HOW DOES ART, ANALOGY, AND MENTAL IMAGERY AID IN COGNITIVE DEVELOPMENT

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ABSTRACT

This study focuses on how art, analogy, and mental imagery aid in cognitive development. This topic is examined through a critical review of published literature. Results of this review illustrated that art, analogy, and mental imagery do aid in cognitive development and make the learning of multiple concepts possible for a greater number of students. The research suggests that a stronger presence of the visual arts in education could strengthen cognitive processing skills. If art and or other disciplines are to be integrated, specific attention must be made to the value of art and mental imagery in creating educative analogical relationships between multiple concepts.

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CH 1: INTRODUCTION

In the current climate of funding issues in the public school system and the presidential mandate for schools to focus on subjects such as math and science in order to produce citizens that are more able to compete in the global economy, visual arts programs have been drastically cut or removed all together. Since the introduction of the No Child Left Behind Act five years ago, the focus has been on higher test scores in core academic areas as proof of student achievement. The arts are not yet seen as compatible with the NCLB testing focus. As a result of this, many educators and theorists who support the arts developed research studies to find facts supporting the significance of the arts in education. The result has been that many arts educators and studies seek to show that arts education programs can improve overall test scores as proof of the value of the arts as core academic subjects (Holcomb, 2007).

Another result of cuts in art education programs is that schools choosing to maintain the arts within their curriculum develop various methods of integrating the arts into the other core disciplines. The integration of the arts into math, science, history, and vocabulary, for example, is believed to make the understanding of complex concepts more accessible to a greater number of students (Holcomb, 2007). Although data from a growing number of research studies document a multitude of relationships between the arts, academic achievement, and social skills, the arts are still considered expendable by a growing number of public schools.

Testing scores aside, the educational community needs to explore on a deeper level how the arts aid students in learning across the curriculum before changes are made to their programs. For example, if art programs are to be eliminated entirely or

integrated, how will non-art educators address the learning needs of artistic students? Whether the arts are to be integrated or other disciplines are integrated, would the cognitive development of all students benefit from the inclusion of an aspect of the arts? Considering the above questions, particular aspects of the visual arts and interdisciplinary curriculum will be explored in greater detail including the use of mental imagery and analogical thinking.

Zull (2000) stated that thinking and remembering is based on mental images. As such, a significant aspect of cognition is the brain's ability to visualize. Visual experiences produce mental images that are analyzed, rearranged, and manipulated during cognitive processing. Zull (2000) recognized that all brains sense the same things, yet he suggested differences arise if one is an expert at knowing which part of their sensory data is important and which is not. If this is the case, will learning combined concepts improve if students become experts at describing, interpreting, analyzing and manipulating both external and internal images? Therefore, with a primary focus on the use of visual art across curriculum, the purpose of this paper is to explore how art, analogies, and mental imagery aid in cognitive development.

Rationale

The research and theories around arts integrated studies has created a debate as to how art improves learning. Some educators believe that integrating the arts into science, math, social studies, and language arts will lead to improved cognitive growth in those disciplines. This thinking is unidirectional, assuming that arts education can be the *cause* for improvement in certain capacities found in other disciplines. Other theories argue that the arts are not causal in supporting enhanced learning, but instead share certain

dispositions, cognitive elements, or ways of thinking with other disciplines. That is, that there are *interactive* relationships between certain cognitive elements found in visual arts and other disciplines (Burton, Horowitz, & Abeles, 2000; Eisner, 2002).

Relationships exist between the goals of interdisciplinary teaching and creating analogical relationships. Some teachers use analogies as a tool to help students make connections between multiple concepts in the classroom. Therefore, methods related to effective analogy use are explored to inform educators involved in developing and implementing interdisciplinary curriculum (Thagard, 1992).

Thagard (1992) contends that analogy is an ideal way for teachers to provide students with the beginnings of understanding in a strange domain. Yet there are questions in the field of education as to the value of analogy use. For example, in 2005, the College Board eliminated the analogy section of the SAT test that had existed since the test was first introduced in 1926, The College Board cited two reasons why the analogy section was dropped: 1) they are less connected to current high school curriculum and 2) to address expressions of concern from educators that the section encouraged rote memorization of vocabulary words (College Board, 2006). Others believe it has never been more important for students to be able to recognize true analogies from false ones (Cohen, 2005). Some educational researchers see the need of analogy use as an instructional method for teaching complex information to diverse secondary classrooms (Bulgren, Deshler, Schumaker, & Lenz, 2000).

One of the cognitive elements shared between the visual arts, interdisciplinary experiences, and analogical reasoning is that memory is created and accessed in the form of mental imagery. The prior knowledge students and teachers bring into the classrooms

from their diverse socio-cultural experiences are often stored in the brain in the form of mental imagery. New visual experiences in the classroom, both real and imagined, are retained as mental imagery. Some of these experiences come in the form of a variety of two-dimensional and three-dimensional visual aids used in the classroom and imagined experiences with literature. As such, mental imagery is one tool students may use to make cognitive connections between prior knowledge and new knowledge or between source analog and target analog across content areas (Sadoski & Paivio, 2001; Pittman, 1999).

Controversies exist in the field of Cognitivism as to the role of mental imagery. One theory, the Dual Coding Theory, offers that the brain uses two systems of cognition: mental imagery and language. This assumes the brain transforms verbal codes from speech or writing into nonverbal images and integrates both the verbal and images into memory and at recall. Other theories, such as verbal associationist theories do not take imagery into account at all. Still others consider nonverbal representation to play a superficial role, but that cognition is carried on exclusively through an abstract verbal code (Sadoski & Paivio, 2001).

As research surrounding visual art integrated curriculum is developing, this paper seeks to find evidence of visual art elements playing a role in cognitive processing of dual or multiple concepts across disciplines. In Burton, Horowitz, and Abeles (2000), Eisner referred to specific abilities needed to process multiple concepts that have been implicated in the arts. These include the ability to integrate divergent points of view, layer relationships, and to construct coherence among relationships within complex forms—as in paintings, choreography, and musical compositions. The relationship to the

above abilities implicated in the arts, to the definition and goals of integrated curriculum and to analogical reasoning will be explored in the research reviewed in chapter three.

Definition of Terms

For the purposes of this paper, integrated and interdisciplinary curriculum is used synonymously due to similarities in definitions used in K-12 education. The definitions of both terms include the combination of two or more subjects and finding meaningful relationships among multiple concepts and life experience (Lake, 2006).

Analogical reasoning is defined as a search for similarities between what is already known, new information, the familiar, and the unfamiliar (Pittman, 1999). Terms needing definition surrounding analogy use include source, target, and mapping. The source of an analog is material that is familiar to students, the target is material unfamiliar to students, and mapping is the cognitive process students use to establish corresponding relationships between the source and the target.

Kaplan (1992) defines a metaphor as a combination of two ideas, presented either verbally or nonverbal images, that share similar features to one another such that one idea is used to organize or conceptualize the other. Due to the similarities between metaphor and analogy, metaphorical thinking and analogical thinking, the terms are used synonymously in this paper.

As stated previously, it is theorized that different disciplines share certain cognitive elements, dispositions, or ways of thinking (Burton, Horowitz, & Abeles, 2000). Considering this, transfer is defined as the ability to apply previously learned information from one discipline or concept to another, using it to help solve a new yet

similar problem. Therefore, for the purposes of this paper, transfer and analogy are considered equivalent processes.

The visual arts and visual art education is considered the study of art history, aesthetics, art criticism, and studio art consisting of painting and drawing, photography, sculpture, ceramics, printmaking, crafts, and multimedia art. The aspects of visual art include visually experienced 2- and 3-dimensional objects. An experience with an image could be visual only or include visual and tactile processing of the object if it was created or manipulated by study participants. Mental imagery is also an aspect of visualizing, creating, and even mentally manipulating 2D and 3D objects and therefore considered an aspect of the visual arts. Visual thinking and mental imaging are used synonymously.

Perception is defined as the ability of the brain to form two and three-dimensional mental images from multiple sensory input.

Statement of Purpose

This paper examines the history and research surrounding the role of art, analogy and mental images upon cognitive processes. With a primary focus on the use of visual art across curriculum, the question guiding this paper is *how can art, analogies, and mental imagery aid in cognitive development.*

Limitations

The visual arts encompass the use of multiple senses, all of which are important to the construction of knowledge (Eisner, 2002). In order to focus effective strategies and components of analogy use, I have limited the majority of my data and theories to the use and influence of vision. A primary relationship that exists between analogy use and the visual arts is the component of mental imagery, structure and object surface similarities in

both 2- and 3-dimensions. Although there is research that points to the sense of touch as being an effective mode of recognizing object and structure similarity and create mental images (Vanlierde, A., & Wanet-Defalque, 2005), I for the most part limited my investigation to research and theories referring to sighted people.

In the area of art integration studies, I am limited in the amount of peer reviewed study that will add to the investigation of the problem. This has left a disproportionate amount of studies on analogy use and mental imaging in other disciplines.

Sources informing the investigation for all chapters of this paper disproportionately reflect Western-European theories, historical references, and cultures.

This paper is also limited in the bias toward social constructivist learning. As the author subscribes to the belief that knowledge is built upon existing schema and develops through interactions with the socio-cultural environment of the individual, the majority of the theory and methods and research may mirror this bias.

Most importantly, I am limited in the bias that consistent and equitably accessible art education is a crucial component in K-12 education.

Summary

The investigation of this question stems from current trends in public education that are shifting approaches to learning from content specific discipline study to interdisciplinary methods. Interpretations of the core disciplines have left a growing number of public school visual art programs to be limited, removed or integrated. Educational, developmental, and cognition theories, practices, and research are explored in this paper with the intent of informing the question how art, analogy, and mental imagery aid in the learning process.

Chapter 2 explores the historical background of subjects related to the guiding question. The history of art and mental imagery use is explored first while analogy use aiding in cognitive development is explored last.

Chapter 3 consists of a critical review of the literature and has been divided into art and integrated concept research, analogy use, and mental imagery. As the investigation for this paper focuses on cognitive development in general, some of the research looks at data from participants younger and/or older than K-12 education. Due to the connections between analogy sources used and student's existing schema from their socio-cultural experiences, data related to exposure and use of metaphor and analogy outside of school is considered.

Chapter 4 concludes with a summary of the research findings, the classroom implications, and implications for further research in the area of art, analogy, and mental imagery.

CHAPTER 2: HISTORICAL BACKGROUND

Visual Arts and Mental Imagery in Cognitive Processes

The history of visual art practices and mental imagery as an aid to cognitive development is reflective of shifting beliefs as to what is involved in cognitive processing. The debate throughout history centered on whether the senses play a role in making meaning. Some believed higher levels of mental activity consist primarily of linguistic and mathematical skills and that information from the senses was not related to real learning and thinking (Ives & Pond, 1980). This debate, one that exists to this day, began with early Western philosophers like Plato. Visual data in particular was not believed provide stable knowledge of the world and could not logically and rationally explain reality. Due to this predominate belief, artisans and craftsmen in Greek society were considered laborers, ranked only slightly higher than slaves (Efland, 1990).

The labor oriented view of the arts and artisans did not shift until the Renaissance. Fine arts began to separate from the crafts during the Renaissance, and art became a theoretical discipline (Efland, 1990). Due in part to the genius status of artists like DaVinci and Michelangelo, high mental capacity became equated with artistic ability. Michelangelo supported this belief by stating, "One paints with the mind, not the hand" (pg. 29). Art academies were founded during this time yet were only accessible to upper class males. Although the Renaissance era art academies introduced a connection between cognitive and sensory abilities, the overall impression at this time was that art was a luxury pursuit having no real purpose.

During the 15th century, the value of the senses waned while the value of linguistics in cognition was strengthened. The development of the printing press during

this time created an increasing reliance on the printed word as the primary vehicle for all worthwhile knowledge (Ives & Pond, 1980). Books containing two dimensional prints did attempt to connect visual images with their verbal symbols. The first fully illustrated reading textbook was published in Germany in 1658 by Comenius (Sadoski & Paivio, 2001). Called the *Orbis Sensualium Pictus*, it was significant in that it stressed the sense experience before the logical, correlated words with things, and reading with writing. The strong use of illustrations connected visual imagery to language during cognitive processing. This book was greatly successful and used into the early 1800's in Europe as well as the United States. More purely linguistic methods involving rote memorization were still the most widely used in the U.S. at this time, so methods of learning involving visual imagery did not replace verbal.

The value of visual experiences in cognitive processes resurfaced again during the Romantic period. From approximately the mid-18th century to the mid 19th century, philosophers like Rousseau and Kant emphasized the value of sensory experiences, observations in nature, and emotions over reason and intellect (Sadoski & Paivio, 2001). The artist was rediscovered and elevated to higher social status as an individual creator. Although fine art education was still only accessible by the elite minority, the ideas of Rousseau and Kant influenced the value of visual experiences in general education methods from the mid-19th century to today.

An education reformer influenced by Rousseau was Pestalozzi. Originating in Prussia, Pestalozzi's technique was based in his theory that people learned through a set of images, sensorimotor patterns and concepts (Sadoski & Paivio, 2001). He believed the learner built upon these impressions to progress to understanding more abstract concepts.

Object visualization and measurement played a crucial role in all levels. Pestalozzi's general principles were summarized in part by Efland (1990) as follows: to bring all things essentially related together, arrange objects according to likeness, and strengthen sense impressions by experiencing objects through different senses. Stated in this matter his principles convey similarities to basic analogy structure and constructivist cognitive processes.

The artistic component of the American common school movement was first influenced by the Pestalozzi method of drawing (Efland, 1990). Unfortunately, Pestalozzian principles were altered by the time they were implemented in the states, becoming a highly ritualized formal procedure—the value of the role of the senses and experiences severed from the original. In the U.S., it is important to note that the only aspect of art considered important and not morally damaging was skill in drawing, its primary usefulness to improve handwriting and in industrial design. The American version of the Pestalozzi method aside, the original techniques mark an early example of scaffold instruction, use of visual and multisensory learning experiences, and insight into cognitive processes.

The next major event in education was the Progressive movement at the turn of the 20th century. This period was influenced by Comenius, Rousseau, Pestalozzi and others and its educational applications were activity-centered (Sadoski & Paivio, 2001). Francis Wayland Parker and John Dewey were considered to be forerunners of the Progressive Era in American education (Efland, 1990). It was during this movement education saw the emergence of social constructivist philosophy and art integrated studies. Parker's philosophy was that children could only find meaning if it was rooted in

their own experiences. As such, he had children develop their own text material and illustrate them. Attention and expression were at the core of his method, involving all the senses and the imagination. Since expression for Parker was more than just the spoken and written word, music, painting, gesture, voice, and modeling were used with multiple subjects.

Dewey's progressive beliefs had a profound influence on the American education (Sadoski & Paivio, 2001). Dewey stated in 1916 that both real and imagined experience was the basis of meaning and learning. He believed that experiences with school subjects needed to have real value and significance to student's own experiences (Efland, 1990). His school was therefore organized around activities and the senses, not subjects, with the arts running throughout. Within these activities, Dewey advocated methods based on active inquiry and experimentation both real and imagined (Sadoski & Paivio, 2001). The focus for both Parker and Dewey in integrating the arts with other educational activities was in creating multiple sensory experiences to help bridge the gap between the familiar and the unfamiliar—hypothesizing art and imagery as the vehicle to secure meaning for children (Efland, 1990). Although progressive methods influenced the theories and practices in American education, they were never widely practiced and remain controversial (Sadoski & Paivio, 2001).

Other educators that believed mental imagery played a valuable role in cognitive development were Rudolf Steiner and Maria Montessori (Sadoski & Paivio, 2001). Steiner began the Waldorf schools and developed a system of that placed mental imagery at the center of learning. Instruction methods relied heavily on the observation of objects and pictures across all content areas. Some of Montessori's ideas were based on the

development of mental images and systematic sensory observation. Montessori believed the visual image would be supported by information from auditory, kinesthetic, and tactile information. Waldorf and Montessori education began in the U.S. as private schools in the early to mid- 1900. Currently, public schools that practice their methods are also becoming education options.

In the field of developmental theories, Jean Piaget gave imagery an important place in cognitive processes (Sadoski & Paivio, 2001). Piaget's theories became a landmark in educational practice and theory beginning in the early 1900s and are influential to this day. He believed mental imagery was necessary for environmental interactions, the development of abstract principles, and problem solving. Mental imagery was not alone, but was combined with language in symbolic functions used within the brain to make meaning. One example of a shift in practices influenced by his theories is in the area of literacy instruction. Reading began to shift from oral to silent in order for mental images to develop more effectively and be used for comprehension and analysis.

Within art education in America, the Expressionism movement was combined with new theories from child psychology that affected beliefs about the role of art in developing knowledge (Koster, 2001). A laissez-faire attitude and the belief in free expression combined with a new admiration for children's art created a long history of focus on the product. This phase in art education with its lack of emphasis on aesthetics, art history, technique, or the role of art in cognitive development gradually created the perception that art does not require a high level of mental or technical skill, teacher training, or financial support. These opinions may have factored into the rationale for the

next wave of scientific research and political influence in the arts from the mid 1960's to today.

According to Ives and Pond (1980) the role and value of images and perception were not factored into the realm of scientific thought during the early to mid 1900s. This was due to the dominance of Behaviorism in American psychology. Behaviorists believed that mental imagery had no functional significance and that memory and thought were primarily verbal (Sadoski & Paivio, 2001). Some of the features of Behaviorist learning in the classroom included content delivered through the language of textbooks and worksheets, instruction dominated by verbal explanation, and standardized tests reliant on verbal ability. Visual images, objects, and multisensory experiences had no place in the creation of meaning where behaviorist methods were practiced.

Adding to the lack of importance of images and perception during the dominance of behaviorist beliefs was the influence of Viktor Lowenfeld (Efland, 1990). Lowenfeld believed individuals inherit, rather than acquire, a disposition to perceive reality through sensory modes like vision and touch. Research and theories in the 60s and 70s started to compete with the scientific community in this area. For example, June McFee contradicted Lowenfeld by citing recent experimental evidence that perception abilities could be explained by environmental practices, specifically during childhood. Due to increasing contradictory data, imagery was reintroduced as an accepted subject for study.

The relationship between mental imagery and the arts began to be explored by the mid-1970s. Studies began to support the functional significance of imagery in problem solving (Ives & Pond, 1980). Some in the field of psychology began to support the idea that mental imagery serves two functions: parallel processing of information and the

creation of analogous forms. In addition to greatly expanding general cognitive capacities, Ives and Pond (1980) stated that these two functions are at the core of arts experiences. The significance of verbal processing was also deemed necessary as a logical and sequential approach to problem solving. As such, research during this time began comparing parallel and sequential processing with differences in the cognitive capacities of children and adults.

The role of art, mental imaging, and the diverse range of cognitive capacities was a significant aspect of Howard Gardner's (1983) theory of multiple intelligences. Gardner's theory emphasized seven different ways each individual processes information: musical intelligence, bodily-kinesthetic intelligence, logical-mathematical intelligence, linguistic intelligence, spatial intelligence, interpersonal intelligence, and intrapersonal intelligence. Mental imaging plays a crucial role in his musical, mathematical, and spatial intelligence theories. The influence to education was that teachers began to think more about learning styles and integrating curriculum in order to teach to a greater variety of cognitive capacities.

Scientific research and practices were also an influence in all disciplines of education. As Efland (1990) stated, science became the model of curriculum changes for all of general education after 1957. Politics directly entered the arts in 1962 under the Kennedy administration (Efland, 1980). An educational research team noticed a disparity between the amounts of federal funding for the sciences compared to the arts. The Arts and Humanities Branch of the U.S. Office of Education funded 17 conferences on the arts from 1964-1966. Many federally funded arts projects during the mid to late 60s promoted the idea of interdisciplinary teaching from the standpoint of boosting morale and

attendance and the philosophy of art as an experience, not as a discipline. Therefore, the federal arts projects during this time were not necessarily reflective of the developing cognitive research and theories.

The contemporary value of art and mental imagery in cognitive development is in part reflected in a growing number of integrated arts programs. The integration of curriculum and the inclusion of the arts in education are also dependent on administrator beliefs and values, funding issues, and research regarding cognitive processes.

Analogy

The use of analogy has been well documented throughout history. Cohen (2005) wrote that analogies were used by Aristotle to reason about man and nature and to create the building blocks of arguments. Use of analogy has been popular throughout the history of politics (Cohen, 2005; Holyoak & Thagard, 1997). From Karl Marx comparison of the proletariat's condition to slavery (Cohen, 2005) to the debates surrounding the analogy between the Persian Gulf War and World War II in 1991 (Holyoak & Thagard, 1997), analogies have been used to shape public opinion. Although analogical thinking is considered the hallmark of human intelligence (Holyoak, Junn, & Billman, 1984) and the use of analogy is widely documented, the use of analogy as an aid to cognitive development had not been explored until the mid to late 1900s.

Where analogies have been implied to aid in cognition is in the field of science. Scientists have long used analogy to form hypothesis (Messaris, 1997). One example Messaris (1997) shared was how the chemist Friedrich von Kekule used a visual analogy to help discover the circular arrangement of the benzene molecule. Kekule apparently

had a mental image of a snake biting its tail and explored the relationship between this image and how the atoms of the molecule were structured.

Throughout the history of education, objects have been used to create analogical representations (Messaris, 1997). These objects include two and three-dimensional visual aids such as maps, scale models, family trees, and diagrams. The prevalence of analogies used in dialogue within and outside of schools and the significance of analogy in education is said to be reflected in the inclusion of analogy question on tests such as the SAT and GRE.

In spring of 2005, the College Board announced that the analogy portion of the SAT would be dropped (Cohen, 2005). The stated reason for the removal was that analogy questions are less connected to the current high school curriculum. Many of the shifting practices in art education, curriculum integration, and mental imaging theories explored in this chapter refer to analogous relationships between two dissimilar structures. Therefore, the recent omission of analogy from the SAT may mark a shift in beliefs about the value of analogical thinking in education and reflect a more current position on cognitive processes. The potential impact of this change has yet to be assessed.

Summary

The roles of art, analogy, and mental imagery have been woven into and out of beliefs about cognition in varying degrees throughout history. Influential to changes in the fabric of dominate beliefs in this area have been the beliefs of philosophers, respected specialists within specific domains, politics, and science. This chapter explored evidence of historical relationships between art, analogy, and mental imagery in cognitive

development. With particular consideration to the growing shift toward art integration and integrated curriculum, the next chapter critically reviews the research relating to these potential components of cognitive development.

CHAPTER 3: RESEARCH

In this chapter I review and critique studies that inform my question: how can art, analogy, and mental imagery aid in cognitive development. I have organized the studies into the three groups. First, the sub-section of art and integrated concepts reviews studies that involve learning art and investigate the idea that learning art enhances or improves performance in other areas. Sub-section two deals with the process and components of analogical thinking as an aid in learning. The third sub-section reviews research on the use of mental imagery in cognitive processes.

Art and Integrated Concepts

A qualitative study by Parsons (2006) explored the complexity of children's visualizations as they read. The ten 4th grade children who participated in this study were also the co-researchers. The children worked with Parsons (2006) to identify and analyze their visualizations and perspectives while reading using the sign systems of written language, spoken language, and symbolic representation.

The children in the Parsons (1999) study identified three different classifications for the visualization process that occurs while reading. The three classifications, picturing, watching, and seeing, were framed in metaphors to signify their position and perspective in the world of the story. The metaphors chosen were used as sources in the process of analogically explaining their thinking, perspective, and visualizations (mapping) to help them and the researcher gain insight into the level of reading comprehension and aesthetic reading experience (target).

The picturing process was assigned the metaphor of builder because snapshots of images were being drawn according to their developing understanding. These still

images would build together into a larger picture as their understanding grew. The watching process was given the metaphor of shadow, TV, or setting, as the children were observing the actions of a character and not yet fully involved in the story. The seeing process metaphor was a bird or video camera and represented living through the experience of the story, level of immersion, having multiple perspectives, and a high level of comprehension. The researcher believed the findings of this study reflect the depth and fullness of children's engaged and aesthetic reading experience and the importance of visualization in this process. The researcher also believed visualization is essential to literacy engagement and made possible by comprehension.

A concern about the study (Parsons, 1999) is that the 10 children who volunteered for the study may have had experience with visualizations from reading comprehension when not all children visualize as they read. Struggling and reluctant readers will not be able to engage in the level of participation, writing, and discussion that the researcher had with the co-researchers/study group. Therefore, educators may have difficulty implementing the process when comparing it to the level of student reading comprehension and aesthetic experience. Parsons does provide probing questions and literature that may be helpful in encouraging a visualization process, but these suggestions need to be tested for effectiveness with a larger and more diverse sample of participants.

Getzels and Csikszentmihalyi (1976) investigated relationships between problem finding behavior and the originality of finished pieces of art. They followed the study participants through the problem finding stage, the problem formulation stage, and the problem solution stage. 31 male artists were asked to choose from a variety (27) objects

and create a still-life drawing. Behavior during object choice was considered by researchers to be the problem finding stage. Aspects of the artist's final object choices and behavior during the selection and arrangement were part of the formulation stage. Choices surrounding when and how the composition became final were part of the solution stage.

Of the six possible correlations between problem behavior variables in the Getzels and Csikszentmihalyi (1976) study and the finished product rating, 5 produced significant relationships to originality. The relationships were significant to $p < .01$ for both the problem finding, problem formulation totals, and to originality of finished product. Overall, higher scores were given to the artists who manipulated a larger number of objects before choosing than to those who chose the most unique objects for their drawing. The artists who received the higher scores in these areas were rated the most original by the artists and art teachers judging the final pieces. The researchers concluded that behavior during the problem finding stage and the problem formulation stage is directly related to the originality of the final piece of art.

There are some questions, however, regarding the generalizability and coding in the Getzels and Csikszentmihalyi (1976) study. As this phase of their study sample consisted of only 31 experienced male art students, the issue of small sample size, gender, and amount and quality of art experience trim the results down to a significantly smaller population, limiting the generalizability. The coding of all the behavior was done by one person and although the researchers extended the coding over a period of time and at random to try to decrease experimenter bias, there is no way to check if code definitions have alternate explanations. One example is the way in which choice of

unique objects was given a high score. What may have been unique to the artists in the study may not have been considered unique by the experimenter. Similar to uniqueness, the relationship between individual artistic values of the judges to the originality scores in the study is also too subjective and affected by socio-cultural factors of the time to produce reliable results.

Burton, Horowitz, and Abeles (2000) asked if certain capacities, dispositions, and ways of thinking that are developed through an arts education have an effect on other subject disciplines and on thinking and learning in general. Understanding that highly diverse art teaching practices abound, this complex study looked at a very diverse sample of programs and practices in 12 different types of schools, 2,406 children, and grades 4, 5, 7, and 8. The data used in this study was generated from both quantitative and qualitative procedures.

Data was generated from a variety of tests. The tests were given to all grades and included a self confidence test, creativity test, and a questionnaire describing their arts experiences. All teachers were asked to respond to questionnaires to determine school climate, and arts teaching and a learning inventory. The qualitative data primarily consisted of interviews, observations, and examination of children's performances, artwork, and writing. Principals and teachers were also interviewed. For the years of in-arts school experience and affects upon each student, the researchers primarily relied on children's memories. Descriptions of coding practices in the study were detailed, with 3 or more researchers coding, but inter-rater reliability figures were not provided. The quantitative testing phase lasted two quarters (winter and spring).

The Burton, Horowitz, and Abeles (2000) study found that arts education improves student's capacities for elaboration compared to students with low art experiences to a significance of $p < .0001$. Elaboration skills include greater attention to detail, expression at a greater length, and multiple perspective taking (Burton, Horowitz, and Abeles, 2000). The researchers proposed that this improvement is achieved through a combination of factors such as years of in-school arts, arts integration, student and teacher collaboration with arts specialists, and collaboration of external providers. Other test data concluded that of all the disciplines to contribute to elaboration skills, an arts education program contributes 11% (R square = .111) of the total.

The study also found that risk-taking scores of students involved in years of in-school arts and arts integration were higher than those with low arts experiences to a significance of $p < .0001$. An in-school arts program with arts integration contributes close to 10% (R square = .095) of risk taking behavior in students. Risk taking in terms of the study was deemed to include performing with expression, taking chances on projects to create something new, willingness to convey ideas of personal value, and following through on an idea, regardless of what others think. The researchers concluded that since elaboration skills and risk taking ability are not specific to art education, a learning relationship exists between art and other disciplines. A high-art education program may provide important access for students with various learning styles to develop and strengthen their elaboration and risk-taking skills.

Not to leave potential benefits to teachers out of the equation, the Burton, Horowitz, and Abeles (2000) study found that a high art program significantly effects teacher innovativeness to $p < .0001$ over low arts programs. For this study, constants of

years of in-school arts, collaboration with external providers, arts integration, and collaboration with arts specialist contribute to 94% (R square= .937) of teacher innovativeness. The benefits of innovative teaching for students were stated to be increased motivation, a decrease in behavioral problems, interest, enthusiasm, and improved access to information. As teacher innovativeness was partially dependent on an arts integration program, the potential benefits share a relationship with other disciplines.

Upon critical review of the Burton, Horowitz, and Abeles (2000) study, there are some concerns of the research methods. The presence of the researchers in the classroom could have had an affect on student and teacher behaviors during observation. It was not mentioned how the tests were administered and duration of time the tests were given. The testing phase results could be affected by stress, fatigue, or time of day depending on these variables. Overall, the sheer scale of the data to be collected, transcribed, coded, and classified increases the risk of human error in this study.

In the Forseth (1980) study, art activities were purposefully integrated with 30 different 4th grade mathematics classes. The goal was to determine if the use of art activities cause any change in the attitudes, creative thinking, and/or achievement in either discipline.

A total of 669 4th grade students were used for this study. The students remained in their usual math classrooms from 8 elementary schools. Pretests were administered to all students at the same time with a different post test given six weeks later. The study took place from March to April in 1976. Attitude tests were given for both math and art. Creative thinking in art was measured using the Torrance Tests for both the pre- and

posttest. The 30 classes were divided into experimental and control groups. Math reinforced by art activities were taught by the regular teachers in the experimental group. The children in the experimental group had at least three art activities per week. The art activities were assumed to reinforce math concepts such as fractions, place value, coordinates, and symmetry. Each lesson across all groups lasted 45 minutes each.

Of the seven dependent variables measure in the Forseth (1980) study, the only variable that received significant results of $p < .001$ was student attitudes toward mathematics. There was no effect on math achievement based on the post-test data. From this, the researchers concluded that the visual thinking provided by the art activities interacts favorably with the logical-mathematical mode of thinking. Attitudes about math improved at a significant relationship ($p<.001$)

The Forseth (1980) study concluded from the data that art activities in math will not improve attitudes toward art or increase creative thinking. I have four concerns about the study. The study only lasted a month and 23 days, which may be too short of time to establish data patterns and sufficient numbers. It was not disclosed whether students involved in the study had any prior art experiences. The level of prior art experience could have a profound effect on the data regarding attitudes toward art and the creative thinking variables being measured. The Torrance Test used to measure creative thinking has low and variable reliability. The fourth concern is the possibility of the Hawthorne effect due to the fact a control group with new, non-art curriculum was not compared against the new art curriculum—newness by itself could have increased attitudes about math.

Stavropoulos (1994) investigated whether a writing intensive approach, introduced to a Discipline Based Art Education (DBAE) program within 4th grade classrooms impacted critical thinking. DBAE art education focuses on art criticism, aesthetics, art history, and studio production. The goal of the standard DBAE method was to develop critical thinking skills through discussion in the area of formal, descriptive, interpretive, and historical dimensions of art understandings. The goal of the writing-intensive approach in this study was whether the effectiveness in developing critical thinking skills is increased compared to a DBAE approach that encourages discussion only.

Three 4th grade classrooms were studied totaling 68 students. 25 of the students served as the control group and did not receive writing exercises with DBAE instruction. The experimental and control groups were similar in their representation of female, male, Caucasian, and African-American. The art work at the center of the study was The Birthday (1923) by Marc Chagall. Students were asked to respond to this piece in writing as a pretest and a posttest. Other lessons and reviews included several of Chagall's other pieces and were in the form of a produced piece, class critiques, and whole group discussion and questioning. The study lasted a full school year, meeting in art classes for one 50 minute class per week.

The Stavropoulos (1994) study discovered that the writing intensive approach to DBAE instruction tripled measurable learning outcomes when comparing the writing pre- and posttest scores. The researcher categorized understanding into lower and higher-order levels and claimed that there were increases in both levels across all dimensions assessed. As there were demonstrated increases in the writing samples of formal,

descriptive, interpretive, and historical dimensions of art understandings, the researcher concluded that the critical thinking skills developed in the DBAE discussion instruction method naturally transferred into written form through the writing intensive approach.

The Stavropoulos (1994) study primarily centers on differences in 4th grade writing abilities. Scores in the written test samples depended on the student's ability to express themselves in writing. Researchers used the Diagnostic Profile tool to score the writing and discovered a large proportion of students in all study groups possessed poor writing and spelling skills. The teacher who performed the DBAE instruction for the study shared that what the students could verbalize was not always communicated through their writing. The researcher concluded from this study is that future assessment studies involving this age group should be directed at transcribed verbal statements.

Davis (1969) focused on the effects of depth and breadth methods of art instruction upon creative thinking, attitudes about art, aesthetic quality of art products, and motivation. Depth instruction allows sustained long-term concentration in one specific area of study and any variety is introduced in such a way as to permit easy transition from one problem to another. Breadth approach was described as a variety of well-chosen activities and subjects dispensed to students to accommodate their individual interests and experiences.

The study involved 126 students enrolled in a beginning art class at a technological college. Two sections of the group met in morning classes, and the other 4 were afternoon classes. Creative thinking tests were given as pre-and post tests. As the primary investigation was comparing depth and breadth teaching methods, the groups were divided in half and taught by two different instructors.

The Davis (1969) study showed nonverbal originality was statistically significant at the $p < .01$ level in groups taught by the depth method of instruction. This signifies that the college students (n=126) within the depth approach art program scored higher originality ratings on either written artifacts and/or produced art pieces than the students receiving the breadth approach art instruction. Because this was the only aspect of the eight areas of creative thinking being studied to show statistical significance, the researcher concluded that the study raised some important questions about the superiority of one teaching method over another.

There are multiple concerns of the Davis (1969) research methods. The length of the study was only fall semester for this particular college and the study sample (n=126) had no known art experience, leading the researcher to conclude that art experiences do not necessarily lead to measurable growth in general creativity. The study used two separate teachers and split the students between them. Much of the data that was insignificant was due to differences in teaching style, not method, affecting the independent variable. One of the teachers provided more 3-dimensional art experiences to his students than the other teacher did, tainting the data on aesthetic product differences between the groups. The different time of day the classes were taught is a variable confounding the data as it relates to student motivation and attention.

Luftig (2000) attempted to identify desirable educational outcomes influenced by an arts education curriculum. This study focused on a particular integrated art program called SPECTRA+, where reading, math and science are taught through the arts and the arts are taught through the other subjects. The study included 615 2nd, 4th, and 5th graders who were involved with the study for one year. Data was generated in the areas of

improvements in creative thinking, and academic achievement in reading and math. No data regarding science integration was collected.

Data was generated in the Luftig (2000) study in the area of creativity and math achievement. Within creativity, subgroups for fluency, originality, abstractness of titles, elaboration, and resistance to early closure were tested. Although the SPECTRA+ program group scored higher ($p < .019$) than either the control and modified control groups in overall creativity, the only subgroup that generated significant scores for the program was originality ($p<.0001$). This means that the students with the arts integrated program generated more unique responses to tasks than the other groups studied. Math achievement was separated into the subgroups math concepts and math application and the only subgroup to receive significant scores for SPECTRA+ was math concepts but this was a function of gender. Males in the arts integration program scored significantly higher than all other groups to $p<.005$, in fact they were the only group to show any improvement between their pretest to posttest scores.

Information as to teacher gender, experience, attitudes, enthusiasm, and teaching models are not provided or factored into the study and all could potentially affect the study results. Two of the five instruments used to measure student test answers were proved acceptable and reliable only by the author himself—one of which he created himself specifically for this study. Therefore, no significant data by other researchers had yet been collected about the reliability and validity of the two test instruments. It is a possibility that the tests themselves could be unintentionally gender bias.

Caldwell and Moore (1991) used drawing integrated with a narrative writing task for 2nd and 3rd graders to test whether the use of drawing created a difference in the

quality of the children's writing. In this study, the relationship between visual art and writing as two important symbol systems were explored. According to the researchers, the primary similarity the two symbol systems share in this study is the process of composition.

The subjects were 42 students divided randomly into a control group and a drawing group. The drawing group received 15 minutes of discussion regarding narrative writing procedures, 45 minutes of drawing exercises related to their writing content, and 30 minutes producing a draft. The control group received the same 15 minutes of discussion and 30 minutes producing a draft, but their 45 minutes was spent in language art exercises. The study lasted 15 weeks and generated 600 writing samples that were scored by 3 raters. An inter-rater reliability correlation (r=.94) indicated that there was high agreement among raters and this agreement was stable for the duration of the study.

The Caldwell and Moore (1991) study found a statistically significant difference between the overall score of the non-drawing group and the overall score of the drawing group (p= .0007). The overall score gain for the drawing group from the pretest to week 15 (posttest) was 2.47 and the gain for the non-drawing group was .67. It is interesting to note that the overall scores between the two groups was fairly equivalent until week 5, when the drawing group scores became consistently higher. The researchers concluded that the data supported their hypothesis that participation in drawing leads to a difference in writing quality when compared to participation in discussion alone.

A concern regarding the Caldwell and Moore (1991) study is that the researchers made an initial assumption that drawing is a previously developed form of expression for children. Children's experiences with drawing may vary greatly, with the possibility of

total lack of experience. Caldwell and Moore (1991) cite Durio's (1975) suggestion that people who have access to a range of personal symbols (like drawing) are capable of more unique responses than those who rely on verbal representation. Therefore, the first five weeks of the data generated may reflect the assumption regarding developed drawing skills, as the scores remained similar between groups up until week five.

Espe (1984) tested whether a set of pictograms developed in America could be understood cross-culturally. These pictograms, called the Graphic Differential, were developed to be a language free research tool providing an alternative to the Semantic Differential. The Graphic Differential, developed in the U.S., provides a tool for measuring semantic meaning and attitudes from images/visual symbols. Espe's (1984) study tested the intra-cultural validity of the Graphic Differential by administering the sorting task to both American and German subjects. If certain visual images or symbols are understood cross-culturally, those images may assist educators in creating visual metaphors and analogical relationships, in developing language skills, and in understanding visual art pieces.

The study participants involved 46 American and 46 German male and female subjects (n=92). The study was performed in Philadelphia and West Berlin. Two images were pictured on each of a total of 15 cards. These cards were referred to as scales. An example of the pictures on one of the cards was a simple drawing symbolizing a happy versus a sad human face. Subjects were given the cards and asked to sort them into different groups according to their meaning. Meaning was completely determined by the participants, as researchers gave no other verbal explanation. The meaning given to the

images were categorized by the researcher into the semantic dimensions of evaluation, potency, and activity.

The Espe (1984) study found that the Americans understood and categorized the images according to their meaning and the German results, in general, were similar to American findings. In the German sample, a couple of the images were misinterpreted frequently, suggesting to the researcher that even simple pictures and symbols may be culture bound to a certain degree. Although the German sample revealed some weak spots when compared to American results, it is possible the cross-cultural validity of the Graphic Differential could be improved by replacing or altering the problematic images.

The cross-cultural validity of the Graphic Differential may have increased dramatically if the Espe (1984) study had included more than two cultural groups for comparison. If the German sample categorized some images as action instead of evaluation, then other cultural groups may also interpret certain images differently than Americans. Therefore, the larger and more diverse the study sample, the potentially less reliable and valid the Graphic Differential tool becomes.

Summary of Art and Integrated Concepts

Evidence of transfer and analogy use or the effects of art practices upon other subjects from the above studies is not convincing. There is suggestive transfer data that certain capacities generally held to be art specific, like elaboration and originality, are found in other disciplines (Burton, Horowitz, & Abeles, 2000; Caldwell & Moore, 1991; Luftig, 2000). Risk taking and teacher innovativeness may also be improved through the arts, but only after years of in-school arts and integration programs (Burton, Horowitz, & Abeles, 2000). Positive results in this area, since transfer was not found specifically, may

suggest the arts provide particular components contributing to the cumulative effects of multi-subject education (Burton, Horowitz, & Abeles, 2000).

The Forseth (1980) study, although tainted by the possibility of the Hawthorne Effect, suggested a favorable interaction between visual and mathematical modes of thinking. This seems to allude to possible support for the multiple intelligence theory and/or potential analogical reasoning. The Davis (1969) study was also confounded but suggested more research comparing single subject teaching methods compared to multi-subject teaching methods are needed. Within such a future study, the possible relationship between single subject instruction (within-domain analogy use) and interdisciplinary study (between-domains analogy use) should be explored.

The Stavropoulos (1994) highlights an important component to educators and researchers in creating transfer learning conditions and assessing student understanding. The study did not generate conclusive transfer data because assumptions were made that verbal expression would transfer equally to written expression. Since this was not the case, and the summative assessments relied fully on written tests, the results were not significant. This suggests a potential need for multiple-sensory assessments in education.

The focus on art and integrated concepts included the use of imagery and mental imaging in the Espe (1984) study. Imagery in this study was equated with symbols representing concepts that could be sorted cognitively and linguistically to a high degree of success among the study sample (n=92). Some studies reported improved writing abilities due to the integration of visual and mental images (Caldwell & Moore, 1991; Stavropoulos, 1994). Others reported improvements in reading comprehension due to integrated imagery and arts (Luftig, 2000; Parsons, 2006). In light of the current research

trend, specific focus on visual imagery and cognitive tasks in relationship to analogical reasoning needs to be addressed in future studies.

Analogy Use

A study by Dent and Rosenberg (1990) investigated the comprehension of visual metaphors as indicated by the use of verbal metaphors. As the researchers included detailed criteria for metaphoric descriptions and these matched components of analogical thinking, the data is relevant to this investigation. There are also strong relationships between mental imaging and the ability to communicate about an image that may be of interest. This study provides possible foundational data in that it looks for differences in age groups of the ability to detect resemblances between objects and between objects and people.

The study elicited descriptions from 5, 7, 10, and 21 year olds (n=120). The researchers also added the element of motion to half of the visual metaphors to test whether motion similarities enhance children's abilities to detect similarities. Verbal prompts were used when objects were first shown to the participants to establish familiarity. Participants were asked to name the object and if the answer was incorrect, they were asked to say what else it could be. Use of metaphors in their responses was recorded.

The Dent and Rosenberg study (1990) found that moving objects received more specific metaphoric responses than did the stationary objects to statistical significance of $p < .001$. Also, metaphoric descriptions increased with age to a significance of $p < .001$. Visual metaphors (compound objects) received a higher number of metaphoric descriptions than standard objects for all of the children groups. In this category, the 5

year olds were significant to $p < .01$ and the 7 and 10 year olds, $p < .001$. The researchers conclude from this data that visual metaphors generate more metaphoric descriptions, improving the ability to ascertain whether the visual relationships were understood. The significance of the moving visual metaphors creating even more responses related to the increased options of object characteristics with which to draw relationships. The data regarding comprehension of visual metaphor increasing with age is stated by the researchers to be related to a differentiation model of perceptual development. That is, children are more able to detect object similarities as they get older.

As mentioned, verbal prompts were used in the Dent and Rosenberg (1990) study when the object was first shown to the participants to establish familiarity. They were asked to name the object and if the answer was incorrect, they were asked to say what else it could be. Naming an object may not necessarily be enough to establish familiarity with it, possibly affecting the participant's ability to respond metaphorically. Inter-rater reliability was fairly acceptable at 84%, with additional 3rd judge included to address potential coding bias. Socio-cultural factors and gender differences were not controlled in this study, and the relationship of gender to visual metaphors may have been enlightening.

Crisafi & Brown (1986) investigated whether very young children can perform similar tasks with different objects. A variety of tests examined the learning and transfer abilities of children on a task requiring the combination of two separately learned solutions to reach a similar goal.

Participants of the Crisafi and Brown (1986) study were 2 and 3 year olds (N=35 and 28 respectively) divided evenly into male and female. Three different problems were

presented to the children in the form of three dimensional objects that looked very different from each other. Although the objects were visually dissimilar, each required locating a token, inserting it into the objects, and retrieving a prize.

The researchers discovered that the ability to recognize the task performance similarities between two different objects were dramatically increased with a reliability of $p<.01$ when the children were told the rules of the task and asked to repeat them. They also found that tasks with both objects and relations that were familiar to the children studied, like putting a coin in a gumball machine, was directly correlated with a high proportion of successful performance to a significance of $p<.001$. The highest performance success, 89%, was with the use of a gumball machine as their familiar object and putting a coin in the machine to obtain a gumball was their familiar relation. Other tasks and objects received only 67% and 17% and were concluded to be unfamiliar to the children. To achieve higher rates of performance success, the researchers conclude that telling the subjects explicitly that the tasks are the same when the objects are different and/or unfamiliar and that they should use the solution from one to solve the other is necessary for the age group.

However, there are some factors affecting the generalizability of the Crisafi and Brown (1986) study. Of the sample subjects, only age, gender, the fact that they attended daycare, and a general location described as a Midwestern, middle-sized town were mentioned. Due to relatively small sample sizes and lack of considerations of both socio-economic status and cultural differences as factors affecting a subject's recognition of familiar objects and relations, the results obtained by their method of study leads to a low rate of generalizability with larger populations. It is also unclear as to the consistency of

the verbal prompting, and if children could have been led to solutions from voice intonation or possibly nonverbal clues.

The focus of the Holyoak, Junn, and Billman (1984) study was to determine the age children first apply simple analogies to perform a goal-directed problem solving task. They were also studying the types of analogical conditions that determined success or failure among their young subjects. The relevance of this study's results will possibly help inform education decisions about how soon analogies could be used in the classroom, methods of use, and factors effecting successful development of analogical reasoning skills.

In the study, children (n=48) were divided into groups according to age, test conditions, and control conditions. One group ranged in age from 4 to 6 and another from 10 to 12 years old. The study methods included storytelling that included clues that could be used to solve a hands-on test using multiple objects. Experimenters asked the subjects to retell the story and questioned them for details they neglected to include to ensure they understood before proceeding to the task. The task was problem- solving in nature requiring balls to be moved from one bowl to another without using their hands. Multiple objects with some basic similarities to objects used in the story were placed near the task for children to experiment with. Subjects were encouraged to come up with as many solutions to the problem as possible. Experimenters provided hints as to possible relationships to the story when the children appeared to run out of ideas.

The Holyoak, Junn, and Billman (1984) study found that preschoolers can use analogies but only under optimal conditions that can be unique from child to child suggesting that multiple analogy sources be available to them. In contrast, they found the

10 to 12 year olds in their study use analogies successfully only when the sources and relationship hints are given. The researchers believed their study supports the possibility that developmental change in preschoolers may be connected to analogical transfer skill and that children my benefit from the use of analogies as soon as kindergarten. Overall, the possible educational and cognitive benefits of analogy use could not be ascertained from the data.

The data from the Holyoak, Junn, and Billman (1984) study was highly variable with regards to the 4-6 year old subjects. Factors attributing to this were the children's various levels of experience in the task demands and objects used, the level of similarity between the source and target objects used, the inclusion of mapping solutions from other life experiences that were outside of the given set of mapping choices, or possible memory limitations. Other potential methodology factors that contributed to a lack of statistical success in the Holyoak, Junn, and Billman (1984) study are small sample size (n=48), the type and frequency of hints given, only one experimenter relating to all the children, and the possibility of unintentional cues (tone; facial expression) that could contribute to experimenter bias. In regards to the 11 year old subjects, there was consistent success with the goals of the task, but only after the analogy was pointed out to them. This suggests that the older children need verbal cues in order to perform an analogical task with the source and targets provided to them.

The development and use of teacher- generated analogies were studied within 8th grade math classrooms by Richland, Holyoak, Stigler (2004). The study explored patterns between analogy use and instructional content. Although verbal analogies were stated as a prominent method of production in math classrooms, the Richland, Holyoak,

Stigler (2004) study revealed the use of non-math analogy sources and visual sequencing during the mapping process. Data accounting for use of visual representations during analogy use within any discipline is relevant to my thesis research.

Researchers coded 25 video and audio samples. Each sample represented one lesson chosen at random from a collection of 81 clips from across the U.S. of public, private, and parochial 8th grade math classrooms. Teachers, students, and lessons were studied for the duration of one school year. 103 analogy samples were analyzed. All lessons were taught by a different teacher and content areas were randomly selected from algebra and geometry units.

Actual use of analogies in the Richland, Holyoak, Stigler (2004) study was found to be between 1 and 11 for each lesson (n=25), with a mean of 4.1 analogies. The study found a significant relationship of $p < .001$ between the source categories teachers used for an analogy and their mathematical goal. That is, different analogy sources were used for teaching math concepts when compared to teaching math procedures. For example, if teachers were focusing on mathematical concepts, they would draw equally from non-math sources, student schema sources, de-contextualized, or contextualized sources. A non-math analogy example used was the comparison of the peel of an orange with the circumference of a circle. Schema analogies compared a real-life experience or general rule with no numbers and in a non-math context. De-contextualized math analogies use only numbers and contextualized math analogies are like story problems—a number problem set in a non-math context. Conversely, when teaching mathematical procedures, teachers used de-contextualized problems as analogy sources with the highest frequency.

For this segment of their study, the researchers concluded that complex patterns exist between the type of sources chosen and the goal of the lesson.

Related to the above conclusion, the Richland, Holyoak, and Stigler (2004) study revealed that when teaching to procedures only, relationships were made between analogy sources and targets using high levels of similarity between the two. When teaching to concepts, comparisons between non-math and schema sources—or non-similar relationships—were almost exclusively used. Their study revealed significance between the variables of surface similarity of analogy source and target to mathematical instruction goal to be $p < .0001$. In conclusion, this information revealed that the math teachers in this study used a high degree of de-contextualized analogy sources and targets when teaching procedures only and these sources and targets were visually and verbally similar to one another.

The Richland, Holyoak, and Stigler (2004) study also provided some additional information as to why teachers chose either procedural or conceptual analogies. They found that teachers used high similarity procedural analogies when responding to a student's expression of difficulty. The degree of significance between surface similar procedure analogies to student expressions of difficulty was $p < .001$. Far distance, or non-math, conceptual analogies were used when there were no signs of student trouble. Researchers concluded that student's expression of difficulty was determined by the teachers in their study to be procedurally based, and that procedure based problems require more transparent and explicit analogies.

Another potential strength of the Richland, Holyoak, and Stigler (2004) study is in regards to the frequency of teacher and student participation in producing the source of

the analogy, mapping components that align the source to the target, and producing the target. They found a significant difference of $p < .001$ in the participant roles of the production of communicated analogies. Teachers retain more responsibility (66%) for production of mathematical analogies than they give students (2%). 33% of the total analogies were produced by a combination of teacher and student or students. When considering the mapping of the connections between the source and the target of the analogy alone, teachers controlled 90% of the process in their study. Richland, Holyoak and Stigler (2004) described the mapping process as the heart of analogical thinking. These facts led the researchers to question the level of student understanding and longer-term conceptual learning with such large numbers of analogies being produced solely by the teachers.

During the mapping process, the Richland, Holyoak, and Stigler (2004) study found that teachers used verbal communication to create explicitness72% of the time and visual or temporal sequencing 28% of the time. The difference is reliable to $p < .001$. Therefore, teachers are most likely to use communicative analogies to make math relationships explicit.

The method of data collection in the Richland, Holyoak, and Stigler (2004) study left me with some question that may have an affect on the researcher's conclusions. They described the classrooms as normal, with no definitions as to the meaning of normal, leaving me with questions as to student level of ability affecting some of their data samples. This fact as well as the time of day the video and audio samples were taken could have had an effect on their results of student level of participation. Teacher gender

was not mentioned and this fact may be a confounding variable in relationship to the high percentage of teacher control of analogy production in their study.

Although the Richland, Holyoak, and Stigler study had 2 coders, their inter-rater reliability tests were inconsistent and methods of disagreement resolution are questionable. Inter-rater reliability was tested on between 13% and 22% of the total samples within each particular category studied. In addition, it was stated that all coder disagreements were resolved by discussion. This leaves a question as to the effects of one person's potential power of persuasion on the inter-reliability data. Procedures for establishing inter-rater reliability are therefore questionable due to the low and inconsistent percentage of overall coding tested and methods used to resolve disagreements between the two coders.

A concern of the Richland, Holyoak, and Stigler (2004) study is the inability to ascertain a relationship between analogy use and student understanding and/or performance in mathematics. Although there is statistically significant data demonstrating teacher's source selection, teacher control of the analogy process, and when and why they use analogy in math, it is difficult to determine the educative effectiveness of these analogical methods without data reflective of gains in student conceptual and/or procedural understanding. The researchers stated this lack of student information was due to the nature of student participation, lack of teacher assessments, and teacher control over the reasoning process. Further studies where students are required to demonstrate analogical reasoning were suggested.

Another study that focused on the use and effectiveness of teacher-generated analogies was done by Bulgren, Deshler, Schumaker, and Lenz (2000). The purpose of

this study was to explore the use of analogies in teaching two particular concepts in the secondary science classroom containing students of diverse abilities. The researchers divided their study into two separate but interrelated phases. Phase 1 focused on the effects of teacher generated analogies after teachers were trained in using analogies for instruction. Phase 2 explored the different types of analogies teachers used during instruction and student satisfaction with the instructional analogy process.

In phase 1 Bulgren, Deshler, Schumaker, and Lenz (2000) study, three teachers were trained in a method of teaching with analogies called the Concept Anchoring Routine which includes the use of a visual organizer. The Concept Anchoring Routine was then used to teach the science concepts of commensalism and pyramid of numbers by three different science teachers, in three separate high schools on a total of 83 students. The students were classified into four different types, high achiever, normal achievers, low achiever, and students with learning disabilities. The researchers considered analogy use that was consistent, organized, and practiced by teachers, contained control groups for comparisons, considered diverse learning abilities, and assumed student's ability to think visually.

Phase 1 of the Bulgren, Deshler, Schumaker, and Lenz (2000) study discovered that all four types of students showed improvements in test performance after use of the analogy Concept Anchoring Routine (CAR). The analogy given for commensalism was a corner lemonade stand, and those who received the CAR lesson answered significantly more correct answers ($p = .000$) than those receiving the traditional instruction method. The analogy that accompanied the pyramid of numbers concept was military hierarchy, and those who received the CAR instruction answered with a significance of $p=.001$

compared to traditional instruction students. The improvement of mean test scores for each subgroup of student abilities was significant at the .05 level for the lower achievers and normal achievers for the commensalism concept, and at p=.05 for the learning disability students and the normal achievers for the pyramid of numbers concept.

Although test performance was improved among all the subgroupings of the Bulgren, Deshler, Schumaker, and Lenz (2000) phase 1 study, there were still some students who did not earn a passing grade with the use of the Concept Anchoring Routine. Some of the subgroup numbers were small (n=11 to 28) and unbalanced which may have affected the statistical comparisons. The time given to this study was short—only six days of 45 minute intervals followed by the test—and was not implemented multiple times. The time factors have an impact on the reliability of any themes or patterns stated. Although the students were given the CAR visual organizer to develop with the teachers, the teacher developed and introduced the source, mapping, and target of the analogy, leaving questions as to student familiarity and experience with the source object comparisons chosen. Another concern of the study is that they were only comparing one particular method of analogy instruction to traditional instruction when multiple analogy instruction methods could be compared.

There are two components to phase 2 of the Bulgren, Deshler, Schumaker, and Lenz (2000) study that are most relevant: different types of analogies teachers used during instruction and student satisfaction with the instructional analogy process. As in phase 1, teachers and students used the Concept Anchoring Routine. The data generated from this study may highlight potential relationships between the type of analogies used and student satisfaction with the analogical reasoning process.

Analogies were used by 10 junior high and high school teachers and 193 students in a variety of social studies and science classes. Analogies were categorized by the researchers (Bulgren, Deshler, Schumaker, & Lenz, 2000) with an inter-scorer reliability of 100%. Analogy categories included within-domain (example: school counselor and genetic counselor) or between-domains analogies (sponge and alveoli), and those identified as having structural (a ladder and DNA) or functional relationships (respiration and fermentation).

Science and social studies teachers used between-domain analogies (10/17, 9/16 respectively) more than within domain analogies (7/17, 7/16 respectively). This reflects the teacher's preference to comparisons between known concepts and new concepts that were not in the same domain. Both groups of teachers showed even greater preference for functional analogies over structural analogies (10/17, 11/16 respectively). This reflects a strong preference on the part of the teachers in this study to use process or function similarities between two different concepts over surface or object similarities. The researchers concluded that all but one teacher (n=9) reached or exceeded their analogical mastery levels by achieving a mean instructional score of 94%. Therefore, it can be concluded to a reasonable degree that the majority of the teachers created analogies using efficient source, mapping, and target relationships within concept domains and similarities.

However, mastery of analogical instruction did not correlate to student satisfaction scores. Students (n=193) were asked seven questions regarding satisfaction with analogy use for instruction. The data generated from their responses yielded a neutral mean satisfaction rating. Researchers stated there was wide variation among the

satisfaction of different classes of students. The comparison of the student satisfaction data with the data on the types and construction of analogies alludes to a number of possible confounding variables that effect student understanding and satisfaction with analogy instruction.

Bulgren, Deshler, Schumaker, and Lenz (2000) summary of their phase 2 results provide some insight into the possible confounding variables that had an effect on student satisfaction. Teacher's (n=10) enthusiasm and implementation of the analogical relationships may have been different and therefore some were more helpful to students than others. They failed to mention specifically in phase 2, as they did in phase 1, that another possible effect on student satisfaction could be their unfamiliarity with the source analogies teachers used.

In contrast to the Richland, Holyoak, and Stigler (2004) study and the Bulgren, Deshler, Schumaker, and Lenz (2000) study, the purpose of the Pittman (1999) study was to explore relationships among 7^{th} and 8^{th} grade students (n=189) acquisition of meaningful understandings through the use of student-generated analogies. The study focused on students learning the complicated process of protein synthesis in a science class. The method of analogy introduction and use, student source, mapping, and target structuring, and quantitative and qualitative data linking analogy use to improvements in understanding was explored.

The Pittman (1999) study generated data from pre- and post multiple choice test comparisons, from the scoring of an analogical drawing test, and from student interviews. The pretest was given when all students had a minimum level of understanding with the subject and the results of both pre- and post-tests were divided by gender. The data

generated from Pittman's (1999) analogical drawing test was a combination of coded scores from a narrative text explaining the analogical relationships chosen and illustration with labeling.

Out of a total of 20 possible pretest points, the results showed the girls (n=90) mean score to be 9.61 with a standard deviation (SD) of 2.9. The boys (n=99) results showed a mean score of 9.90 (SD=2.2). After the analogical research process was completed, the posttest mean scores were girls 15.10 (SD= 2.5) and boys 12.53 (SD= 3.0). The researcher concluded that the students improved their understanding after use of student-generated analogies, and that girls outperformed boys on the multiple choice test scores.

Out of a possible 10 points for the analogical drawing test, the mean score for girls was 5.8 (SD= 1.8) and for boys was 7.3 (SD=1.5). The researcher concluded from these results that boys outperformed the girls to a significance of $p < .01$on the drawing test portion of the study. Pittman (1999) also concluded that when comparing the overall content of the multiple choice results to the drawing test results, students still had an incomplete understanding of protein synthesis. Another fact to come out of the testing portion of the study was that 90% of the students selected a source topic for their analogies that were outside of science. Reasons for this latter fact were attended to in the interview portion of the study.

The interview portion of the Pittman (1999) study provides insight into student learning preference and analogy use preference. All of the 189 students who participated in this study preferred analogy use to learn science over lectures, discussion, and lab. In addition, 60% of the boys stated they preferred student-generated analogies to teacher-

generated analogies when only 30% of the girls made such a statement. As to why 60% of the girls preferred teacher-generated analogies even though the girls had more complete analogies than the boys, the researcher suggested possible lack of confidence in their knowledge of science. When asked why they preferred analogies and why they chose the sources they did, students made reference to how the learning was more meaningful and interesting because they made it happen using a topic they were more familiar with. The researcher concluded that this overwhelming preference to use of analogy is reflective of constructivist beliefs that personal interpretation and deeper meaning is more effective when it is based on prior knowledge and experience.

There are some concerns regarding the Pittman (1999) study that may have an effect on the data. First of all, with regards to the results of the pre- and posttests, the data would be supported if it was compared to data from a control group who went through the curriculum with the traditional lecture, discussion, and lab methods of instruction and to data from teacher-generated analogies. Without the control and comparison information, it is difficult to ascertain whether the use of student-generated analogy alone was the cause of the increased scores in the posttest. Secondly, the researcher was also the teacher for this study and as such, she introduced, modeled the use of, and scored the drawing tests leaving the obvious question as to researcher bias in this study. Third, potentially bias statements were made regarding the gender differences pointed out in this study. There may be discrepancies in the data provided that does not support the researcher's conclusions. For example, it was stated that girls displayed a lack of creating true analogies when they all (n=90) met the researcher's scoring

requirements for creating complete analogies. This example could also be reflective of inaccurate or misinterpreted scoring guidelines.

The study scored student recall a month after the study was completed. Response time was correlated with efficient memory recall and no data from coded interview responses was given to reflect the number of students able to answer the factual questions. More data reflective of student's deeper understanding of protein synthesis through analogy use would have lent support to the reported data. Visualization techniques were used to facilitate understanding and memory recall by the students as alluded to in the interview portions of the study, but only examples were given and no data with which to ascertain the magnitude and effectiveness.

A qualitative study by Coll and Treagust (2001) investigated student's use analogies, along with their alternative conceptions for mental models of chemical bonding. The researchers of this study were looking for whether students made analogies in interview discussions to help explain their understanding of a chemical bonding process. As science students, the study sample was exposed to many two- and three-dimensional models in their curriculum and classrooms that are retained to visual memory and the researchers believed that the use of analogies would be used to help describe the relationships within models.

The researchers used an interactive interview method to gather data from Australian secondary school (n=2), undergraduate (n=2), and postgraduate science students (n=2). The students were asked to describe the bonding process of ionic, metallic, and covalent substances and given focus cards depicting chemical bonding events. Participant's descriptions were audio taped and all spontaneously created

drawings representing their mental images were collected. Six independent experts interpreted, summarized, and validated the findings.

Coll and Treagust (2001) found that all of the students used the relevant "sea of electrons" analogy to describe the metallic bonding process. The two secondary school students were found to be more descriptive while communicating the process while the older students (n=4) were brief and vague. Other analogies using worldview objects and conceptions were used when students were struggling to explain or prompted to explain their mental or sketched model of the chemical process. Researchers concluded that overall, learners across all academic levels make some use of analogy to support their explanations of their mental models and to explain events depicting model use.

The small sample size of the Coll and Treagust (2001) study leaves a concern as to the generalizability of the results. The semi-structured interview environment may have affected the number of analogies elicited. Researchers believed this may have led students to react as if the interviews were a type of oral exam, encouraging use of instructor generated explanations to the chemical bonding questions asked when researchers were actually looking for student's worldviews. Also, it is not clear whether interviewer questions were consistent for each of the 6 sample subjects, and whether nonverbal cues contributed to interviewer bias.

In order to get some insight into the role visual metaphors play in advertising, the Kaplan (1992) study analyzes basic features of visual metaphors in automobile and alcohol full-page magazine ads. His reason for the choice of advertising subject is an assumption that the purpose for using a metaphor will be clear in most of the examples.

Kaplan (1992) classified ads into three different codes: 1) use of graphic conventions, 2) the reader's perceptions of how things appear in their world, and 3) the reader's cognitions about the real abstract qualities of the service or product. If more than one code was used, the researcher isolated the most dominant form of metaphor. One ad per month was taken from Newsweek, Life, and The New Yorker from 1989 to 1990 totaling 464 advertisements.

Of the 464 total ads Kaplan (1992) used as his study sample, 144 of them met the criterion for containing visual metaphors. This means that roughly one-third of the automobile and alcohol ads for a year employed visual metaphors to convey meaning. In addition, 80% of the alcoholic beverage ads had visual metaphors that identified the product directly to another context. An example of this is a bottle of product shown in the form of a mountain peak. The author concluded these results reflect the greater need for alcohol ads to distinguish themselves from one another on the basis of various abstract qualities. Automobile ads used comparisons in 88% of the samples. An example of this is a luxury vehicle shown next to an art masterpiece. Therefore, automobile ads contain concrete and abstract attributes.

Kaplan (1992) believed these results are therefore consistent with the belief that metaphors are particularly well suited for evoking mental images of abstract qualities. The author also concluded from the ads sampled that the type of visual metaphor used in the alcohol ads were more likely to challenge the reader's perceptions rather than conceptions. This conclusion was based on the results that the beverage ads focused on orientation of concepts in a physical context. An example of this according to Kaplan

(1992) is that in our culture, more is associated with better and upward direction is linked to happy.

The most obvious concern of the Kaplan (1992) study is how the data generated applies to student and teacher visual metaphor exposure. The subscription to a year supply of the magazines the sample advertisements came from implies membership to a particular socio-economic class. The magazines themselves do not typically cater to a young adult audience, not to mention the intended target audience of the automobile and alcohol advertisements. The other potential problem with the study was in how the metaphors were coded. Categories were generated for the metaphors based on assumptions of how they would be received by an imagined audience, when input from subscription holders may have provided more concrete evidence. In all, without data regarding how the visual metaphors were interpreted by the public and whether they were regarded as successful by the technology companies, the overall effect of visual metaphors based on their prevalence in advertising can only be hypothesized.

Another study by Kaplan (1990) looked at communication technology ads using visual metaphors in two types of magazines. The researcher classified Newsweek and Life magazine as general interest, and Scientific American as technology interest. Kaplan (1990) was working with the belief that cultural values play a role in shaping technology and these values and personal beliefs mediate public acceptance and use of new products. He specifically compared types of visual metaphors used in order to draw conclusions about how communication technologies are valued in American culture.

From a five year sample (1984-1988), Kaplan (1990) took 88 ads from the general interest magazines and 129 from the technology interest magazine. All of the ads used in

the sample were communication technology based and the most visual metaphors (57%) were found in the magazine that catered more to technology interests—Scientific American. In contrast, visual metaphors were used in the general interest magazines with less frequency (28%). In addition, both the general interest and the technology interest magazine ad samples used text to reinforce the visual metaphor (72% and 91%, respectively).

The researcher concluded that visual metaphors are used in communication technology advertising to provide interpretative frameworks for organizing the new information presented. Due to the predominate type of metaphor used in the sample, the focus in all magazines was to make associations between the unfamiliar and familiar objects and feelings through visual metaphors.

The primary critique of the 1990 study is that categorization of types of metaphors used was based on assumptions by the researcher as to how they were interpreted by the public. Exposure to the sample ads at a frequency and duration comparable to the study method is reflective of middle to upper socio-economic class, limiting hypothesized effects of such ads to that particular group of people.

The next two studies are directly related to the issue of transfer, and the conditions under which it may be more likely to occur. The first study (Sweller, 1983) investigates whether transfer of skills or strategies from one problem to subsequent problems may be heavily influenced by the problem-solving strategy used in the previous problems. In this study, the researcher explores the affects of providing feedback without providing information about the end goal. This method is compared to providing information about the end goal of the particular task without giving feedback of steps

chosen. The assumption is that increasing the amount of feedback for a greater number of steps during solution strategizing would provide a greater number of options to solving similar future problems. In contrast, it was assumed that providing the specifics of the goal of the task and no feedback blinds the problem solvers to alternative approaches to similar problem solving tasks. This affect was labeled by the researcher as means-ends problem solving. The idea was that in means-ends analysis when the specifics of the goal are given, the problem could theoretically be solved without anything learned, so there would be nothing to transfer.

The Sweller (1983) used 60 undergraduate psychology students. No gender information was provided. The participants were divided into 5 groups with two of them set up as the control. All subjects were asked to build a pyramid structure consisting of numbered cardboard squares. Two different pyramid building tasks were presented to the groups. During the first task, three groups were given feedback during each step of the task and allowed to record their method for future reference while the control groups were only told to complete the task. The number of moves each group took was recorded and correlated with time to complete the task in seconds. A second task was provided to all groups and the researcher believed the groups that received feedback would complete the task in fewer steps and with much improved time over the control groups.

In the Sweller (1983) study, significant differences were found ($p < .05$) between groups with feedback provided and those with no feedback and the speed of solving the second problem. The increase of steps and feedback also increased the speed of solution on the transfer problem. In one group, the time was reduced from 471 seconds to 88 seconds on task two. Since the study subjects (n= 60) knew the steps were correct due to

the feedback provided, their ability to refer to and use these moves was increased. The researcher concludes that the feedback method provided a greater sequence of tested moves to choose from to solve the next similar problem, increasing their future problem solving potential.

Although the researcher (Sweller, 1983) believed transfer occurred in this study when closely sequenced steps received feedback, he acknowledged that this is merely one example of a technique capable of accomplishing this exchange. Therefore, things learned through another method could have the same effect, suggesting the need to do comparison studies of various problem solving methods. The testing method used in this study is quite removed from typical educative tasks and problems within a typical learning environment making application of the data outside of a formal research environment difficult. Also, a more diverse group of participants should be included where gender, age, and socio-economic diversity is considered.

Perfetto, Bransford, and Franks (1983) explored whether college students (n= 60) would spontaneously use potentially relevant information as solutions to later problem solving tasks. The researchers hoped their findings would indicate whether problem solving failure is due to previous information being accessed and then rejected, or not accessed at all. The researcher's assumption is that the relationship between the two tasks would be so obvious that the uninformed group would spontaneously access and use the prior information.

Subjects were divided into two groups, one was informed of the possible connection between the two separate sets of written tasks and the other group was uninformed of a possible relationship. First, all groups received sentence clues and were

asked to rate them on truthfulness. Second, all groups received a set of written problems (n=12) but only half of them were told that the sentences previously rated may provide clues to the solutions. No mention of a connection was provided to the other half of the group.

The Perfetto, Bransford, and Franks (1983) study found subjects in the informed group produced more correct solutions than both the uninformed group and the control group to a significance of $p < .01$ respectively. A questionnaire later given to all participants revealed that it did no occur to the uninformed group to use the prior information as clues to the second task. The informed group questionnaire revealed that the secondary task problems acted as retrieval cues that permitted access to the prior information. The researchers conclude from these results that the uninformed subjects' problem solving failure does not appear to be due to memory retrieval and rejection but to total lack of spontaneous access, disproving their original hypothesis.

In the Perfetto, Bransford, and Franks (1983) study, alternate choices were not considered until the results of the study were in. When looking at all the subjects answers to the 12 problems individually, they found that while all generated an answer to the problems, many of the answers were inadequate. Some of the participants would obtain answers from within the sentence they were working on while some accessed other sources of knowledge and experience for relevant answers. Based on this result, it can be assumed that memory may have been accessed and applied to solve the problem, but it was knowledge unique to the individual participant's life experiences, not memory of information gained from a task done 3-5 minutes prior. Therefore, it is not a question of whether appropriate information was accessed, but whose appropriate information was

accessed—the researchers or the participants. The results of this study may be flawed if alternate correct answers were not considered.

Conclusion of Analogy Studies

In reviewing the analogy studies together, certain similarities present themselves. First, the ability to see and communicate analogical relationships between objects is present in preschool and young children (Crisafi & Brown, 1986; Dent & Rosenberg, 1990; Holyoak, Junn, & Billman, 1984; Parsons, 1999). Factors affecting analogous relationships are familiarity with the object and the surface similarity between the source object and the goal object (Holyoak, Junn, & Billman, 1984; Richland, Holyoak, & Stigler, 2004) and teacher control of the analogy (Holyoak, Junn, & Billman, 1984; Bulgren, Deshler, Schumaker, & Lenz, 2000; Perfetto, Bransford, & Franks, 1983; Richland, Holyoak, & Stigler, 2004) .

Use of analogies by students has been shown to aid in communicating relationship understanding (Parsons, 1999; Coll & Treagust, 2001). Student-generated analogy use has been suggested to be very useful for teachers as formative assessments (Coll & Treagust, 2001; Parsons, 1999; Pittman, 1999; Richland, Holyoak, & Stigler, 2004) as they provide insight to student's prior schema and to exactly what area the student may need guidance in. The possible teacher-generated and student-generated preference for between-domains analogies (Bulgren, Deshler, Schumaker, & Lenz, 2000; Pittman, 1999) is intriguing, for in both cases, the relationships were more concrete and structural—that is, sharing similar surface similarities—implying the perhaps subconscious choice (when given one) of creating a relationship that contains more opportunity for imagery.

Additional studies allude to possible improvements in analogy relationships when 3-dimensional and/or moving objects are utilized, suggesting motion analogies can be drawn in addition to surface similarity analogies (Dent & Rosenberg, 1990). Analogical relationships may be better understood and communicated by the student with the addition of student-drawn images (Coll & Treagust, 2001; Pittman, 1999). Analogy sources used by both teachers and students may be influenced by the types of visual metaphors present in advertising within their environment (Sweller, 1990 & 1992).

Mental Imagery

One study that attempted to discover if and how effective mental imagery is used in learning was done by Jorgensen and Kintsch (1973). College students (n=32) were provided simple sentences (noun, verb, noun) that were assumed to be either easy (high imagery value) or difficult (low imagery value) to imagine. An example of an easy sentence is: cat has fur; and a difficult one was: calendar projects movies. The researchers assumed that any student using imagery to determine whether the sentence was true or not would have longer reaction times to those who did not process sentence meaning through mental images.

Two tests were performed; one that did not suggest the use of mental images and one that specifically instructed students to construct a mental image of the phrase as they read them. This was to help the researchers determine the number of the 32 students that actually use mental imagery.

The results of the Jorgensen and Kintsch (1973) stated in part that sentences with a high imagery rating were evaluated more quickly compared with the reaction time of low imagery sentences to a significance of $p < .005$. The instructions to use imagery had

no significant effects in student reaction time. In evaluating whether the phrases were true or false, true sentences were responded to faster than false, statistically significant to $p < .005$. Since the faster evaluations happened with or without instruction to use images, researchers concluded that the use of mental imagery in the task provided was a natural strategy of the students. The researchers' belief was that encoding of information with imagery was a secondary process, which explains their original assumption that those who use imagery will take longer to evaluate the study than those who do not. After reviewing the data, Jorgensen and Kintsch stated that information coded as imagery is highly and efficiently accessible in memory and used in psychological functions such as deciding whether a sentence is true or not.

Students participating in the Jorgensen and Kintsch (1973) study were not given enough time to form mental images. The researchers stated that at the time of their study, data from Paivio (1966) on how much time it takes to form a mental image reported 3 to 5 seconds, and their students were only given up to 2 seconds to respond. Speed in evaluating the sentences could have been related to use of basic verbal codes or other possible confounding variables, like time of day the tests were given. Giving instructions to use mental imagery does not necessarily mean mental imagery will be used, and this could also explain why the instructions had no significant effect. The researchers concluded that since their study used only noun relationship sentences, further research needs to be done to determine relationships with more semantically complex sentences and imagery use to compare with their results.

Another study to determine the role and effects of imagery in retrieving information from memory was done by Kosslyn (1976). Where the Jorgensen and

Kintsch (1973) study focused on adults, the Kosslyn (1976) study used first graders (n=14), fourth graders (n=14), and adults (n=14) as subjects.

Kosslyn (1976) believed the size and association strength of images would affect the reaction time of subjects. As quickly as possible, subjects were asked to determine (true or false) whether various animals had various properties and to form their opinion from a visual image. If imagery is used and certain animal properties are smaller, or low area, (like a cat's claws are to a cat's head) then it is assumed it will take the subjects more time to evaluate and larger properties/high area will take less time. The researcher hopes to use this method to distinguish mental imagery use over other forms of accessing information. When images were not used in the study, the reaction time of the subjects was assumed to be based on the strongly associated words (like cat/claws evaluated before cat/head). The study category for this result was high association/low area.

The Kosslyn (1976) study reported a statistically significant ($p < .001$) difference in the evaluation times of adults to those of the children when no imagery instructions were given. While imagery instructions did not have a significant affect on the children's times, there was a significant difference ($p < .01$) in the evaluation times for adults. This means that when told to use imagery, adults took much longer to evaluate the sentences than when no imagery instructions were given. Within the no imagery category, both adults and 4th graders evaluated the high association phrases faster than the low association. When explicitly told to use imagery, all groups evaluated the lower association/high area faster. These results follow the researcher's original hypothesis.

The first graders, however, made faster evaluations of true or false phrases with low association/high area for both imagery and no imagery instructions. This means, for

example, that they would have chosen the phrase cat/head as true faster than choosing cat/claws with or without the use of imagery. The researcher concluded children need more time to evaluate phrases and objects especially if they have smaller properties. Kosslyn (1976) also concluded that object properties become increasingly easier to retrieve from memory as people get older when the process does not require using imagery. In addition, the study subjects self-reported to have used imagery spontaneously during the no imagery instruction sessions. When compared to similar statements by the other groups, more first graders claimed to use imagery spontaneously.

As animals were used as the primary subjects of the phrases, the study sample was told explicitly to image the entire animal, not just part of it, in relationship to the animal property presented. This instruction may have had an affect on the evaluation times of all the age groups, but especially the adults. As the researcher observed, the experience and familiarity to the objects lead to greater ease in memory retrieval. Adults may be able to pinpoint the specific area of the animal the property is associated with faster than children. This is due to the concern that children may not have entire animal images in memory because of developing perspective skills. Being told to view the entire animal imposed an outside and additional process beyond what adults and children may do naturally, adding time to the process of evaluation.

Another study that looks into the effect of images and verbal material is by Smith, Miller, Grossman, and Valeri-Gold (1994). This study specifically investigated vocabulary retention through the use of images. The researchers were also interested in investigating whether left-brain thinkers benefited more than right-brain thinkers with the addition of images in learning vocabulary.

Two separate studies were given to a total of 169 college students enrolled in a developmental reading class. The Smith, Miller, Grossman, and Valeri-Gold (1994) study generated data from immediate and delayed (3 weeks) posttests. Subjects were divided into left and right brain thinkers and each group was divided into those that were provided images and those that were not. The images provided were intended to compliment word definitions and sentences.

Results of the Smith, Miller, Grossman, and Valeri-Gold (1994) study showed the groups who received the images scored significantly higher ($p < .01$) than those who did not receive the images. There also was a significant difference ($p < .01$) between the brain groups as to who benefited the most from the images. The left-brain thinkers receiving the images to compliment their word definition and sentence benefited the most when compared to the left-brain group that did not receive the image. There was no significance between the right brain thinking groups that received the images and those that did not. In response to the latter result, the researchers hypothesized that the right-brain group receiving only word definition and sentence may have spontaneously generated their own images. The researchers conclude from this data that since performance was significantly better with use of images than without for both right- and left-brain thinkers that visual learning needs to be expanded throughout the education system.

The researchers of this study (Smith, Miller, Grossman, & Valeri-Gold, 1994) refer to two potential confounding variables that need to be considered. For the division of the study participants into right- and left-brain thinkers, a hemispheric performance test called SOLAT was used. These tests are not the most sophisticated measure of right-

or left-brain learning preference. Therefore, cross-group contamination may have influenced the test scores. The second factor is the hypothesis that the right-brain thinkers may have generated their own images whether they were given one or not. This may mean the right-brain group had a leg up on the left-brain group by either having two images versus one, or one image versus none. This leaves the left-brain thinkers at a disadvantage from the onset of this study. The researchers concluded that another study with larger group sizes and more participants was needed clarity this potential variable.

Related to the use of mental imagery are questions regarding the role of visual experience in this process. Studies that provide insight into the type, frequency and quality of visual experiences would be helpful in order to frame the development of mental imagery. Vanlierde and Wanet-Defalque (2005) looked at the role visual experience plays by comparing adult participants who became blind early in life (n=10), later in life (n=9), and sighted individuals as the control group (n=27). The early blind lost their sight by age 3 and the later blind by between 6 and 9 years of age.

Subjects were told to create mental images of objects ranging in size from an aspirin bottle to a bus. They were then to image various distances and positions of the objects which they were told to estimate and report to the researchers. In a second test, they were given particular distances with which to imaging the objects and told to estimate where the left and right edges were located on a ruler. If visual mental imagery plays an important part in memory and problem solving, it is relevant to understand how a lack of visual experience affects the ability to use mental imagery.

The Vanlierde and Wanet-Defalque (2005) study found that participants who became blind later in life and sighted people were able to imagine an object's edges

extending the boundaries of their view, when the early blind participants could not. For large objects, distances estimated by the early blind were significantly shorter than those estimated by the sighted to p =.007, although their 3-dimensional visualization of smaller objects was excellent. The later blind results were overall very similar to those of the sighted participants. The researcher concluded that these results suggest that visual experience with perspective is necessary in order to be able to visualize an object close enough to not see its edges. The laws of perspective can only be learned through visual experiences, according to the researchers, since they cannot be accessed by other sensory modalities.

There were two possible problems that may have had an affect on the data in the Vanlierde and Wanet-Defalque (2005) study. First, the participant groups were small and unbalanced in numbers as the early blind had10 adults, the later blind had 9, and the sighted group had 27 adults. Data from the sighted group is influenced by its size in comparison to the other two groups. Secondly, all participants had to estimate distances seen in their mental imagery, and there was no explanation in the study as to how this was communicated to the experimenters. Whether they just guessed or were allowed to guess by pacing in out and having it measured is unknown, but either way, data comparisons between groups made from these estimations leave room for error.

Summary of Mental Imagery Research

In support of Piaget and Inhelder's (1971) theory that children access and represent information primarily from memory (as cited in Kosslyn, 1976), studies do show that children use mental images when evaluating certain forms of language and literature experiences (Kosslyn, 1976; Parsons, 2006). The predominate use of mental

imagery may be due to children's developing experiences with language and linguistic systems (Kosslyn, 1976). The data also suggests that both adults and children are capable of using imagery when accessing memory (Kosslyn, 1976; Jorgensen & Kintsch, 1973; Smith, Miller, Grossman, & Valeri-Gold, 1994; Vanlierde & Wanet-Defalque, 2005) with significant educative results in regards to vocabulary retention (Smith, Miller, Grossman, & Valeri-Gold, 1994) and literary comprehension (Parsons, 2006). The value of imagery use and vocabulary may ultimately depend on the complexity or abstraction of the word, in which case a network of relationships may be required before meaning is made (Jorgensen & Kintsch, 1973).

Some of the studies in the mental imagery group supported Paivio's (1971) dual coding theory stating that human memory is enhanced by both verbal and imaginal (or non-verbal) processes (as cited in Smith, Miller, Grossman, & Valeri-Gold, 1994). Studies suggested that the use of images enhances human memory whether an individual has strengths in visual thinking or not (Smith, Miller, Grossman, & Valeri-Gold, 1994; Vanlierde & Wanet-Defalque, 2005). Also, access of memory may be even further enhanced by other sensory modes like touch and sound and visual experience with multiple perspectives (Vanlierde & Wanet-Defalque, 2005). In all, as language and vocabulary are strong components across multiple disciplines, the strengths and benefits of image use to long-term memory in students needs to be further studied in other context specific areas.

CHAPTER 4: CONCLUSION

The previous chapter explored research related to art, analogy, and mental imagery as a potential aid to cognitive development. In this chapter I will first provide a summary of the findings from the research and provide links between the findings and historical background. Second, I will explore the relationships of the findings to potential classroom implications. As most of the studies alluded to implications for further research, that subject will be review last.

Summary of Findings

Elements of the visual arts were found in many of the studies. A brief review of the elements of visual arts includes visually experienced 2- and 3-dimensional objects. An experience with an image could have been visual only or included visual and tactile processing of the object if it was created or manipulated by study participants. Mental imagery is also a component of visualizing, creating, and even mentally manipulating 2D and 3D objects and therefore considered an element of the visual arts. As such, many of the studies under the separate headings of art, analogy use, and mental imagery in chapter 3 will be integrated in this chapter.

Evidence of the use of art as an aid to cognitive development is generated when art elements played a role in creating significant data measurements and/or posttest results compared to the control group or groups. 2D images, real and imagined, were experienced by participants in Coll and Treagust (2001), Dent and Rosenberg (1990), Parsons (2006), Pittman (1999), Smith, Miller, Grossman, and Valeri-Gold (1994), Stavropoulos (1994), and Vanlierde and Wanet-Defalque (2005) with significant data results. 3D objects, real and imagined, were experiences by participants of Crisafi and

Brown (1986), Dent and Rosenberg (1990), Getzels and Csikszentmihalyi (1976), Holyoak, Junn, and Billman (1984), and Vanlierde and Wanet-Defalque (2005) again with significant data results over non-object users. In addition, the laws of perspective and spatial reasoning, a key component of visual art education and necessary in multiple disciplines, can only be learned through visual experiences (Vanlierde & Wanet-Defalque, 2005).

Another finding common to multiple studies was that young children, children, young adults, and adults use mental imagery in their learning (Burton, Horowitz & Abeles, 2000; Coll & Treagust, 2001; Crisafi & Brown, 1986; Dent & Rosenberg, 1990; Getzels & Csikszentmihalyi, 1976; Holyoak, Junn, & Billman, 1984; Jorgensen & Kintsch, 1973; Kosslyn, 1976; Luftig, 2000; Parsons, 1999; Pittman, 1999; Richland, Holyoak, & Stigler, 2004; Smith, Miller, Grossman, & Valeri-Gold, 1994; Stavropoulos, 1994; Vanlierde & Wanet-Defalque, 2005). Of these studies, the youngest to use mental imagery were of preschool age and the oldest was 68.

Specific cognitive tasks improved by the use of mental imagery were memory recall including vocabulary retention, communicating understanding, recognition, understanding relationships, and literary and science comprehension. When accessing memory, both children and adults are capable (Kosslyn, 1976; Jorgensen & Kintsch, 1973; Smith, Miller, Grossman, & Valeri-Gold, 1994; Vanlierde & Wanet-Defalque, 2005) with significant educative results in regards to vocabulary retention (Smith, Miller, Grossman, & Valeri-Gold, 1994). The value of imagery use and vocabulary for younger children may ultimately depend on the complexity or abstraction of the word, in which case a network of relationships may be required before meaning is made (Jorgensen &

Kintsch, 1973). Children in particular predominately use mental images when evaluating certain forms of language and literature experiences (Kosslyn, 1976; Parsons, 2006). The strong use of mental imagery is due to children's limited and developing understanding of language and linguistic systems (Kosslyn, 1976). The use of mental imaging and ability to communicate literary and science comprehension through imagery can be done by children as young as 10 (Coll & Treagust, 2001; Parsons, 2006).

The above relationships between mental imaging and vocabulary, language, and linguistic systems are reflective of the theories of Sadoski and Paivio (2001) as was discussed in chapter 2. Data showing stronger linguistic retention and understanding due to use of mental imaging supports that imagery and verbal codes are used simultaneously during cognitive processes. This data contradicts behaviorist theories of cognition. Use of imagery as a feature of cognitive processes in general reflect the beliefs of Piaget and educational reformers like Rousseau, Dewey, Pestalozzi, Steiner, and Montessori.

In addition, studies suggested that the use of images enhances human memory whether an individual has strengths in visual thinking or not (Smith, Miller, Grossman, & Valeri-Gold, 1994; Parsons, 2006; Vanlierde & Wanet-Defalque, 2005). Access of memory may be even further enhanced by other sensory modes like touch and sound and visual experience with multiple perspectives (Vanlierde & Wanet-Defalque, 2005). A couple of studies attempted to control the use of mental imagery by giving directions to either use or not use them, but found that mental imagery was used spontaneously by their participants as a learning tool (Jorgensen & Kintsch, 1973; Kosslyn, 1976).

In reviewing the analogy studies together, certain similarities present themselves. First, the ability to see and communicate analogical relationships between objects is

present in preschool and young children (Crisafi & Brown, 1986; Dent & Rosenberg, 1990; Holyoak, Junn, & Billman, 1984; Parsons, 1999). Factors affecting analogous relationships are familiarity with the object and the surface similarity between the source object and the goal object (Holyoak, Junn, & Billman, 1984; Richland, Holyoak, & Stigler, 2004) and teacher control of the analogy (Holyoak, Junn, & Billman, 1984; Bulgren, Deshler, Schumaker, & Lenz, 2000; Perfetto, Bransford, & Franks, 1983; Richland, Holyoak, & Stigler, 2004).

Use of analogies by students has been shown to aid in communicating relationship understanding (Parsons, 1999; Coll & Treagust, 2001). Student-generated analogy use has been suggested to be very useful for teachers as formative assessments (Coll & Treagust, 2001; Parsons, 1999; Pittman, 1999; Richland, Holyoak, & Stigler, 2004) as they provide insight to student's prior schema and to exactly what area the student may need guidance in. The possible teacher-generated and student-generated preference for between-domains analogies (Bulgren, Deshler, Schumaker, & Lenz, 2000; Pittman, 1999) is intriguing, for in both cases, the relationships were more concrete and structural—that is, sharing similar surface similarities—implying the perhaps subconscious choice (when given one) of creating a relationship that contains more opportunity for imagery. The features of analogical thinking reflect the general educational principles and practices of Pestalozzi while the study reporting greater success with student generated analogies reflects the beliefs of Rousseau and Dewey.

Additional studies allude to possible improvements in analogy relationships when 3-dimensional and/or moving objects are utilized, suggesting motion analogies can be drawn in addition to surface similarity analogies (Dent & Rosenberg, 1990). Analogical

relationships may be better understood and communicated by the student with the addition of student-drawn images (Coll & Treagust, 2001; Pittman, 1999). This reflects the beliefs of art masters and art educators throughout history beginning with Aristotle, as artistic images are a form of communication that create analogies between self and environment. Analogy sources used by both teachers and students may be influenced by the types of visual metaphors present in advertising within their environment (Sweller, 1990 & 1992).

Classroom Implications

The implications for the classroom regarding art and mental imagery as an aid in cognitive development are overall supportive of the use of both. As mental imagery was generated by all age groups and used spontaneously, educators should be aware of its potential value as insight into individual student's prior knowledge. Imagery may also provide an alternative entry point to learning in multiple content areas thereby potentially connecting with a greater number of students. Intentionally using mental imagery techniques could strengthen the cognitive abilities of all students, irregardless of their existing levels of imagery, verbal coding strengths, and age. In addition to cognitive development, another benefit to including art and mental imagery in all lessons is a potential increase in motivation and relevance for students.

The implications regarding analogy use is that it can be a tool for educators to aid in cognition processes, especially between integrated concepts, but teachers and students need to become familiar with the features and development of an analogy. There may be different levels of understanding between teacher-generated and student- generated analogies that need to be explored. Teacher generated analogies may not provide the

student with a familiar object or function with which to establish the object similarity necessary to make analogical relationships. This is due to the simple fact that an object or function familiar to the teacher may not be familiar to all students. There may also be a difference in performance between students with stronger visual thinking skills and their abilities to complete the relationship generated by the teacher and students with strengths completing relationships based on verbal similarities.

Richland, Holyoak and Stigler (2004) described the mapping process as the heart of analogical thinking. If so, the use of student generated analogies with teacher guidance may be a better instructional approach to improve learning. Yet, in their study, teachers controlled over 90% of the analogy processes. These facts led the researchers to question the level of student understanding and longer-term conceptual learning with such large numbers of analogies being produced solely by the teachers. Educators interested in applying analogical instruction methods should consider these facts.

The Richland, Holyoak, Stigler (2004) study found that different analogy sources were used for teaching math concepts when compared to teaching math procedures. This implies that teachers need to critically compare the sources of analogies to the goal of their lesson.

As there were benefits to analogy use in the studies, it is also clear that weak or ineffective analogical connections could be created by teachers and students or already exist as part of teacher and student prior knowledge. Time needs to be given to analyze features, steps, methods, and existing beliefs prior to introducing or discussing analogy in the classroom.

Implications for Further Research

In all, the cognitive development skills enhanced through visual and mental imagery are integral components across multiple disciplines. The strengths and benefits of image use to long-term memory in students needs to be further studied in all content specific areas of education. Studies that further explore the relationship to mental imaging and creating 2D and 3D objects in achieving improved understanding are necessary. These would need to include studies over longer durations than most of the studies in this review, and follow up testing to check for prolonged understanding 6 months or more after the research has concluded. With regards to visual art education and experience specifically, all of the research studies above could have generated additional data by including in their group divisions participants who were known to have prolonged and consistent exposure to visual art. This additional data when compared to existing experimental and control group data could potentially link visual skills, visual use, and improvements in learning.

Further research into the area of analogy use as an aid in cognition should include more comparisons between the data from teacher-generated analogies and data from student-generated analogies. Significant differences in the resulting data of this type of study could have a considerable impact on analogy instruction methods. As some of the studies stated familiarity with an object and surface similarities between source and target objects factors into successful analogical mapping, studies that focus on methods of developing and enhancing object familiarity and surface similarities would add insight to current research. These methods could include greater use of visual art, mental imagery

and multisensory experiences during the source development stage as factors affecting the conclusions.

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