5. You should encourage the students use their body to make some movements, faces and noises as if they are cold and freezing.

6. Then, tell the students that you are going to raise the temperature, and the ice will melt to become liquid water.

7.You clap your hands faster, and the molecules start to move faster, detach from each other.

8. Start to clap faster, explaining that the temperature get warmer and that the water turns into vapors. The students will mover faster and faster (running, jumping) and away from each other.

9. Go from cold to hot and back. You want the students to understand what the temperature is, and what they are (vapors, liquid water or ice) according to the tempo of your clapping.

10. Have a student volunteer take your place in clapping

11. You may use a tambourine or another noise maker to dictate the tempo

12. have other students volunteer to be the molecules

This is a good activity to explain the concept of evaporation. Discuss with the students how it happens, and what kind of energy enables the water molecules to become vapors and evaporate.