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THE USE OF ANIMATION AS A TOOL FOR CONCEPT LEARNING

DISSERTATION

Presented in Partial Fulfillment of the Requirements for
the Degree Doctor of Philosophy in the Graduate
School of The Ohio State University

By
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1997

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ABSTRACT

Since animation has been widely incorporated into educational media, there is a need to better understand the effect of animation in educational practice. Adopting Vygotsky's notion in the Media ZPD Model, this study is to investigate the use of animation as a tool for concept learning. The design includes two independent variables: Presentation Method (Animation, Still-visuals, and No-visuals) and Audio Mode (Audio and Silent). Combining the two independent variables yields six different treatments. Through randomization, 144 5th-graders were assigned to one of the six treatment groups. In the experiment, the Group Embedded Figures Test (GEFT) was first given. Next, variations of the visuals, "Cube," were presented. Then, a posttest was administered. Research questions include the determination of difference and interaction among each independent variable and the relationship between the posttest scores and the GEFT scores. The results indicated that two Audio Modes (Audio and Silent) have no significant difference in presenting visuals. There is an interaction between the GEFT and the presentation methods. The analyses showed that for Field-dependent (FD) learners (1) Animation and Still-visuals have no significant difference; (2) Animation is significantly higher than No-visuals; and (3) Still-visuals is also significantly higher than No-visuals. Whereas, for Field-independent (FI) learners, different ways of presenting visuals have no significant differences. The analyses also showed that inappropriate use of media can hinder FI students from learning. In addition, there is a positive
and moderate relationship between the posttest scores and the GEFT scores. Then, some possible reasons that might result in no measured impact of animation were considered. The findings not only reflect the pure effect of the animation but also suggest empirical evidence—the information about a learning style (i.e., FD vs. FI) in relation to the use of animation as a tool for visual concept learning. Hence, implications and recommendations are made for quality education.
Dedicated to My Parents
ACKNOWLEDGMENTS

I wish to express my sincere appreciation to my adviser, Dr. John Belland, who inspired me intellectually and assisted me methodologically with his connoisseurship in media study.

My appreciation is also extended to the members of my dissertation committee, Dr. Robert Wagner, who guided me with his expertise in the field of educational film, and Dr. William Taylor, who encouraged me to think over the function of media for educational purposes.

I am grateful to many of my teachers and friends who helped me in the process of forming the conceptual framework and analyzing the research data in this study.

I am indebted to my family who supported me in pursuit of my academic advancement.

This study was supported by five elementary schools in the Columbus, Ohio, area. Without their support, this study could not be possible.

I also wish to thank the National Science Council of the Republic of China for giving me this opportunity to upgrade my knowledge in media use and educational research.
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CHAPTER 1

INTRODUCTION

THE STATEMENT OF THE PROBLEM

As technology has advanced in recent years, so have the techniques for producing educational media. The making of animation is a good example. The technique of making animation through the use of computers has become more user-friendly and popular. Consequently, animation has been widely incorporated into various media formats for educational purposes. However, a popular medium does not necessarily equate with a "good medium." Therefore, there are some questions worth considering. For instance:

"Is animation an appropriate medium to present knowledge?"

"Can animation help students learn concepts efficiently?"

"Is animation an effective tool for school instruction?"

School teachers, instructional designers, and media producers are concerned about these questions because any answers to these questions can influence their ways to contribute to education. Hence, the researcher feels that there is a need to investigate the use of animation as a tool for concept learning.
Animation is usually found in films, videos, and computer software. In classroom settings, animation is commonly used to illustrate difficult concepts to facilitate instruction. Often, students seem to prefer watching a video to reading a book. Animation segments in video sometimes are the most impressive parts that students remember. For elementary students especially, watching an animated video is something like watching a cartoon program. As a result, teachers assume that many difficult concepts become easy to learn through this visual presentation. In mathematics and science courses, for example, animation is used as a handy tool. A short segment of animation can illustrate abstract concepts that classroom teachers may spend twenty or thirty minutes explaining.

However, studying the effect of animation is not an easy job. In many formats of media, animations are presented together with audio. Animated images seldom appear by themselves. The nature of combined effect makes the discrimination of pure animation impact difficult. Moreover, the visual part of an animated sequence may include texts and symbols. The auditory part of an animated sequence may contain narration, background music and sound effects. All these variables inevitably hinder many researchers from investigating the pure effect of animation. However, educators mainly put their emphases on the combined effect of animation. They value animation's overall function as a tool in delivering knowledge that instructors intend to teach.

In studying the use of animation as a tool for concept learning, researchers need to consider some essential components in the learning process. Specifically, they are the process of concept formation, the way of coding incoming messages, and
the nature of moving images. These components represent mental activities and perceptual processes operating inside the human brain. In addition, these components are interrelated with one another in order to achieve the projected goal—forming new concepts. Since these components are mental functions, it is necessary to approach mediated learning from a cognitive perspective.

From the cognitive point of view, these components reveal some important hints for us in inquiring into the essence of learning through using animation. Then, it is necessary to take the following thoughts into consideration. First, understanding a learner's actual and potential ability helps us explain how concepts are formed through using animation. Second, knowing how incoming messages are encoded and decoded through visual and auditory channels helps us explain the impact of animation. Third, recognizing the nature of moving images helps us explain the usability of animation as a tool for delivering concepts. As a result, the value of using animation is based upon the interpretation of these hints.

In the following sections, the researcher will delineate the approach to this study by examining various viewpoints regarding the use of animation as a tool for concept learning.
The Functions of Media

Although animation has been used in many forms of educational media, the functions of media are still debatable. Therefore, to study the effectiveness of animation, there is a need to analyze the functions of media in the first place.

Educators have different viewpoints on the functions of media. For example, Clark (1994) viewed media as a conveyor of instructional information. But, Kozma (1994) proposed that media and methods together influence learning. To mediate the debate, Ross (1994) commented that Clark's viewpoint on why media do not influence learning is based on a scientific and positivistic perspective while Kozma’s stance on media capabilities is based on an applied perspective.

To continue the discourse on the functions of media, Tennyson (1994) also added that media will always be embedded in a complex association with instructional methods, learner variables, content, context, and risks. In addition to the application level, Kozulin and Presseisen (1995) further suggested that new directions for learning theory and cognitive education be based on the combination of Vygotsky's "psychological tools" paradigm and Feuerstein's Mediated Learning Experience (MLE) approach. Inevitably, the functions of media are interpreted by various cognitive learning theories.

No matter what kind of learning theories and viewpoints that educators hold, the function of media as a guide for learning is fundamentally certain. For instance, according to Gagné (1985), media, such as objects and pictures, are
frequently used to perform the function of learning guidance by providing "encoding images" (p. 297). Hence, the function of objects and pictures as a learning guidance is clear. It is because the concepts embedded in the pictorial displays are illustrated by means of a set of coded representational images.

However, to further study how media facilitate learning, the understanding of media's function alone is not adequate. It is also necessary to investigate the nature of its representational methods, that is, its coding system.

**Coding System**

From the cognitive perspective, a coding system includes a set of sense-making methods through the presentation of media. Salomon (1979) proposed that the ways media structure and present information, that is, their "symbol systems," are media's most important attributes when learning and cognition are considered (p. 216). According to Bruner (1973), there are three kinds of presentations. These are enactive representation, iconic representation, and symbolic representation—knowing something through doing it, through a picture or image of it, and through some such symbolic means as language (p. 316). Therefore, various representational fashions can be employed to code the projected learning information that educators intend to send to their learners.

For instance, the projected learning information needs to be decoded in order to be meaningful. In the process of decoding, it is necessary to process the in-coming messages and make sense out of these symbol systems. Addressing
this point, Paivio and Begg (1981) held that there are three "levels" of processes related to the concept of meaning: "representational, referential, and associative levels of symbolic meaning" (p. 115). Hence, there are different levels of processes in terms of generating a particular "meaning."

On the other hand, when we investigate the process of learning and cognition through the use of media, the way information is presented becomes an important concern. In some cases, different types of signs and symbols need to be employed to clarify certain topics. For other purposes, diagrams or graphic visuals should be displayed in different manners. Signs and symbols are used to facilitate learning, but they may be presented differently because all media need to be used in a proper manner. Thus, how learners can be assisted in structuring their new knowledge depends on an appropriate coding system.

**Signs to Facilitate Learning**

To address these learning and cognitive concerns, Lev Vygotsky's (1896-1934) theory of cognitive development is increasingly receiving attention. Vygotsky saw the importance of using signs as tools to facilitate teaching and learning. To explain Vygotsky's notion, Van der Veer & Valsiner (1991) stated that:

The mnemotechnical and other aids used by human beings to improve their performance have the character of signs, Vygotsky claimed. They are social artifacts designed to master and thereby
improve our natural psychological processes. As examples of signs he lists words, numbers, mnemotechnical devices, algebraic symbols, works of art, writing systems, schemata, diagrams, maps, blueprints, etc. (Vygotsky, 1930aa/1982, p. 103). From this list it is obvious that any stimulus that can signify another stimulus may be seen and used as a psychological instrument or sign. This was indeed Vygotsky's point of view. (p. 219)

Vygotsky's learning theory of using signs as tools to improve psychological processes within the zone of proximal development (ZPD) is obviously compatible with those of contemporary educators. For instance, Gagné (1985) indicated that concepts can often be introduced by means of instruction with accompanying pictures or diagrams (p. 105). Both theorists recognized that signs and symbols are characteristics of psychological instruments because Vygotsky and Gagné saw the importance of mediated function in delivering concepts to facilitate teaching and learning.

For educational purposes, signs, such as pictures and diagrams, are often employed as useful tools to help teach and learn novel ideas and abstract concepts. Therefore, for basic concept learning activities, the mediated function of signs as a psychological instrument is valued.
**Concept Learning**

Educators place stress on the "mediated function of signs" because they see the importance of constructing new concepts. Clearly, every single concept may act as a fundamental element in other higher level learning activities, such as principle learning, application learning, and so forth. To relate the importance of concept learning, Gagné (1985) indicated that:

> In addition to having concrete references, concepts possess the additional property of freeing thought and expression from the domination of the physical environment . . . once concepts have been mastered, the individual is ready to learn an amount of knowledge that is virtually without limit. (p. 109)

Not only educators but also psychologists imply that the mastery of rudimentary concepts leads to mental readiness for acquiring new knowledge. According to Vygotsky (1986), there are two kinds of concepts: scientific concepts and spontaneous concepts. "Scientific concepts that originate in classroom instruction . . . (spontaneous) concepts evolving in everyday life" (p. 158). Vygotsky believed that "the two processes—the development of spontaneous and of nonspontaneous (scientific) concepts—are related and constantly influence each other" (p. 157). The way the two kinds of concepts interact with each other and, thus construct a new meaning, is what educators are concerned with.
In terms of Vygotsky's notion of learning through the concept interaction, it is the educators' responsibility to design, produce, and utilize media as effective tools in order to shorten the distance between students' scientific concepts and spontaneous concepts. In other words, the appropriate use of media, or the "signs" as Vygotsky termed, will shorten the distance between students' prior knowledge and desired outcomes from which learning can be enhanced. For instance, Klima (1974) commented that "in multi-media materials or films . . . information communication about phenomena, ideas, or systems is being served, graphically and many times dramatically, for the promotion of better understanding and the generation of possible new knowledge" (p. 54). The examples of utilizing graphical images to help learn new concepts are widespread.

**Moving Images**

In order to enhance learning, especially learning the concept of movement, media theorists have long thought of utilizing the effects of moving images (such as in multi-media materials or films), rather than just static graphics. To describe the visual images in a motion picture, Gibson (1979) noted that what we call the motion picture—as distinguished from the still picture—might better be called the progressive picture—as distinguished from the arrested picture (p. 302). Thus, motion picture is characteristic of its progressive presentation. Gibson further elaborated the attributes of those continuous moving images as such:
The progressive picture displays transformations and magnifications and nullifications and substitutions of structure along with deletions and accretions and slippage of texture. These are the "motions" of the motion picture . . . They are thoroughly saturated with meaning. (p. 293)

In many cases, such as in science or mathematics lessons, the concept of movement of an object can best be presented through the use of progressive displays of moving images. These progressive displays are actually illustrating the concepts of movements, gradual changes, or even procedures by means of animated moving pictures. This is how moving images can be used for the purposes of education and scientific visualization.

To apply the theory of utilizing "progressive pictures" in educational practice, Heinich, Molenda and Russell (1993) noted that moving images have an obvious advantage over other visual media in portraying concepts in which motion is essential to mastery, such as tying knots or operating a potter's wheel (p. 203). Operational processes in which sequential movement is critical can be shown more effectively by means of moving images as well. The increasing popularity of animation is the reflection of utilizing moving images. These moving images serve as educational tools to convey the concepts that are related to movement.
Educational Implications of Animation

In the case of displaying moving images, animation is a special form of motion picture. Oftentimes, animated images are artificially made from manipulated photography to display artistic expressions. Also, animation is widely used for educational purposes. Heinich et al. indicated that computer-generated animation sequences are being used more and more in instructional video programs to depict complex or rapid processes in simplified form (p. 198). Milheim (1993) observed that "the use of animation in computer-based instruction is unique since the learner is sometimes able to control various aspects of the animated presentation during the instructional process" (p. 171). In practice, animation to facilitate instruction can be found in many different forms of visual media.

Even though animation is available in different media formats, designers are concerned with its attributes, such as simplification, amplification, and so forth. For example, animated sequences with simplified figures or graphics are usually employed to help teach meaning or concepts. To justify the unique function of this simplification, Brown (1971) posited that simplified line drawings or pictures can be more effective as information transmitters than either shaded drawings or real life photographs; full realism pictures can flood the viewer with too much visual information. Blinn (1989) also recommended that animators avoid overloading information in delivering mathematical concepts because the unnecessary information can be confusing.
By means of simplified presentation, animation functions as an effective transmitter to deliver information. However, the degree of simplification is another important consideration for educators. Wagner (1953) commented that:

Educators, nevertheless, while aware of the dangers of oversimplification, are also sensitive to the potential of animation for a variety of worthwhile purposes. (p. 173)

Nevertheless, simplification is just one of the attributes that animated imagery possesses. The concerns about many other attributes are also seriously addressed by educators. Thus, the manipulation of those attributes indeed deserves media designers' special attention if they are to make animation a tool for learning.

**Animation as a learning Tool**

It is apparent that the function of animation is similar to a learning "tool." According to Wagner (p. 173), we can, through animation, not only show "how things look," but also "what they mean." With its multi-purpose potential, this tool is designed to illustrate and clarify the meaning of certain concepts.

To better explicate Vygotsky's notion of tools, Miller (1993) indicated that "psychological tools" include language systems, counting systems, writing, diagrams, maps, conventional signs, and works of art. Also, some tools that influence thinking are "physical devices" such as computers, calculators, and
typewriters (p. 388). It is evident that animation functions as a psychological tool as well as a physical tool. Therefore, Animation is a "content" psychologically as well as a "form" physically. Both content and form contribute to the formation of new concepts in the context of mediated learning.

Animation is usually adopted in such media "platforms" as films, videos, television programs, and even computer networks. Also, it is widely used in interactive multimedia environment such as Compact Disk devices (CD-ROM, CD-I, etc.) or Digital Video Disc (DVD) systems (Bunzel, 1996). No matter how animation is used, educators are concerned about how to combine media's physical and psychological attributes and turn them into the desired function. Therefore, it is essential that media producers build educational concerns into their productions. However, the real value of animation rests upon both its format and its content. For educational purposes, animation can be functional only when it is appropriately designed and used.

THE RESEARCH QUESTIONS OF THE STUDY

The research questions of this study are to determine the instructional effectiveness of using visuals, especially animated visuals, for concept learning. The specific research questions to be addressed in this study are:
1. **Is there a significant difference among the presentation methods** (Animated-visuals, Static-visuals, and No-visuals) **on scores on the performance test of knowledge of the presented concept when learners are exposed to visuals in the mediated instruction?**

2. **Is there a significant difference between the audio modes (Audio and Silent) on scores on the performance test of knowledge of the presented concept when learners are exposed to visuals in the mediated instruction?**

3. **Is there any interaction effect among the presentation methods, the audio modes, and the GEFT scores when learners are exposed to visuals in the mediated instruction?**

4. **What is the relationship between the scores measured by the Group Embedded Figures Test (the GEFT) and the scores measured by the performance test (the posttest) for those learners who receive the mediated instruction?**

**THE PURPOSE OF THE STUDY**

This study investigates the effects of using media, especially animated visuals, as a tool to deliver instructional information to elementary students. Specifically, it has the following significant goals:
1. To determine the instructional effectiveness of animation,
2. To examine elementary students' learning styles (i.e., FD vs. FI),
3. To build evidence for the theoretical framework,
4. To present school teachers with information for using media in a more effective fashion, and
5. To provide designers and producers of educational media with an empirical basis for future production.

ASSUMPTIONS

This study is conducted under the following assumptions:

1. It is assumed that the age of the participating subjects is appropriate. This assumption is based upon Vygotsky's (1986) notion which maintained that the development of scientific concepts was interrelated with school instruction in childhood (p. 174).

2. It is assumed that the visuals presented in this study were "age-appropriate" for the participating subjects. This assumption is based upon the previous research findings that supported the "age-appropriateness" of these visuals (Cambre, Johnsen, & Taylor, 1987).
3. It is assumed that the content of the visuals used in this study was appropriate. This assumption is based upon the researcher's understanding obtained by examining the content of textbooks and teacher's guides for elementary mathematics.

4. It is assumed that the subjects in this study had no familiarity with the visuals presented. This assumption is based upon asking the subjects' instructors about the selection and use of media materials in their regular class activities.

DEFINITIONS OF TERMS

The important terms used in this study are defined in the following paragraphs.

Performance Test

1. Constitutive Definition:

   According to Gagné (1985), "performance is the behavior that students are required to do or perform in order to demonstrate that they have mastered the prescribed instruction. The performance that accompanies the learning of a new capability is simply a verification that learning has occurred." He noted that "assessing performance in this manner is what is meant usually by giving a test."
Also, Gagné indicated that "the functions served by such a test are (1) establishing that the newly learned capability has reasonable stability, and (2) providing additional practice that serves to consolidate what has been learned."

2. Operational Definition:

In this study, "performance" is defined as the scores on the posttest, measuring subjects' understanding of the concept taught through the visual presentations. Since this performance test is conducted after the treatments, it is also called the "posttest." The term "performance test" is interchangeably used with the term "achievement test" in this study.

Concept

1. Constitutive Definition:

According to Merrill, Tennyson, and Posey (1992), a concept is defined as "a set of specific objects, symbols, or events which are grouped together on the basis of shared characteristics and which can be referenced by a particular name or symbol" (p. 6). According to Vygotsky (1986), there are two kinds of concepts: scientific concepts and spontaneous concepts. "Scientific concepts that originate in classroom instruction . . . (spontaneous) concepts evolving in everyday life" (p. 158).
2. Operational Definition:

In this study, "concept" is defined as the attributes of the subject matter: a mathematic "cube." The concept of "cube" is displayed through different methods and modes of presentation.

Visual

1. Constitutive Definition:

According to Heinich et al. (1993), "the primary function of a visual as a communication device is to serve as a more concrete referent to meaning than the spoken or written word." They also indicated that visuals can be classified into three categories: representational, analogic, and arbitrary.

2. Operational Definition:

In this study, "visual" is defined as the means of presenting graphical images. There are two kinds of visuals, namely animated graphics and static graphics.

Presentation Method

1. Constitutive Definition:

According to Heinich et al. (1993), "in the presentation method a source tells, dramatizes, or otherwise disseminates information to learners. The source may be a textbook, an audiotape, a videotape, a film, an instructor, and so forth."
Reading a book, listening to an audiotape, viewing a film or videotape, and attending a lecture are examples of the presentation method" (p. 8).

2. Operational Definition:

In this study, "presentation method" is defined as the three strategies to display visuals. These three strategies are displaying animated graphics, displaying static graphics, and displaying no graphics.

Audio Mode

1. Constitutive Definition:

According to Heinich et al. (1993), "by audio media, we mean the various means of recording and transmitting the human voice and other sounds for instructional purposes. By listening to audio, we are able to understand the main ideas, details, or inferences." Meanwhile, visual displays are usually accompanied by auditory sources. The auditory part of visual presentation can include all sources of sounds, such as narration, background music, or special sound effects. However, the focus is on the narrated explanation of the content.

2. Operational Definition:

In this study, "audio" is defined as the auditory part of the presentation. The audio mode is either "audio" or "silent."
LIMITATIONS

In terms of the design and practice, this study has some limitations. These limitations are described in the following paragraphs.

1. To present the concept of "cube," video presentation is one of many possible instructional methods. This study can only reflect the instructional impacts of animated displays in this type of instruction.

2. It is not within the scope of this study to appraise the effects of subjects’ individual differences and demographic, geographic, and socio-economical influences. Although these factors do influence mediated instruction, this study focuses primarily on the effects of visual learning, especially the effect of animated displays.

3. The findings would be more thorough if data collection were not confined to a limited time. When time permits, other approaches of knowing such as naturalistic inquiry and dynamic assessment (Das, Naglieri, & Kirby, 1994, p. 161) can be taken. Then, more insights can be explored and described. This will be done in future studies.
SUMMARY

Since animation has been widely incorporated into various media formats, educators are concerned about the effect of animation especially in cognitive instruction. Hence, the researcher feels that there is a need to investigate the use of animation as a tool for concept learning.

To approach this subject matter, the researcher first examined media's functions and coding systems, then discussed representational signs designed for learning. Often, concepts are presented through the progressive displays of moving images. Animation at this time acts as a psychological and a physical tool. Therefore, understanding the function of animation in mediated instruction is meaningful.

Primarily, this study is to determine the instructional effectiveness of animated visuals for concept learning. The specific research questions investigate the differences among the presentation methods and the audio modes, the existence of interaction among the factors, and the relationship between the posttest scores and the GEFT scores.

The purpose of this study extend not only to the determination of animation effect on elementary students, but also to the building of evidence for theoretical frameworks. More practically, this study provides school teachers, instructional designers, and media producers with an empirical basis for quality instruction and production.
This study is conducted under the following assumptions: (1) the age of the subjects was appropriate; (2) the visuals were age-appropriate; (3) the content of the visuals was appropriate; and (4) the subjects had no familiarity with the visuals presented. The important terms are defined constitutively and operationally. Also, the limitations are listed. More insights will be explored and described in future studies.
CHAPTER 2

REVIEW OF THE LITERATURE

THEORETICAL BASES

The ground theories of this study are threefold. They are based upon Vygotsky's notion of Concept Formation, Paivio's theory of Dual Coding, and Gibson's notion of Visual Motion.

Vygotsky's Theory of Concept Formation

According to Rogoff and Wertsch (1984), Vygotsky's concept of "the zone of proximal development is a dynamic region of sensitivity in which cognitive development advances" (p. 1). This idea plays the central role in Vygotsky's theory. Vygotsky (1978) defined the "Zone of Proximal Development" (ZPD) as:

The distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers. (p. 86)
Vygotsky not only elaborated the notion of the ZPD, but also other important elements in the zone of development concerning cognitive learning—scientific concepts and spontaneous concepts. In the zone of proximal development, the two kinds of concepts are functioning as two magnetic forces ready to meet. Once these two kinds of concepts meet with each other, new knowledge will hence be generated. Vygotsky (1986) further described how scientific concepts and spontaneous concepts interrelate with each other in the Zone of Proximal Development in this way:

The strength of scientific concepts lies in their conscious and deliberate character. Spontaneous concepts, on the contrary, are strong in what concerns the situational, empirical, and practical. These two conceptual systems, developing "from above" and "from below," reveal their real nature in the interrelations between actual development and the zone of proximal development. (p. 194)

Even though "learning" can result from the interaction between the two kinds of concepts, the scientific concept seems to be able to trigger this very interaction.

For this reason, scientific concepts are usually taught in the schools. In mediating new knowledge from school instruction, Vygotsky compared the function of scientific concepts to a portal. He stated that:

Scientific concepts, with their hierarchical system of interrelation, seem to be the medium within which awareness and mastery first
develop, to be transferred later to other concepts and other areas of thought. Reflective consciousness comes to the child through the portals of scientific concepts. (p. 171)

The scientific concept is compared to a gateway in the zone of proximal development, leading to the acquisition of a new concept or knowledge. Consequently, there must be a medium, functioning as a tool to bring in the messages for concept formation. In Vygotsky's theory, words or signs are able to function as psychological tools in the process of concept formation. He posited that "learning to direct one's own mental processes with the aid of words or signs is an integral part of the process of concept formation" (p. 108). According to him, "once the child has achieved consciousness and control in one kind of concept, all of the previously formed concepts are reconstructed accordingly" (p. 192). Vygotsky then concluded that "concept formation is the result of such a complex activity, in which all basic intellectual functions take part" (p. 106).

Relevant Notions

Vygotsky's theories, especially his notion of the ZPD, have had increasing influences on educational theory, research, and practice. He has even been described as a "fragile genius in time and place" (Davydov, 1995; Youniss, 1994). Valsiner (1994) commented that the advancement of the Vygotsky's ZPD concept is a 'Neo-Vygotskian' form. For instance, Van Geert (1994) reformulated Vygotskian theory in a mathematical model for instructional application.
Vygotsky vs. Piaget Concerning Cognitive Learning

The advancements of Vygotsky's notion are multi-directional. In addition to the cultural line in Vygotsky's theory of cognitive development, Moll (1994) reclaimed the importance of natural line—the material, or natural component of cognitive development is crucial to Vygotsky's theory. This consideration accordingly leads to a comparison between Piaget's notion and Vygotsky's notion. Piaget's theory has been a cornerstone in the field of child development and cognitive learning for years. The primary difference between the two thinkers concerning cognitive learning rests upon the priority of developing a mental infrastructure. Panofsky, John-Steiner, and Blackwell (1990) pointed out that for Piaget, the development of mental structures precedes the learning of logically or systematically organized concepts, whereas for Vygotsky, the learning of systematic concepts precedes the development of an elaborated logical structure (p. 253).

The sequential order of conceptional maturation is not the only difference between the two thinkers. In contrast to Vygotsky's notion of operational function, Piaget viewed mental images as a set of intermediate symbol systems. Thus, Piaget (1969) made some remarks on the semiotic or symbolic function of images as such:

Mental images . . . generally speaking, delayed translation of the subjects' preoperatory or operatory level of comprehension. The image is far from sufficient to give rise to operatory structurations.
At the very most, the image, when it is sufficiently adequate... can serve to refine the subjects' awareness of states which the operation will later connect by means of reversible transformations. (p. 79)

Another different viewpoint between Piaget and Vygotsky is the notion of "shared cognition." According to Sprinthall, Sprinthall and Oja (1994), Vygotsky did not believe that a learner should be isolated in a booth to build his or her own conceptual tools. Instead, the learner's cognitions should be shared with other people (p. 122). Santrock (1994) held that it is inappropriate to say that the child has a ZPD; rather, a child shares a ZPD with an instructor (p. 223). In the meantime, Piaget's viewpoints concerning cognitive development are based on the progress of mentally operational stages. In contrast to Vygotsky, Piaget did not put emphasis on how social interactions with others can improve the capability of cognitive problem solving.

Nevertheless, in light of those different viewpoints, Glassman (1994) commented that both theorists, Piaget and Vygotsky, started from basically the same place in developing their contributions to the study of development. In the long run, through a dialectical integration of the two theorists' notions, new and important theoretical contributions may be possible.
The Nature of Concept Formation

According to Merrill, Tennyson, and Posey (1992), a concept is defined as "a set of specific objects, symbols, or events which are grouped together on the basis of shared characteristics and which can be referenced by a particular name or symbol" (p. 6). The point of "shared characteristics" implies that learners should be able to refer certain attributes of a concept to the objects, symbols and events with which they are familiar in their prior experiences. Ausubel, Novak, and Hanesian (1978), held that "learning what concept words mean obviously demands more sophisticated prior knowledge about their corresponding referents than do other forms of representational learning" (p. 54). Prior knowledge seems to be a base upon which new concepts can be built.

However, not every student is adequately equipped with prerequisite experiences, especially when cognition begins to get involved with abstraction and generalization. In understanding abstract concepts, the thinking processes need to be upgraded to a level at which the relationships of symbolic representations can be induced and deduced. For higher levels of thinking processes, then, Luria (1976) noted that "perception begins to go beyond graphic, object-oriented experience and incorporates much more complex processes which combine what is perceived into a system of abstract, linguistic categories" (p. 162). At this thinking level, human perception is a cognitive experience in itself. It becomes a process in which direct impressions are related to the complex abstract categories.
The process of concept formation may vary with age as well as personal aptitudes. According to Luria, Vygotsky believed that although a "young child thinks by remembering, an adolescent remembers by thinking" (p. 11). Also, Ausubel et al. (1978) held that "the criterial attributes of the concept are acquired through direct experience, through successive stages of hypothesis generation and testing and generalization" (p. 56). However, there is something in common-mental dynamics. People's mental dynamics that activate these functions are basically identical. These mental capabilities help receive in-coming messages from sensory faculty and transform them into the rational consciousness. Thus, concept formation is a thinking process. New knowledge can be generated as a result of this process upon which more mature concepts will be based.

Mediated Function

In light of the transitional process, Zinchenko (1985a) proposed that in Vygotsky's account of concept development, the stage of generalization that he called "pseudoconcepts" corresponds most closely to the concept of "object meaning" (p. 102). Thus, "object meaning" acts as a "bridge" between external and internal tool-mediated action (p. 102). At the same time, Zinchenko and Davydov (1985b) also held that "the solution to the problem of the external and internal lies in this idea: action and meaning (sense) are two sides of a single coin" (P. x). Consequently, the "object-meaning" becomes more and more mature when action and meaning interact with each other. The concept, then, can be gradually developed.
Zinchenko's metaphor of the "bridge" implied that there is a transaction in the process of learning. This transaction can be mediated through using instruments and other well-designed methods. For instance, Bruner (1985) indicated that to carry out a Vygotskian project on "learning by transaction" there are three kinds of notions necessary: the use of props and instruments, the specification of processes, and the procedures with the more proficient partner (p. 25). Obviously, physical instruments and methodological procedures are able to help transact the meaning of concepts.

In the process of transaction, this metaphorical "bridge," namely the mediated function, can even stimulate the learners' response with appropriate methods. Therefore, through the process of discussion with learners, it is possible to identify and assess "what and how" learners develop their concepts and construct their meanings. For example, Stanley (1993) proposed that the "Dynamic Assessment," based upon Vygotsky's notion, is able to provide educators with a modified method to assess learners. However, Wertsch (1994) commented that we don't have the tools (theoretical and methodological) to think about such processes in a productive way. Based upon those propositions, the theories and methods for curriculum, learning, teaching, and evaluation should be carefully developed so that educators can transact meaningful learning activities in a more productive way.
Educational Implications

In delivering scientific concepts, media play an intermediary role. Thus, the appropriate use of educational media as tools becomes essential. Adopting Vygotsky's notion of mediation, Martin (1990) proposed that visually informative examples as mediators for classroom activity can be helpful tools for learning. Therefore, through images, video can communicate information, make inferences, and present role models (p. 376).

Also, media can help learners attain new concepts by presenting instructional cues and prompts. Thus, designers and producers need to be aware of how to select appropriate cues for media in the process of production. Those cues are the facilitators for better learning results. Croft and Burton (1995) posited that selecting which cues to include in visuals should be based on the understanding of the level of previous experience, the pacing of the lesson, and the learners' individual differences (p. 152). Clearly, they pointed out the necessities and considerations for mediated learning in attaining concepts, especially through the use of visuals.

On the other hand, some concerns about media use from other studies deserve our special attention. For example, when adopting Vygotsky's learning theory, the research done by The Cognition and Technology Group at Vanderbilt Learning Technology Center (1993) revealed that if students always have access to dynamic visual images that support their comprehension, they may fail to develop their own internal mental model building skills (p. 74). Hence, the amount of assistance educators should provide for learners during the learning
process, the multimedia environment in this case, is indeed an important consideration for educational media designers. Instructional media, like graphics or video clips, can function as a powerful link between spontaneous concepts and scientific concepts. This link also offers teachers relevant examples to refer to in the class. However, all media need to be carefully designed and selected for specific instructional purposes.

**Paivio's Theory of Image Coding**

A two-channel coding theory, *Dual Coding Theory*, was proposed by Allan Paivio to help explain the process of image coding. According to Paivio (1986), the most general assumption in the theory is that:

There are two classes of phenomena handled cognitively by separate subsystems . . . nonverbal (symbolic) subsystem as the imagery system . . . include the analysis of scenes and the generation of mental images . . . the language-specialized system will be referred to as the verbal system. (p. 53)

To elaborate the notion of the dual coding process for in-coming messages, Paivio (1986) further indicated that the idea of separate subsystems means that the two systems, both image and verbal, are assumed to be structurally and functionally distinctive. They are different and independent but they are also interconnected. Therefore, this theory is basically dealing with the nature and the process of a representational system (p. 54). In school settings,
most of the educational audio-visual media are characteristic of both image and verbal subsystems which include visual images, texts, auditory narrations, etc. Therefore, the Dual Coding Theory seems to support the effectiveness of mediated instruction in many ways.

An interesting question appears when the two systems are caused to code in-coming information. That question can be asked like this: "Which system can function more effectively?" According to Paivio and Csapo (1969), recalled pictures exceeded concrete words, which in turn were recalled better than abstract words. Thus, their study implied that pictorial presentation can be more effective than verbal presentation. Paivio (1991) further reported that picture superiority under free recall conditions can best be explained in terms of an additive contribution of pictorial and verbal memory codes, in which the contribution of the former is decidedly greater than that of the latter (p. 99). His findings seemed to imply that the combination of image and word presentation is capable of achieving more effective learning results in mediated instruction.

Paivio also noticed that the images that are characteristic of movements have more coding components than those of the regular still images. He (1979) proposed that "more mature imagery incorporates the implicit motor components of imitative acts in its capacity to symbolize movements and transformations" (p. 30). This "implicit motor component" symbolizes the visual movement of objects. Also, to a certain degree, it helps viewers perceive the transition of movement. Hence, in viewing moving images, learners are able to link together the meaning of each separate visual image that is sequentially
displayed. As a result, the concepts embedded in the moving images can be transmitted. The meaning of the entire sequence, then, can be understood.

Relevant Notions

Studies that support Paivio's Dual Coding Theory take diverse approaches. They range from media use, to language in reading, to image processing (e.g., Mayer & Anderson, 1991, 1992; Danan, 1992; Sadoski, Paivio, & Goetz, 1991; Kounios & Holcomb, 1994; Lapadat & Martin, 1994). Researchers are also interested in physiological investigation. Thus, they have investigated how mental images are related to the temporal filter and neural adaptation as a substitute for actual perception (e.g., Shepard, 1978; Kosslyn, Backer, & Provost, 1985; Busey & Loftus, 1994; Gilden, Blake & Hurst, 1995). However, there are many studies that explore the nature of pictorial images from various perspectives.

The Nature of Image Coding

To describe the nature of pictorial images, Wade and Swanston (1991) noted that pictures have a dual reality— they exist as objects and, in addition, they signify other objects and spaces than they occupy (p. 188). Working from this point of view, Kosslyn (1983) proposed that "the image does not depict an object as it might really appear, but is a symbolic representation . . . the image is a notation, a visual aid to abstract thinking" (p. 179). These researchers
approached the nature of image coding from a perspective of symbolic representation.

However, the investigation of encoding and decoding processes is another important approach as well. Since moving images are distinctive in their movements, the mechanism to encode the in-coming messages need not be confined only to static image encoding. This process implies that encoding visual movements may be conducted through different channels. Krumhansl (1984) proposed that motion and form information are encoded by separate systems. This notion, to a degree, explicates the multiple attributes of moving images. In other words, the information that carries multiple messages may be encoded through multiple receiving systems.

On the other hand, in decoding processes, visual movements represent different kinds of data structures and they may be interpreted differently. According to Kosslyn, these functions of the brain in imaging can be divided into two classes: structures and processes (p. 113). He held that "structures are used to represent information . . . processes operate on or through the media structures to interpret or transform the data structures" (p. 113). His theory of imaging intends to describe the cognitive functions of the human brain from an information processing approach.

Addressing image maintenance of the human brain, Kosslyn (1994) further indicated that there are two kinds of images: visual-memory images and attention-based images (p. 325). He argued that attention is a selective aspect of processing (p. 87). From this point of view, visual materials that include both
visual and attention incentives may cause mental images to remain longer in the human brain. Thus, the question of how information, especially visual images, is coded to perform high level psychological functions, deserves more educational attention.

Educational Implications

In the practice of media use for education, pictorial materials are usually mixed up with verbal messages. For example, Simpson (1995) suggested that encoding visual media messages should increase the accurate integration of visual and verbal symbols (p. 255). Thus, a faithful communication between encoders (media designers) and decoders (students) is important. By means of accurately integrated visual and verbal materials, this communication plays an essential role in delivering the planned educational objectives.

For instructional purposes, educators usually put emphasis on the combined effect of visual and symbolic presentation rather than just the impact from visual presentations alone. For instance, Pettersson (1995) suggested that pictures used in information and instructional material should always have captions to guide the understanding of the content (p. 144). He also suggested that lecturers and teachers should be given proper guidance, for example, special instructions in pictorial presentation (p. 144). This would also provide his or her readers and listeners with an ability to interpret visual messages in the audio-visual materials more efficiently.
However, a faithful communication through the use of pictorial presentation does not mean that more effective learning can really happen. According to Dwyer (1972), "the use of visuals specifically designed to complement oral and printed instruction does not automatically improve students' achievement" (p. 89). He (1978) further reported that "the use of motion as an attention gaining cue is not an effective instructional technique for improving student achievement when the instructional presentation utilizes the more realistic visuals" (p. 183). Abed's study (1994) on dimensionality and its effect on retention and visual scanning supported that "realism in illustrations is not necessarily facilitating: in the present investigation it proved to be distracting." Those studies lead us to reconsider the value of utilizing visuals for better learning.

Thus, to decide when to use realistic or representational visual images is difficult. Eugenio (1994) held that the research on visual realism is still inconclusive. Nevertheless, visual images function as important representational carriers, especially in teaching and learning abstract concepts. It is essential that media designers as well as educational researchers further explore how visual images are coded and employed for instruction. It is this understanding that determines the effectiveness of visual learning.

**Gibson's Theory of Visual Motion**

According to Gibson (1994b), movement involves three separable, but closely related problems: a moving object, a stable environment, and the
locomotion in a stable environment (p. 318). These are the three essential factors that generate human perception of visual motion.

The distinction between still images and moving images, in terms of the three essential moving factors, lies in the visual movements that are added to the still images. Human eyes are actually seeing a sequence of still images as well as an illusion of movement. Optically and psychologically, figures or objects that move in the motion pictures are sending information of visual movements to viewers. As a result, the moving image carries more information than just the image itself—the meaning associated with the movement. Gibson (1966) noted that:

The information in a still picture consists of the variables of structure in its optic array. The information in a motion picture contains the additional variables of transformation in the array with all the invariant variables under transformation remaining to take the place of the formerly frozen structure. A motion picture is therefore much richer in information than a still picture. (p. 234)

Hence, motion is a complex visual experience. On the one hand, it consists of a continuous display of still pictures. On the other hand, human eyes interpret a series of visual images as motion. According to Gibson (1950), "a combination of successive and adjacent order over the retinal mosaic would seem to be the fundamental stimulus condition for this impression of motion" (p. 134). Thus, the concept of motion has to deal with an object that makes successive movements in a given visual field.
However, motion is also a relative concept that exists between the moving objects and the stationary environment. Gibson (1994a) elaborated the notion of relative movement with such comparisons as: "rigid motions of objects relative to a stationary earth with a stationary observer . . . elastic motions of certain substances when the remaining environment and the observer are stationary" (p. 181). While objects are moving, observers are sometimes moving as well. In comparison, observers are relatively static to a certain degree. Therefore, they can attend to the information that moving images are emitting to them.

Psychologically, in light of selective attention, motion image is capable of bringing its viewers to another world—a world of images. For instance, when watching a motion picture or television program, viewers naturally do not pay attention to the realistic environment. Instead, they pay attention to another "realistic world inside the screen." The viewers and this "quasi-realistic environment inside the screen" turn out to be static, relative to the moving scenes on the screen. Gibson (1966) noted that:

The motion picture (including the television screen) is another matter. It dramatically freed the observer from having to perceive only a single unique view of the apparent environment, the observer being forever fixed to one spot and the environment frozen in time. (p. 234)

Maybe, this quasi-realistic environment can be made more realistic through different perspectives. Gibson (1950) raised a question about the
presentation of time and environment: "Abstractly, the question is how to produce a series of impressions which, for the reader, the hearer, or the observer, creates an objective world flowing in objective time?" (p. 160). Probably, filmmakers are more qualified to answer this question than physicists or psychologists.

Relevant Notions

In exploring the phenomena of visual perception, Gibson developed an "interactionist" view and inspired many later studies on visual motion (e.g., Blake, 1994; Nakayama, 1994; Greeno, 1994). Generally speaking, the studies of visual motion are making attempts to explain "how, what, and why" the images that can move contribute to human perception.

The Nature of Moving Images

McBurney and Collings (1977) raised a question: "What determines what we attend to?" They held that we notice those things that are large, loud, colorful, moving, or repeated (p. 147). Obviously, the "object that can move" is one of the important attractors of viewers' attention. This answer somewhat explicated the theories of "Selective Attention." Kosslyn (1994) pointed out the functions of motion: it "first, helps to delineate an object itself, providing another cue as to the location of edges and regions, and second, motion cues can be used..."
to recognize an object" (p. 153). Thus, people selectively attend the images that can move because they are able to identify those images with ease.

However, in investigating the elements that contribute to the perception of visual motion, the correspondence between visual identification and cognitive process is essential. Ullman (1979) noted that "correspondence" is the "process that identifies elements in different views as representing the same object at different times, thereby maintaining the perceptual identity of objects in motion or change" (p. 8). Rensink and Enns (1995) found that rapid visual search cannot access the primitive elements formed at the earliest stages of visual processing. Mack et al. (1989) indicated that the direction of apparent motion tended to be determined by the direction of motion perceived at first, regardless of the character of the elements. Assumably, to interpret visual motion, other factors besides correspondence may also exist, and they deserve our investigation as well.

Some factors that are related to human vision also decide "what and how" people perceive the motion of image. For instance, to explain the concept of relative movement, Arnheim (1969) held that we can recognize a movement only by comparison with something stable (p. 288). Also, Wallach (1986) stated that a moving object changes its position relative to stationary objects that surround it (p. 1). According to McBurney and Collings (1977), it appears that the movement experience requires a perceptible rate of change in the position of some stimulus element with respect to another; for example, the figure with respect to ground, to another figure, or to the boundaries of the visual field (p. 208). Hochberg (1971) indicated that the contour seems to belong to the figure rather than to the
ground. Moreover, the figure has the nature of a thing, as contrasted with the ground which does not. As a result, the viewer’s perception of visual movement is subliminally dominated by those factors.

In the meantime, the perception of visual motion may also be affected by the way images and objects are presented within a spatial frame. Thus, human perception toward the moving images in a visual environment is determined by a figurative border—the "frame of reference." This frame may confine a viewer's scope of attention to a certain degree. Gibson (1994b) noted that the moving objects appear in "the background of the motion, or the frame of the window" (p. 320). Johansson (1994) also indicated that "every common motion state can move relatively to a frame of reference. This is the fundamental principle" (p. 130). Similarly and relatively, the frame of reference, which could be as big as a movie screen, and as small as a television screen or a computer monitor, functions as a stationary visual field for the viewers of moving images.

Educational Implications

From a learning standpoint, recognition is more or less determined by viewers’ reasoning methods in interpreting instructional visual aids. By means of an appropriate method, novel concepts that are embedded in the media can make sense with greater ease. Braunstein (1976) proposed that, when a perceiver is confronted with an unusual stimulus situation, the "heuristic reasoning method," namely, a provisional and plausible reasoning method, is recommended (p. 154). Its purpose is to discover a solution to interpret the
visual literacy with the aid of available cues and self-reasoning capabilities. Braunstein held that heuristic processes have greater efficiency in solving a wide variety of problems, such as the symbolic logic and pattern recognition (p. 155). For learners, this can be an important reasoning alternative in approaching new concepts through viewing instructional visuals.

From a teaching standpoint, on the other hand, moving images can be employed to deliver abstract concepts and illustrate complex procedures. Animation is one way to do this. Kemp and Smellie (1989) described animation as "the single-framing procedure" that "can be further used in recording things that normally cannot move to make them appear as if they are moving on the screen" (p. 263). There are many examples in instructional practice, such as successive drawings, slight movement of three-dimensional figures and objects, or progressively developed parts of a diagram, etc. By incorporating various symbol systems into media production and presentation, the projected subject matters can be illustrated in a more effective fashion (Salomon, 1979, p. 52.) The contents and expressions of animated visuals may vary. However, they all reveal the same phenomenon—the motion.

In discussing the instructional effectiveness of video media, Wetzel, Radthe, and Stern (1994) pointed out that animation is effective when used to cue learners to the important aspects of a presentation. However, they also indicated that the effectiveness of animation in instruction appears to be confined mainly to younger learners (p. 97). Thus, the function of animation in learning situations needs to be further explored.
CONCEPTUAL FRAMEWORK

Based upon Vygotsky's notion of Concept Formation, Paivio's theory of Dual Coding, and Gibson's notion of Visual Motion, the researcher developed the "Media ZPD Model"—which displays how media are incorporated into learners' cognitive fields. This model is shown in Figure 1.

In the Media ZPD Model, instructional media (in both realistic and symbolic representations) are carrying messages into learners' Zone of Proximal Development in different kinds of modes (verbal or nonverbal, auditory or visual, static or dynamic, and so forth). The messages, functioning as learning cues, trigger scientific concepts (the learning objectives at potential developmental level) and act on spontaneous concepts (the learners' prior knowledge at actual developmental level). Consequently, during the up-and-down interactive processes, new concepts can be formed.
REALISTIC AND SYMBOLIC REPRESENTATIONAL MEDIA

(VERBAL, NON-VERBAL; AUDITORY, VISUAL; STATIC, DYNAMIC; ETC.)

POTENTIAL DEVELOPMENTAL LEVEL

SCIENTIFIC CONCEPTS

CONCEPT FORMATION

SPONTANEOUS CONCEPTS

ACTUAL DEVELOPMENTAL LEVEL

MEDIA ZPD MODEL

Figure 1: The Media ZPD Model.
**Historical Development**

The original idea of animation emerged long before the actual appearance of animated images. In tracing back the history of animation, Madsen (1969) noted that:

Over 300 centuries ago Neanderthal man drew pictures on his cave walls of the creatures he hunted and who hunted him... He wanted his pictures to come alive—to be animated... To create this impression of images in motion, he drew many lines to represent the movement of a single limb, or he drew multiple limbs on a single animal... (p. 3)

It seems that human ancestors could have known some 300 centuries ago that the images of movements consist of individual actions. At least, they were capable of expressing the idea of animation with a series of images of movements by primitive hand-drawing techniques a long time ago. In the following paragraphs, the researcher will review the development of animation which has been far beyond our ancestors' primitive expressions on the mural drawings. Although animation techniques have emerged and become mature through ages all over the world, the facts, reviewed in this study, primarily reflect a developmental experience in the United States.
Then, what is animation? Animation may as well be described as a visual expression that is generated or manipulated by non-live photographic impressions. However, people may have different answers in terms of their own interests and emphases. Animation is generally defined as an illusion of movement, which depends on the persistence of vision. It can be achieved by quickly displaying a series of images that show slightly incremental changes in one of the depicted objects (Morrison, 1994; Solomon, 1994). This definition is based upon the techniques of manipulating mechanical devices, resulting in motion effects that viewers can visually perceive.

However, contemporary motion picture theorists (e.g., Anderson & Anderson, 1980, 1993; Nichols, 1980, 1993) considered that the term "persistence of vision" is an inaccurate and inadequate explanation for the apparent motion found in a motion picture. At most, such an explanation might account just for the sense of constancy of the light source. According to Anderson & Anderson (1993), motion in the motion picture is an "illusion." It is called the "short-range apparent motion." To human eyes, the motion in a motion picture is "real motion" because the human visual system cannot distinguish between short-range apparent motion and real motion. Anderson et al. also emphasized that viewers' actual interface with motion pictures is essential because viewers can "process movement in active meaning-seeking ways."
The Birth of Animation

Although contemporary theorists tend to interpret human beings' capability of vision from a psychological viewpoint, it is still debatable how pioneer inventors took advantage of this capability to create animated images. Crafton (1993) indicated that "as many pioneers of animation later recalled, it was not any of these optical devices (magic lantern, stroboscope, etc.) that inspired them. Rather it was flipbooks—sequential drawings that produced an illusion of motion when thumbed—that first whetted their curiosity" (p. 7). No matter what stimulated the creation of animated images, human beings had long been intrigued with making pictures move through an array of devices.

However, the first animated film did not emerge until the early twentieth century. Crafton (1993) did a thorough study on the early history of animation before the birth of Mickey Mouse. He noted that Emile Cohl, a Frenchman, was generally considered the first animator to make a film. However, according to Crafton, "the first film that Cohl directed in 1908, Fantasmagorie, was also arguably the first true animated cartoon" (p. 60). In the United States, Winsor McCay's early animation work, Gertie the Dinosaur (1914), his third and most memorable film, became the enduring masterpiece of pre-Disney animation. There is no doubt that early animated films were full of originality and expression despite the primitive techniques.
Growing Up with Diverse Techniques

Animation can be created without any specified technical boundaries. However, in the early 1900s, animation productions were mainly restricted by available technologies. Pioneer animators could only realize their imagination by utilizing unsophisticated mechanisms. For instance, early cartoons did not start with using "cels." Instead, they "were all drawn and photographed on paper" (Culhane, 1986, p. 16). But, the hand-drawing method was just the beginning. Many other techniques were invented and utilized from then on.

Through the years, animation has appeared in diverse forms. Generally, they could be categorized by production materials and techniques. According to Hoffer (1981), there are four classes of animation: cel-animation, object-animation, drawing-on-film animation, and computer animation (p. 90). In addition, Halas & Manvell (1976) used the term "fluid animation" to include all types of cel-animations (p. 262). Also, the terms "abstract animation" and "pictorial animation" are utilized to indicate artistic expressions and technical directions (Russett & Starr, 1988, p. 7). No matter how animation is classified, the name of animation represents its unique tradition. In the following paragraphs, some important animation techniques are reviewed.

Stop-motion Animation One of the early technical advancements was the "stop-motion" technique. This type of animation is made by photographing a series of "stopped" positions frame by frame, in which "motion" is achieved (Frierson, 1994, p. 272). Early in 1897, Vitagraph used the stop-motion technique in the film A Visit to the Spiritualist (Hoffer, 1981, 187). Also, in 1900, J. Stuart

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Blackton in Edison's film The Enchanted Drawing drew a face of a fat man who smiled off-and-on by using the stop-action technique (Hoffer, 1981, p. 9). It is a convenient method to create moving images. Even today, this technique is still widely used with manual or electronic manipulations.

**Cel Animation**  
With this transparent material, a film can be animated by many layers of drawings on clear celluloid sheets—briefly called "cel." At the photographic stage, the painted cels can be overlaid on a background drawing to create visual effects. In 1906, J. Stuart Blackton and Albert E. Smith used the cel technique to create an animation film called Humorous Phases of Funny Faces (Hoffer, 1981, p. 10). Since then, the cel animation technique has become so popular that most of the commercial animation films, such as Disney cartoons, have used it as a fundamental technique. Halas (1990) indicated that "since its invention, no better material has been found . . . than the transparent cellulose acetate . . . Why? It is easy to handle. It is flexible . . . it is unlikely to go out of fashion, not even with the newer technologies" (p. 18).

**Clay Animation**  
Plasticine was invented early in 1897 (Frierson, 1994, p. xv). However, filmmakers in America did not use plasticine as a production material until 1908 when two clay-animated films were released: A Sculptor's Welsh Rarebit Dream and The Sculptor's Nightmare (p. 43). To photograph clay animation, animators can change either the position of the clay mass in the frame or its appearance relative to some previous frames (p. 2). Since clay figures can move in a three-dimensional space, they can create their own perspectives and cast their own shadows (p. 2). Although production is complicated, the visual effects of clay animation are distinctive.
**Other Forms of Animation**

Animated images can be generated in diverse ways. Some animation techniques may not be found regularly in commercial films. However, they are considered valuable in educational practices. For instance, the "Cutouts and Collage" technique is an easy way to create motion. Animators just need to move a piece of paper around under a camera, alter its size or shape, and photograph it one frame at a time (Halas, 1990, p. 18). Using "Toys and Puppets" as objects and figures is another convenient method to make animation (Anderson, 1970, p. 94; Halas, 1990, p. 21). The "Pixilation" technique can be achieved by filming live people as if they were animated characters (Anderson, 1970, p. 95). Maybe the easiest way to create animation is "Painting Pictures under the Stop-motion Camera." This technique can be accomplished by drawing or painting pictures progressively and exposing them under the camera (Halas, 1990, p. 20). Oftentimes, those simple techniques provide educational media producers with many practical alternatives to create animation.

**Combination Animation**

In practice, animated images are usually created through a combination of many techniques. The examples of using combined techniques can be found even in the literature of early animation history. For instance, in 1917, Max Fleischer, himself in live-action, interacted with the cartoon figure *Koko the Clown* (Thomas, 1991, p. 27). In late 1920s, Walter Lantz used a "live-action/animation combination technique" in one of his films *Colonel Heeza Liar* (Solomon, 1994, p. 24). Obviously, techniques of combination animation can add more visual varieties to sole filming techniques.
One of the examples in 1990s is the film *Jurassic Park* (1993). Most of the traditional dinosaur films such as *Gorgo* or *Godzilla* utilized limited techniques in a primitive way. But, by incorporating the "Dinosaur Input Device" (DID) into this film, Steven Spielberg's animation team merged two technologies—stop-motion and computer animation—in an electronic fashion (Shay & Duncan, 1993, p. 132). Shay et al. indicated that through the years dinosaur movies helped develop many animation techniques—"stop-motion, Claymation®, men in rubber suits, cable-driven puppets, radio control puppets, go-motion, etc." But, the production team for the film *Jurassic Park* created an important filmmaking technique—the "full-motion computer animation" (p. 139).

**The Adoption of Computer Technology**

Although animation has appeared for a long time, the history of adopting computer technology in making animation is relatively short. Solomon (1994) noted that the first computer-generated images were created during the early 1950s at the Bell Laboratories and various universities, notably MIT (p. 300). Since then, animation techniques have been becoming more versatile and complicated.

In the early stages, most of the computer graphics and animation were generated in the laboratories as an experimental combination of technical manipulation and artistic expression. According to Russett (1988), early experimental animators, such as Ed Emshwiller, even generated real-time forms of video animation early in 1972, which used computers to completely calculate,
update, and electronically manipulate the graphic artworks during the actual taping process (p. 206). They were really using technology to manipulate the invisible interstices that lay between the frames.

It took about twenty years for computer animation technology to become mature enough to gain official recognition. Machover (1992) noted that 1988 was the first year in which an Academy Award went to a computer animation. This animation was *Tin Toy*, made by Pixar (p. 39). In 1995, the first feature-length animated film, *Toy Story*, produced fully with Computer Graphic Interface (CGI) by Pixar and Disney, was released (Maestri, 1995, p. 30). At the same time, a Canadian-made television animation program for American Broadcasting Company (ABC), *ReBoot*, an all-CGI series, was on network TV (Animation Magazine, 1995, Oct/Nov, p. 10). Computer animation technologies have made tremendous progress in no more than ten years.

Traditional animation production includes many unique techniques, such as cel, cut-outs, and clay animation. However, the adoption of computer animation does not mean those traditional animation techniques are going to be extinguished. For instance, a question worth asking is, "What is the future of clay animation in the next decade?" Frierson (1994) commented that using clay objects to generate three-dimensional (computer) data files seemed a "clear-cut union of the two technologies" (clay animation and computer technology). It will be a "model of hybridization" that could be applied to a wide variety of animation techniques (p. 188). Clearly, other types of traditional animation will also need to find their own compatibilities in this digital world. Consequently, a new age is coming that sees the various technologies integrated.
Those animators who started their careers in the early ages felt sentimentally about the technological changes. Shamus Culhane (1986) said, "I was a link with the primitive past, before sound, color, or tape . . . I am convinced that computer animation will produce beautiful works of art—beautiful beyond our most fantastic dreams" (p. 438). When the film Gertie the Dinosaur was made in 1914, Chuck Jones was two years old. Reminiscing from this hand-drawing animation to the current age of computer animation, Chuck Jones remarked, "It all happened within my lifetime" (Kenner, 1994, p. 2). In the future, contemporary computer animators will share the same feeling with those trailblazers in respect of the technological changes. However, they must first undergo the hardship of generating artistic expressions through the technological advancements.

Communication through Visual Expressions

Most image consumers can relate animation to a series of paintings, drawings, engravings or even sculptures. However, they seem to neglect its function as a tool to deliver people's meaning and thinking. Bendazzi (1994) commented that "animation film falls victim to . . . two errors. One . . . in mistaking animation for animated drawings . . . ; another, in considering it simply as a sort of cinema" (p. xix). Obviously, it is not appropriate to refer animation to just a technical product. The true value of animation rests upon how people utilize these types of visual expressions to communicate with others.
Functionally, animated expression is an alternative to introduce the ideas that are beyond our imagination. Commenting on an interview with the animator Faith Hubley, Priestley (1994) related that:

(Faith) Hubley has rejected narrative structure all of her life. She feels that "the obligation of animation is to deal with material that live action can't, and to look for that form and content which is beyond an actor, which is beyond the adaptation of even a very fine book. (p. 26)

Based upon her experience and professionalism, Faith Hubley believed that the good use of animation could better serve viewers rather than an actor or a book. Her remarks also implied that animation is capable of delivering certain messages whereas other media may not—concepts or thoughts.

Hence, when a story is told in an animation clip the "meaning" of the story becomes the subject matter. What is meant is much more important than the moving images themselves. Hoffer (1981) quoted an animation definition from one of the pioneer animators, Norman McLaren, as such:

Animation is not the art of drawings that move, but the art of movements that are drawn. What happens between each frames is more important than what exists on each frame. Animation is therefore the art of manipulating the invisible interstices that lie between frames. (p. 5)
In this definition, the art of movement is stressed. Through the movement of images, thoughts and concepts can be delivered with more variety. As a result, viewers enjoy this way of watching and knowing. To a certain extent, it explains why average viewers are interested in "what happens in animation" rather than "how to make animation." There is no doubt that "what happens in animation" is an essential concern for viewers. However, this concern is essential for media designers as well. It is this concern that determines "what to teach and what to learn" once an animation sequence is used for educational purposes.

**Educational Implications**

Just a few years after the birth of animation, people started to use animated sequences as educational tools. Hoffer (1981) noted that the use of animation for instructional purposes in the United States started in 1916 when the film unit at the Henry Ford Motor Company was formed and simple animation techniques were incorporated into some of Ford's training films (p. 16). But, that was just the beginning.

Since then, films that incorporated animation into education and training have increased in great number. For instance, animated films that taught soldiers how to operate weapons with correct procedures were produced back around the 1920s (Crafton, 1993, p. 158; Koszarski, 1993, p. 1). Also, before and after the Second World War, many instructional films with animation that taught concepts have gained popular acceptance. In the meantime, the subject matters were widely covered, ranging from illustrating the flow of Mississippi River in
the film *The River* (Wagner, 1953, p. 155) to describing the symptom of cancer in the film *The Traitor Within* (Kinder, 1950, p. 224).

**Reasons to Use Animation**

To facilitate teaching certain concepts which are related to visual motion, chart and graph materials are often animated. This is the most primitive form of animation that can be made by school teachers themselves. Thus, action and movement are introduced into an otherwise "still" chart (Dale, 1954, p. 217). However, according to Madsen (1969), the instructional film that is entirely animated is exceptional. Research has shown that animated sequences are used in a third of all live-action instructional films, a proportion that has remained constant from Edison's films to today's productions (p. 15). This stability is because single concepts can be clearly delivered in short units rather than in a longer film with a traditional format (Miller, 1993, p. 49).

To visually facilitate concept learning, controlling and selecting animated images appropriately may serve education as a proper tool. Wagner (1953) indicated these concerns as follows:

> The true educational significance of animation is perhaps in the elimination of unnecessary detail, in the high degree of control and selectivity involved, and in the simplification, amplification and dramatization made possible thereby. (p. 174)
However, helping learn new concepts is just one of the reasons to use animation. There are many other instructional occasions that are worth doing so. According to Caldwell (1978), there are six reasons for using animation in educational materials: (1) to draw the eye, (2) to portray phenomena unphotographable from real life, (3) to exaggerate something the filmmaker wants his/her audience to notice, (4) to inject humor, (5) to depict a setting that would be costly or impossible to build, and (6) to make a dull and possibly embarrassing subject digestible (p. 12). In general, these reasons can be applicable to animations that appear in various formats of mediated instruction.

Park and Gittelman (1992) also did a study on the selective use of animation and feedback in computer-based instruction. They suggested five specific instructional conditions in which visual motion can be used effectively: (1) demonstrating procedural actions, (2) simulating system behaviors, (3) representing invisible movements or phenomena explicitly, (4) illustrating structural, functional, and procedural relationships among objects and events, and (5) focusing the learners' attention on important concepts. This study also implied that visual display and feedback should be selectively used according to the specific learning requirements of a given task. Therefore, an appropriate use of animation to help teach and learn is still the ultimate guideline, even though these studies provide educators with many supportive reasons to include animation in school instruction.
Progress and Application

With current technologies, animation can be generated in a sophisticated manner to present a three-dimensional concept for educational and scientific purposes. Some computer animators (Watt & Watt, 1992) indicated that three-dimensional computer animation for scientific visualization can be produced directly from models or sets of equations specifying the dynamic behavior of structures or machines (p. 339). Others (Foley et al., 1994) applied animation products to the simulations of scientific phenomena (p. 435). Rhyne and Martin (1995) suggested that in dealing with scientific data sets, there are three classes of visualization tasks. They included the following: (1) analysis and exploration, (2) decision support, and (3) presentation. With its versatile functions, animation can be used not only for educational purposes but also for advanced scientific research.

However, for educational purposes, Charles Csuri's endeavor in combining art and curriculum through computer animation cannot be ignored. Csuri (1973, p. 1) developed the real-time animation techniques during 1969 through 1971 in the Computer Graphics Research Group at the Ohio State University, later expanded as the Advanced Computing Center for the Arts and Design (ACCAD). ACCAD's programs included the development of video tapes and films for instructional purposes. Csuri is described as an "Old Master" in a new medium (Trachtman, 1995, p. 56). As a computer artist, as well as an educator, he also "incorporated the curriculum aspect which supports the outgrowth of content from his educational objectives" (DeMaria, 1991, p. 288).
On the other hand, a strict distinction between computer images and video images has become unnecessary because the media industry has already incorporated computers into video production to create better visual effects. Consequently, animation can be generated in combined techniques. Vepierre (1992) commented that from television in schools to "telematics" in wider education, the combination of computers and video has become an essential marriage. Vepierre also suggested that readers discover the limitless possibilities offered by the use of a computer combined with a video.

In the meantime, Beekman (1994) indicated that a growing number of computer multimedia applications can also use "video footage" to put "motion" into presentations (p. 174). Other than using regular animated sequences, "video images" have also become an important source of moving images for computer screen display. Nevertheless, this presentational method has expanded the definition and utilization of animated imagery into another spectrum.

To help produce animation more effectively and efficiently for instructional purposes, Horton (1995) provided some useful guidelines. These guidelines included: (1) do not overload the viewer with meaningless animation by showing too much too fast, (2) do not put a busy background behind animated characters, (3) pay more attention to the overall contours of shapes, and (4) make all critical events clear from outline contours alone. Since personal computers are now accessible to most educators, more knowledge on how to better create computer animated materials will be necessary. These guidelines are helpful considerations, especially in designing multi-media computer assisted instruction. However, more research findings and guidelines to help
school teachers and media designers develop their animated teaching materials are needed.

RESEARCH FINDINGS ON ANIMATED VISUALS

In examining the instructional film research from 1918 to 1950, Hoban and van Ormer (1950) noted that the report was largely confined to experimental studies and much of the research data applied to learning results: namely, the achievement of various educational objectives (p. 1-1). To justify the experimental rationales for visual research, Dwyer (1994) also held that it is only through experimental research that actual cause and effect relationships can be established among variables. For decades, the methodological paradigms have remained primarily unchanged. In recent years, however, naturalistic inquiries with a qualitative approach have gradually become popular as well.

Qualitative Perspectives

Early studies in the design and production of animated sequences presented qualitative values, especially for instructional film and television formats. For instance, Caldwell (1973) investigated the utilization of animation in instructional films and videotapes and generated 16 guidelines for producers and 39 principles for designers. The guidelines and principles were divided

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according to learner characteristics, such as cognitive style and development, and learning task requirements (p. 404). The implications were closely related to the production of instructional film and television programs.

Also, Cambre (1984) evaluated children's preferences and information acquisition behaviors by using the animated sequences of 3-2-1 CONTACT video program format. The animated sequences were analyzed according to such categories as dimensions of appeal and age appropriateness. The results showed that children, 8 to 12 years old, liked and acquired information from both humorous and serious animations. Both animated expressions were appropriate for conveying science information within the 3-2-1 CONTACT format. Cambre also indicated that youngsters equate cartoons with entertainment. However, they did acquire educational information from them. This implied that animated expression could be appealing in any form as long as the content fitted age-related characteristics.

Through the interaction with practicing classroom teachers, Baker (1986) investigated how the attributes of computer generated graphics could be applied to instruction. She also examined the factors that would determine adoption and adaptation of this technology. The analysis of the interview responses yielded three teacher constructs: an opportunity view of curriculum, instructional media as human expression, and the concept of teachers as contributors to, rather than consumers of, curriculum and instructional development. This study provided numerous implications and research questions regarding the design of computer generated animation for instruction, utilization, teacher education, and curriculum development.
Quantitative Perspectives

In addition to qualitative studies, there are many empirical evidence for instructional application. For example, in investigating the effect of computer graphics on solving algebra word problems, Reed (1985) suggested that visual graphics should be more effective if the design were embedded within a more complex tutorial program. Park and Gittelman (1992) found that animated visual displays would be more effective than static visual displays if animation were selectively used to support the specific learning. Torres (1991) reported that low prior knowledge students profited more from the instructional enhancement strategies (i.e., animation) than students with high prior knowledge. Christel (1994) added that motion video rather than a slide show within an interactive video course would lead to a better recall performance.

In practice, animations are usually presented with verbal cues. Thus, Mayer and Anderson's (1991) study "Animations Need Narrations" included a verbal description given before (words-before-pictures) or during (words-with-pictures) the animation. They reported that the word-with-pictures group outperformed the words-before-pictures group on tests of creative problem solving. This study implied that in the context of computer assisted instruction the use of animation could be successful if both verbal and pictorial functions were employed. Mayer and Anderson (1992) did another study on "Instructive Animation: Helping students build connections between words and pictures in multimedia learning." The results suggested that pictures and words were most
effective when they occurred contiguously in time or space. Mayer and Anderson's studies provided empirical evidence to support Paivio's Dual Coding Theory.

Rieber did a series of animation studies as well. His early study (1988) found that animation and practice did not promote learning scientific facts and concepts. He later reported (1990) that animated-graphics were superior to static-graphics and no-graphics so long as practice was provided. Rieber (1991a) indicated that students successfully extracted incidental information from animated graphics without risking the intentional learning but were also more prone to developing a scientific misconception. He (1991b) further proved that the learnings were effective only when the animated lesson frames were presented in groups, or "chunks," of textual and visual sequences. These findings provided valuable instructional implications.

**Diverse Approaches and Findings**

Since animation can be utilized for most mediated instruction, animation studies cover diverse disciplines and take various approaches. For example, Thomas, Nye, and Robinson (1994a, 1994b) indicated that preschool children had difficulty understanding pictures both as things in themselves and as representations of something else. Campbell, Collis and Watson (1995) reported that the success at problem solving was related to logical operational ability, but not to vividness of visual imagery. Layne (1994) maintained that the indexing of visual or pictorial images should be based on their attributes. Mattaini (1995)
held that graphic visualization was a valuable tool to enhance communication in social work practice with children and families. Shih and Alessi (1993) as well as Wilcocks and Sanders (1994) presented instructional methods by which computer graphics and animation might stimulate the formation of appropriate mental models and transfers. Williamson and Abraham (1995) reported that animations might increase conceptual understandings by prompting the formation of dynamic mental models of the phenomena.

Educators are always interested in learning retention. Thus, how animation impacts recall is another research focus. Mayton (1991) investigated the effects of animation and found that animated visuals contributed to the recall of information. Cornett (1994) supported Mayton's findings by indicating that animation might be an effective method of training, if long-term retention of skills were the ultimate goal. However, Hays (1995) studied spatial ability and the effects of computer animation on short-term comprehension and long-term conceptual understanding. The results indicated that the difference was not statistically significant. According to Palmiter (1991), animated demonstrations were an effective way to show users how to perform procedural tasks immediately, but limited later retention and transfer of procedural tasks.

When comparing the different levels of animation treatments, many studies reveal that the groups receiving instruction via dynamic visuals performed generally better than the groups receiving instruction via static visuals or no visuals (e.g., Zavotka, 1985; Ponick, 1987; Baek, 1988; Asoodeh, 1994; Snead, 1988; Trethewey, 1990).
However, the findings were not in agreement. The studies that detected no significant differences on animation effects among the tested groups were in great number as well (e.g., Caraballo Rios, 1985; Smith, 1989; Harrison, 1993; Cregger, 1994; Wong, 1994).

Among other educational spectra, several studies also provided similarly diverse findings. For instance, Hsieh (1993) reported that although animation enhanced adults' high level cognitive retention, it did not help adults' learning when the learning tasks required mathematical concepts. But animation did help increase continuing motivation. Chen (1995) found that providing different levels of visual complexity in motion visuals had no significant impact on children's comprehension of the intended learning. These findings can be a warning for those who ignore the media effects on learning while only pursuing the visual stimuli of animation.

**Animation Effect**

To obtain better learning effects, it seems that animation should be used in company with other media or cues. Wilson (1993) studied the effects of map and animation advance organizers on learning in a complex computer-based information system. The study revealed that the combination of both cues was the most effective method. Sun (1994) did research on teaching young children compositional concepts to enhance music learning in a computer learning environment. The results showed that visual representation of the notation
affected the subjects’ attitudes toward their products, and the combination of visual and aural feedback affected their compositional styles as well.

Another example of adopting additional cues extends to the use of text. Towers (1994) conducted a two-experiment study using computer-based instruction to determine the effects of both static and animated visuals on student learning. The results showed that there were no significant differences between the text-plus-animated and text-only groups. Meanwhile, there were no significant differences among any of the treatment groups on cued-recall or comprehension measures. Moreover, the study supported the positive effects on the use of static illustrations.

According to Towers, the absence of animation effects in his study was consistent with about 50% of the research concerning the effect of animated visuals on learning. However, the other 50% of the researchers involved in this kind of research reported positive animation effects. Thus, Towers concluded that whether or not animation facilitates learning remains an open question.

These studies not only unveiled an open question but also disclosed a practical need—a need to continue investigating whether animation facilitates learning. This is the very need that motivates the researcher to conduct this study.
SUMMARY

The ground theories of this study are threefold, including Vygotsky's notion of Concept Formation, Paivio's theory of Dual Coding, and Gibson's notion of Visual Motion. Based on these theories, the researcher developed the Media ZPD Model. In this model, instructional media carry messages into learners' Zone of Proximal Development. The messages trigger scientific concepts and act on spontaneous concepts. Consequently, during the up-and-down interactive processes, new concepts can be formed.

The historical development and educational implications of animation are reviewed—reflecting primarily experience in America. Animation may as well be described as a visual expression that is generated or manipulated by non-live photographic impressions. For 300 centuries, animation has been developing with diverse techniques, including stop-motion, cel, clay, combined forms, and computer animation. The use of animation for instructional purposes in the United States started in 1916. Although technology has made animated instruction possible, quality materials and appropriate methods are essential.

Many investigations of animation effects take an empirical approach. However, applied studies of animated instruction vary in methodologies and findings. Often, when comparing different visual treatments, many studies have revealed that the groups using dynamic visuals performed generally better than the groups using static visuals or no visuals. However, the findings were not in agreement. The studies that detected no significant differences on animation
effects among each group were in great number as well. Hence, this study
discloses a practical need—a need to continue investigating whether animation
facilitates learning.
CHAPTER 3

DESIGN AND METHODOLOGY

Every concept is a fundamental element for higher level learning. Therefore, concept learning plays an important part in school instruction. However, teaching and learning concepts is not easy because concepts are often abstract. Consequently, teachers may take advantage of visuals as illustrative representations. For instance, in elementary schools, some teachers argued that students need a concrete representation of the process during the teaching of "multiplication" (Englert & Sinicrope, 1994). In high schools, a conceptual model for teaching the concept of "percent" became a helpful tool (Bennett & Nelson, 1994). At the college level, the use of visual imagery was found to improve comprehension of the concept of "condensation and evaporation" (Ewing & Mills, 1994). Examples of making use of visuals to facilitate instruction are many.

Hence, the major purpose of this study is to investigate the effectiveness of visual presentations, especially animation, for concept learning. To do this, a video segment, "Cube," that displayed the concept of the relationship of the volume of a cube to its edge, was employed. Since "cube" is a fundamental concept in mathematics and science curricula, it is an ideal subject matter for
concept learning. After presenting the visuals, the researcher investigated whether or not the treatment contributed to learning the "cube" concept.

In this study, visual presentations included animated images and static images, in comparison with no visual image. Subjects who participated in this study were at the elementary level. Prior to the experiment, a Group Embedded Figures Test (GEFT) was also given. Scores on the GEFT were used to measure students' ability to disembed hidden figures. After presenting the visuals, a performance test was administered to measure the students' understanding of the concept of the relationship of the volume of a cube to its edge. Results of the two tests were analyzed in order to determine the effectiveness of using visual presentations in developing this concept.

The procedures and details in this study are described in the following sections.

RESEARCH DESIGN

The experimental phase of this study was conducted in school settings. One hundred and forty-four students were used as the subjects. Before the experiment, subjects were randomly assigned to one of the six treatment groups. Subjects in each group received a different stimulus according to the treatment assigned to that group. One of the six groups acted as the control group having
received no stimulus at all. After the treatment, each subject took a posttest. Hence, this study was a True Experimental Design. More precisely, it was a Randomized Posttest-Only Control Group Design (Campbell & Stanley, 1963; Fraenkel & Wallen, 1996). The structure of the research design is described in Figure 2.

Before the experimental stimulus was given, a Group Embedded Figures Test (GEFT) was also administered in order to investigate the subjects' ability to disembed hidden figures. The test results were used as a reference to help explain the posttest scores. Therefore, this study used the Analysis of Covariance (ANCOVA) statistical procedure to analyze the variance of the main effects of the independent variables by employing the covariate—the GEFT scores (Ary, Jacobs, & Razavieh, 1996).

In the ANCOVA design, there were two independent variables (Presentation Method and Audio Mode). There was one dependent variable (the posttest). The scores of the GEFT were used as the covariate for the analysis. Within the first independent variable "Presentation Method," there were three levels: Animated-visuals, Static-visuals, and No-visuals. Within the second independent variable "Audio Mode," there were two levels: Audio and Silent. Therefore, combining the two independent variables yielded six different treatments. One of these six treatment groups (the "Silent" with "No-visuals" group) acted as the control group. The arrangement of the two independent variables and the covariate for the six treatment groups are shown in Figure 3.
1. The Audio Mode

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<th>X 1 (Animated-visuals)</th>
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<tr>
<td>R</td>
<td>X 2 (Static-visuals)</td>
<td>O</td>
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<tr>
<td>R</td>
<td>X 3 (No-visuals)</td>
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</tbody>
</table>

2. The Silent Mode

<table>
<thead>
<tr>
<th>R</th>
<th>X 4 (Animated-visuals)</th>
<th>O</th>
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</thead>
<tbody>
<tr>
<td>R</td>
<td>X 5 (Static-visuals)</td>
<td>O</td>
</tr>
<tr>
<td>R</td>
<td>6 (No-visuals)</td>
<td>O</td>
</tr>
</tbody>
</table>

Figure 2: The Structure of the Research Design.
### INDEPENDENT VARIABLE 1:
**PRESENTATION METHOD**

<table>
<thead>
<tr>
<th></th>
<th>ANIMATION</th>
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<th>NO PICTURE</th>
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</thead>
<tbody>
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<td>AS</td>
<td>AN</td>
</tr>
<tr>
<td>SILENT</td>
<td>GEFT</td>
<td>GEFT</td>
<td>GEFT</td>
</tr>
</tbody>
</table>

**INDEPENDENT VARIABLE 2:**
**AUDIO MODE**

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<tbody>
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<td>AUDIO</td>
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<td>AS</td>
<td>AN</td>
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<tr>
<td>SILENT</td>
<td>GEFT</td>
<td>GEFT</td>
<td>GEFT</td>
</tr>
</tbody>
</table>

Note:
AA = Audio-animated-visuals group
AS = Audio-static-visuals group
AN = Audio-no-visuals group
SA = Silent-animated-visuals group
SS = Silent-static-visuals group
SN = Silent-no-visuals group
GEFT = Group Embedded Figures Test

Figure 3: The Arrangement of the Independent Variables (Presentation Method and Audio Mode) and the Covariate (Group Embedded Figures Test) for the six treatment groups.
HYPOTHESES

Based on the research questions, the null hypotheses in this study are as follows:

Ho 1: There will be no difference among the presentation methods (Animated-visuals, Static-visuals, and No-visuals) on scores on the performance test of knowledge of the presented concept when learners are exposed to visuals in the mediated instruction.

Ho 2: There will be no difference between the audio modes (Audio and Silent) on scores on the performance test of knowledge of the presented concept when learners are exposed to visuals in the mediated instruction.

Ho 3: There will be no interaction effect among the presentation methods, the audio modes, and the GEFT scores when learners are exposed to visuals in the mediated instruction.

Ho 4: There will be no relationship between the scores measured by the Group Embedded Figures Test (GEFT) and the scores measured by the performance test (the posttest) for those learners who receive the mediated instruction.
Because Vygotsky (1986) maintained that the development of scientific concepts was interrelated with school instruction in childhood (p. 174), the researcher assumed that elementary students may better fit the research context described in the theoretical bases of this study. Thus, this study used elementary students as the subjects.

The subjects who participated in this study were from five elementary schools in the urban and suburban areas of Columbus, Ohio. These elementary schools were located in different school districts from both public and private school systems. Therefore, the accessible population covered a wide range of diversity. All the participants were 5th-grade students. Hence, they were similar in age and academic experience.

The process of acquiring these participants can be seen in Appendix E (i.e., Human Subjects Review Committee's Letters of Approval), Appendix F (i.e., The Letter to the Parents and the Consent Form), Appendix G (i.e., The Letters to the College of Education, the Ohio State University), and Appendix H (i.e., The Letters to and from the Participating Schools).

In total, 172 elementary students were included in this study. At the beginning, 28 students were used as the subjects in the pilot test. Then, 144 students were observed in the experiment. The researcher went to the
participating elementary schools to conduct the experiment and collect data during the Spring Quarter, 1996. To make this study more meaningful to these subjects, the concept of "cube" embedded in the visuals was delivered as a regular 5th-grade lesson topic in the context of a mathematics course.

IMPLEMENTATION

First of all, the researcher introduced the activities and procedures of the experiment to the subjects. Then, the researcher explained how to take tests with a written instruction prepared in advance. The oral and written instructions can be seen in Appendix D. The implementation of this experiment included the arrangement of randomization, visual presentations, and data collection. It can be divided into the following steps:

Step 1:

First of all, subjects were randomly assigned to different treatment groups before the experiment. Among all the participating schools, every class followed the same assigning rule. The grouping structure is based upon the two independent variables of the research design. For the independent variable "Audio Mode," there were two levels (Audio and Silent). For the independent variable "Presentation Method," there were three levels (Animated-visuals, Static-
visuals, and No-visuals). Thus, the two independent variables consisted of six groups. In every class, each student was assigned to one of these six groups. With the help of classroom teachers, students' names on a list were called. In sequence, the researcher gave a number, 1 through 6, to each student when he/she was called, representing their groups. The "Silent" group with "No-visuals" treatment acted as the control group.

The groups are listed below:

(1) Audio-animated-visuals group (AA),
(2) Audio-static-visuals group (AS),
(3) Audio-no-visuals group (AN),
(4) Silent-animated-visuals group (SA),
(5) Silent-static-visuals group (SS), and
(6) Silent-no-visuals group (SN).

Through the process of randomization, there was only a slight difference in number among each group. In the experiment, each subject was exposed to one of the six treatments assigned to that group. The procedure of random assignment provided for equivalence among each group.

Step 2:

The second step was the administration of the Group Embedded Figures Test (GEFT) in the experimental settings. The settings were in the classrooms of
the participating schools. At the beginning, the researcher introduced the purpose and procedure of the GEFT to the subjects. After the introduction, subjects were advised to practice two sample questions provided by the GEFT booklet. The researcher made sure that all subjects understood and followed the instruction to answer the GEFT questions. Then, the GEFT was administered. Using a pencil, students were required to trace the simple form that they found over the lines of the complex figure. The researcher followed the testing guidelines noted in the manual to administer the GEFT.

**Step 3:**

The third step was the presentation of visuals and audio treatments. In this phase, subjects received one of the six treatments assigned to their groups.

Therefore, among the Audio Groups, subjects were presented with animation (for AA group), nine still graphics (for AS group), or no graphics (for AN group), according to their assigned treatment. Animation was shown on a video monitor with audio. Also, a video with nine still graphics were displayed with audio. Subjects in the No-visuals group listened to the same audio information as well, except they viewed no visuals.

Also, among the Silent Groups, subjects were presented with the same animation (for SA group), nine still graphics (for SS group), or no graphics (for SN group), according to their assigned treatment. The same procedures were
followed but with no audio. The Silent-no-visuals group (SN group), which was the control group, received nothing at all.

During the experiment, the videotape and audiotape were played two times for the subjects. This was conducted with two practical concerns. On the one hand, the length of the presentations was too short—the video and audio presentations were only one minute long. Thus, repetition may be needed. On the other hand, the time available for this experiment was limited—subjects needed to follow their class schedules. Thus, time needs to be well managed. Considering these two practical situations, the researcher played the videotape and audiotape twice for the subjects to obtain clarity.

The video and audio presentations were given in an insulated classroom in order to avoid audio interference. During the experiment, each group took turns to enter the classroom to receive the stimulus. In the process of viewing the video and listening to the audiotape, subjects paid attention to the stimulus provided by the researcher. No conversation or discussion among the subjects was allowed during the visual and audio presentations. These viewing and listening processes were completed in about fifteen minutes.

In each school, subjects' teacher along with one to two research associates from the Ohio State University took care of the waiting groups while the viewing group was receiving the treatment. Before and after the visual and audio presentations, no conversation or discussion among the subjects was allowed. Under the supervision of classroom teachers, subjects in the control group
worked on their own projects and had no access to mathematics materials at all. The entire processes were completed in a quiet and smooth atmosphere.

Step 4:

The fourth step was the administration of the posttest. The posttest was a performance test administered immediately after the visual and audio presentations. When subjects of all six groups returned to their mathematics classrooms, the researcher told them how to take this test. Then, the test began. All the subjects had to take this test. In the test, questions related to the concept "cube" as shown in the visuals were asked. The test was in a paper-and-pencil format. To receive scores, subjects were asked to mark the correct answers and give appropriate responses. Each step in the school settings was conducted with the assistance of one to two Ohio State University graduate associates to ensure smooth implementation of the experiment.

After the experiment, subjects had an opportunity to review all types of visuals. A brief discussion was held after the viewing. Subjects actively expressed their viewing experiences toward different types of visuals. In general, they felt that viewing and listening to this presentation was an interesting experience. Also, they felt that it was interesting to see how others learn the concept "cube" from different presentation methods. The entire procedures took approximately 50 minutes to complete. After these steps, the data collection procedures were finished.
VISUAL PRESENTATIONS

The visual presentations included animated visuals and static visuals. The subject matter embedded in the visuals was the concept of the relationship of the volume of a cube to its edge. The animation was originally produced in video form and displayed in a 3-2-1 CONTACT video program format. The same animation format was once evaluated in a formative study (Cambre, Johnsen, & Taylor, 1987). According to that research, the "appeal" and "age-appropriateness" (8-12 years old) of this animation were confirmed.

This animated video clip ran for about one minute. Since it was a segment in a 3-2-1 CONTACT video program and introduced only one concept (i.e., the "cube" concept), the length was not as long as a regular video or a computer-assisted instruction program. Therefore, this video was played twice for the subjects to obtain clarity. The animated video was presented both (1) in audio mode for the audio group and (2) in silent mode for the silent group.

The static graphics were selected from this same animation that illustrated the same subject matter. There were nine still images displayed in the still graphics video. The same subject matter was displayed sequentially by these nine still images to the subjects with or without audio information. Also, the video was played twice for the subjects to obtain clarity. The nine frames of still images can be seen in Appendix B.

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The audio presentations for each experimental group were the same—the identical auditory part used both in audio tape and video tape. The narration in the audio presentation introduced the "cube" concept. Four fifth-grade mathematics teachers (i.e., subjects' teachers) checked and confirmed the difficulty level of words used in the narration beforehand. Since the Audio-No-Graphic (NA) group received no visual stimulus, subjects in this group only listened to this audio presentation. Like other experimental groups, the same audio was also played twice for the subjects in this group to obtain clarity. The narration of the visual presentations can be seen in Appendix C.

To make preparations for the presentations, the animation video was edited in advance. The researcher reproduced a video of still graphics for the Still Graphics (AS and SS) groups. Also, the researcher reproduced an audio cassette tape including only audio narration for the Audio-No-Graphic (NA) group. No stimulus was prepared for the Silent-no-visuals group (SN) because this group was the control group.

INSTRUMENTATION

The research instruments employed in this study included a Group Embedded Figures Test and a performance test.
**Group Embedded Figures Test**

In this study, a Group Embedded Figures Test (GEFT) was conducted to measure subjects' capability to find a simple form when it is hidden within a complex pattern. The scores on the GEFT reflect the extent of competence at perceptual disembedding. This test was developed to assess cognitive styles by testing the tendency of "Field-Dependence-Independence." Witkin et al. (1971) noted that "In a field-dependent mode of perceiving, perception is strongly dominated by the overall organization of the surrounding field, and parts of the field are experienced as 'fused.' In a field-independent mode of perceiving, parts of the field are experienced as discrete from organized ground" (p. 4). According to Witkin et al., "extremely high correlations have been found between the (visual) EFT situation and both tactile and auditory disembedding tasks" (p. 5). Hence, the GEFT is an appropriate instrument to reflect learners' disembedding capability in visual and auditory learning situations.

Many studies have utilized the scores on the GEFT as a reference to interpret student learning and media effects. For instance, researchers have incorporated the GEFT scores into such studies as attitude change by using instructional film and slides, cognitive style dimension, animation effects, interpretation of editorial cartoons, effects of filmic coding elements, and effects of color coding (e.g., Kloock et al., 1982; Chinien, 1986; Cambre, Baker, & Belland, 1987; Hunters et al., 1991; Lynch, 1986; Dwyer & Moore, 1992). Often, many scientific concepts were employed to study the relationship of logical thinking and disembedding ability. Concept formation was found positively
associated with high performance on the GEFT. For example, "Euclidean Space" and "Projectile Motion" are two concept learning studies that include the GEFT scores as a reference in the process of data analysis (e.g., Lynch, 1986; Pirkle et al., 1988; Harding, 1990). Therefore, those studies have secured the usability of the GEFT in conducting mediated concept learning studies.

According to Witkin et al. (1971, p. 28), reliability of the GEFT was obtained through the correlation between parallel forms with identical time limits. The coefficient of correlation .82 was computed by the Spearman-Brown formula. Meanwhile, validity of the GEFT was evaluated by another measure of psychological differentiation—Witkin's Articulation of Body Concept (ABC) Scale (p. 29). The ABC scale measured the degree of articulation of the body concept by drawing human figures. The correlation between the GEFT scores and ABC scores was substantial: .71 (with male undergraduates) and .55 (with female undergraduates).

The Group Embedded Figures Test was administered in a paper-and-pencil format. Subjects who participated in this study took the GEFT in group settings. In the process of administering the GEFT, the researcher followed the testing instructions and procedures explained in the manual. In the process of grading subjects' test booklets, the researcher also followed the scoring guidelines noted in the manual.
Performance Test

After displaying the visuals, a performance test was administered. This test measured subjects' knowledge about the concept of the relationship of the volume of a cube to its edge, as presented in the visuals. All six groups received the same test in order to make a comparison. The test was in a paper-and-pencil format with multiple-choice questions, show-and-tell graphic questions, and a cube-drawing question. It was also administered in group settings. The performance test can be seen in Appendix A.


This reviewing process helped the researcher determine which types of questions were appropriate for 5th-grade students. Then, the researcher generated 34 prototype questions asking about the "cube" concept presented in the video. After sifting out inappropriate questions, 15 out of the 34 prototype questions were saved as the test items. Finally, the researcher asked educators in
the relevant fields to contribute their expertise making suggestions and
evaluating the test items for accuracy and usability.

Validity

To ensure the validity of this performance test, the researcher asked five university professors and six 5th-grade elementary school teachers to review each item. The fields of these content experts included Mathematics, Mathematics Education, Item Analysis, Visual Literacy, Mediated Education, and so forth. The content experts expressed their concerns about various factors including types of questions, item number, length of treatment and testing time, prior knowledge, item difficulty and discrimination, motivational and challenging question techniques, scoring techniques, etc. Revisions were made based upon their suggestions. Therefore, both content validity and face validity were secured.

Reliability

To ensure the reliability of this performance test, the researcher first conducted a pilot test by using 28 5th-graders prior to the experiment. After the pilot test, an item analysis was executed. Each item was analyzed by the Test and Questionnaire Analysis System (TQAS) computer software (D'Costa, 1985). The internal consistency reliability coefficient reported by the TQAS was .72. On
the basis of the item analysis results, these test items were revised to improve
their suitability for this age group.

Another measure of reliability was accomplished by using expert raters. That is, the test items were re-examined by computing the inter-rater reliability after the revision. The revised version of the test items was used later for 144 subjects in the real experiment. After the experiment, subjects' answer sheets were graded. Two school teachers were asked to rate subjects' responses in order to obtain an objective scoring standard. The coefficient of correlation that reflects the inter-rater reliability was calculated by the Statistical Analysis System (SAS®) computer software (SAS Institute, 1989-1992). The inter-rater reliability reported by the SAS® computation was very high ($r = .98, p < .001$). Hence, the reliability of the performance test was further confirmed. The results of the Correlation Analysis can be seen in Table 1.

According to Diederich (1973), usable teacher-made tests achieved reliabilities between .60 and .80. For research purposes, an acceptable reliability coefficient ranges from .30 or .50 (Ary, Jacobs, & Razavieh, 1996, p. 282) to .70 (Fraenkel & Wallen, 1996, p. 163). It has been suggested that "reliability estimates in the range of .70 to .80 are good enough for most purposes in basic research" (Kaplan & Saccuzzo, 1989, p. 110). Hence, the reliability of this testing instrument was ensured.
Analysis of Item Difficulty

To confirm the fitness of each test item, an analysis of item difficulty was conducted. According to Allen & Yen (1979, p. 121), item difficulties of about .30 to .70 maximize the information the test provides about differences among examinees.

After the revision, the item difficulty indices showed that 12 out of the 15 items did fall in the range between .30 and .70. That is, only 3 items were not in this range. These three items that showed lower or higher difficulty values were either motivational (Item 4) or challenging items (Item 8 and Item 14) purposely developed for these subjects. T. Cameron (personal communication, February 28, 1996) and M. McMullen (personal communication, March 6, 1996) maintained that motivational and challenging items were necessary for this age group. Also, according to R. Lattimore (personal communication, April 18, 1996), the average difficulty level of these 15 items was appropriate for 5th-grade students in general.

Analysis of Item Discrimination

To verify the fitness of each test item, an analysis of item discrimination was also conducted. According to Hopkins et al. (1990), items with an index of discrimination above .40 are considered "very discriminating items;" those above .30 are considered "discriminating items;" and those above .10 are considered "marginally discriminating items" (p. 274).
After the revision, the item discrimination indices indicated that, out of the 15 items, 7 items were "very discriminating items." In addition, 7 items were "discriminating items." Only one item (Item 4) was rated as a "marginally discriminating item" because it was an easy one. Most subjects were able to answer this easy question (Item 4) correctly. Hence, this question served a motivational function in this study. The analysis showed that most of the "very discriminating items" were grouped in the middle of the test. Whereas, the "discriminating items" were located both at the beginning (easy items) and at the end (difficult items) of the test. According to R. Lattimore (personal communication, April 18, 1996), the sequence of these items was appropriate in the context of concept learning. The evidence above showed that the items in the performance test fitted the subjects in this study. The analyses on item difficulty and item discrimination can be seen in Table 2.

DATA ANALYSIS

Each item in the GEFT and the posttest was graded with quantitative scores. The test scores were coded into computer data sets with numerical values for statistical analysis. Then, the data were analyzed by the following statistical procedures: PROC ANCOVA (Analysis of Covariance) and PROC CORR (Analysis of Correlation). SAS® computer software, running on the mainframe computer at the Ohio State University, was employed to do the analysis.
In the process of data analysis, linearity of the data set was first examined. Then, null hypotheses were tested. Also, planned pairwise comparisons were conducted. When any interaction was determined, further analysis was conducted to investigate the interaction effect. Means and adjusted Least Squares Means were reported to elaborate the results of these analyses. Also, the relationship between the GEFT scores and the posttest scores was examined. Relevant tables and figures that display the results of data analysis were generated in order to summarize the findings.

<table>
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<th>POSTTEST2</th>
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<td>.9853 ***</td>
</tr>
<tr>
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<td>---------</td>
<td></td>
<td>.9809 ***</td>
</tr>
<tr>
<td>POSTTEST2</td>
<td>---------</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note:  
***  $p < .001$  
POSTTEST  =  Final Scores  
POSTTEST1  =  First Rater's Scores  
POSTTEST2  =  Second Rater's Scores

Table 1: Summary Table of the Correlation Analysis for the Inter-rater Reliability.
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<th>2</th>
<th>3</th>
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<tr>
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<td>.4231</td>
<td>.3077</td>
<td>.9102</td>
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</tr>
<tr>
<td>DISCRIMINATION</td>
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</tbody>
</table>

Table 2: Summary Table of the Item Difficulty and the Item Discrimination for the Performance Test.
SUMMARY

This study is designed to determine the effectiveness of visual presentations, especially animation, in developing the "cube" concept.

The research design in this study is a Randomized Posttest-Only Control Group Design. There are two independent variables, one dependent variable (the posttest), and one covariate (the GEFT). The first independent variable "Presentation Method" has three levels (Animated-visuals, Static-visuals, and No-visuals). The second independent variable "Audio Mode" has two levels (Audio and Silent). Therefore, combining the two independent variables yields six different treatments. Four hypotheses were tested to determine the differences among each treatment group and the interaction between the independent variables. Also, the relationship between the posttest scores and the GEFT scores was examined.

In total, 172 subjects were included in this study (28 subjects in the pilot test and 144 subjects in the experiment). The subjects were 5th-graders at elementary schools in the urban and suburban areas of Columbus, Ohio. The visual stimulus used in this study was age-appropriate for the subjects. The implementation includes (1) randomly assigning subjects to one of the six groups, (2) giving the GEFT, (3) presenting visuals, and (4) administering the posttest.
There are two instruments in this study: the GEFT and the performance test. Former studies on mediated instruction and concept learning support the use of the GEFT in this study. In addition, the validity of the performance test was first confirmed. Then, a pilot test secured its reliability. Item difficulty and discrimination were also examined to ensure the revision.

Data were analyzed by PROC ANCOVA and PROC CORR procedures via SAS® computer software. Results are displayed in the tables or figures in order to summarize the findings.
The major purpose of this study is to investigate the effectiveness of visual presentations, especially animation, for concept learning. To do this, one hundred and forty-four 5th-grade students were observed in an experiment in the Spring Quarter, 1996. The subjects who participated in this study were from elementary schools in the urban and suburban areas of Columbus, Ohio.

The design includes two independent variables: Presentation Method (PM) and Audio Mode (AM). Within the Presentation Method, there are three levels: Animated-visuals, Static-visuals, and No-visuals. Within the Audio Mode, there are two levels: Audio and Silent. Therefore, combining the two independent variables yields six different treatments. Through randomization, the subjects were assigned to one of the six treatment groups. The Silent group with No-visuals treatment served as the control group.

Before the experiment, the Group Embedded Figures Test (GEFT) was given. Scores on the GEFT were used as the covariate to control for variability which could not be controlled experimentally. In the experiment, variations of a video segment, "Cube," that displayed the concept of the relationship of the
volume of a cube to its edge, were employed for the visual presentations. Visuals and audio were presented in six different ways for the six treatment groups as described above. After presenting the treatment, a posttest was administered. Scores on the posttest were used as the dependent variable. Then, data were analyzed by SAS® computer software. The Analysis of Covariance (ANCOVA) procedure and the Correlation (CORR) procedure were used to do the statistical analysis.

This chapter first reports the descriptive statistics about the posttest scores and the GEFT scores. Also, Trend Analysis data are presented in order to verify the linearity of this data set.

Then, the data related to testing each hypothesis are presented. The alpha level of .05 was used for all statistical tests. To investigate the differences among the treatment groups, planned pairwise comparisons were conducted. The Means and the adjusted Least Squares Means of the treatment groups were reported to elaborate the contrasts and the impacts. Also, the omega-squared indices were computed to provide a relative measure of the strength of the independent variable investigated. When any significant interaction was found, the data from each level of the relevant independent variable were analyzed separately. Finally, the relationship between the GEFT scores and the posttest scores were examined to better understand the influence of the covariate.

Relevant tables and figures that describe the results of the analysis were developed to illustrate the findings.
First of all, the scores on the posttest and the Group Embedded Figures Test are reported in order to outline subjects' overall performance in this study. Also, the mode and the median for the two tests are noted. The descriptive statistics for the two tests are shown in Table 3.

In addition, two data charts are presented. One illustrates the frequency distribution of the posttest scores (Figure 4). The other illustrates the frequency distribution of the GEFT scores (Figure 5).

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>N</th>
<th>MEAN</th>
<th>STD</th>
<th>MINIMUM</th>
<th>MAXIMUM</th>
</tr>
</thead>
<tbody>
<tr>
<td>POSTTEST</td>
<td>144</td>
<td>7.4305</td>
<td>2.3730</td>
<td>2.0000</td>
<td>14.0000</td>
</tr>
<tr>
<td>GEFT</td>
<td>144</td>
<td>4.9791</td>
<td>3.9498</td>
<td>0.0000</td>
<td>17.0000</td>
</tr>
</tbody>
</table>

Note:
Posttest Mode = 7.
GEFT Mode = 1.
Posttest Median = 7.
GEFT Median = 4.

Table 3: Means and Standard Deviations for the Posttest Scores and the Group Embedded Figures Test Scores.
Figure 4: The Frequency Distribution of the Posttest Scores.
Figure 5: The Frequency Distribution of the GEFT Scores.
Before testing the hypotheses, a trend analysis was conducted to test whether or not this set of data could be described in a "straight line" (Keppel, 1991, p. 144). When the linearity of the data was confirmed, multiple comparisons were conducted to analyze the data.

Hence, an ANCOVA procedure was conducted to do this preliminary analysis. The statistical analysis indicated that no effect of quadratic term (GEFT*GEFT) was significant, $F(1, 139) = 0.04, p = .84$. This procedure ensured the appropriateness of using the General Linear Model (GLM) in data analysis.

The results are shown in Table 4. Also, a straight line chart (Figure 6) is presented to portray the linear trend of this data set.
<table>
<thead>
<tr>
<th>SOURCE</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
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<td>38.8032</td>
<td>2</td>
<td>19.4016</td>
<td>4.11 *</td>
</tr>
<tr>
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<td>1</td>
<td>0.1908</td>
<td>0.04</td>
</tr>
<tr>
<td>ERROR</td>
<td>655.6242</td>
<td>139</td>
<td>4.7167</td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>805.3055</td>
<td>143</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note:
* p < .05

PM = Presentation Method
GEFT = Group Embedded Figures Test
GEFT*GEFT = Quadratic Term

Table 4: ANCOVA Summary Table for the Posttest as a Function of the Presentation Method and the Group Embedded Figures Test: The Trend Analysis.
Figure 6: The Linear Trend of the Data Set.
HYPOTHESIS TESTING

An overall ANCOVA procedure first tested the null hypotheses concerning the differences among each level of the two independent variables: the Presentation Method (Ho 1) and the Audio Mode (Ho 2). Also, this ANCOVA procedure detected the null hypothesis concerning the existence of interaction (Ho 3). Then, a Correlation Analysis examined the null hypotheses concerning the relationship (Ho 4) between the GEFT scores and the posttest scores.

In this overall ANCOVA model, all the factors and interactions (AM, PM, PM*AM, GEFT, GEFT*AM, GEFT*PM, and GEFT*PM*AM) were included in order to determine the existence of any interaction. When any interaction was found, procedures that remove the interaction effect were taken in order to investigate the main effects in detail.

The hypotheses in this study are stated in null form based on the research questions. Following each null hypothesis, the results of the analyses are reported. Tables and figures for the results were made to illustrate the analysis.
**Testing the Null Hypothesis 1**

The Null Hypothesis 1 in this study is stated as follows:

**Ho 1:** There will be no difference among the presentation methods (Animated-visuals, Static-visuals, and No-visuals) on scores on the performance test of knowledge of the presented concept when learners are exposed to visuals in the mediated instruction.

The overall ANCOVA procedure was conducted in testing the Null Hypothesis 1. The statistical analysis for the Presentation Method is reported as follows: $F (2, 132) = 5.88, p = .0036$. Since there is an interaction between the GEFT and the PM, it is necessary to consider subjects' ability to disembed hidden figures (reflected by the GEFT scores) while discussing the impacts of the Presentation Method. Hence, the impacts of the Presentation Method will be discussed later in the analysis of the interaction.

The statistical analysis for the Presentation Method is shown in the ANCOVA summary in Table 5.
**Testing the Null Hypothesis 2**

The Null Hypothesis 2 in this study is stated as follows:

Ho 2: There will be no difference between the audio modes (Audio and Silent) on scores on the performance test of knowledge of the presented concept when learners are exposed to visuals in the mediated instruction.

The overall ANCOVA procedure was conducted in testing the Null Hypothesis 2. The statistical analysis shows that a significant difference does not exist between the two audio modes, $F (1, 139) = 0.72, p > .05$. Therefore, this study fails to reject the Null Hypothesis 2.

This analysis indicates that the audio modes (Audio and Silent) have no different impacts on scores on the performance test of knowledge of the presented concept when learners are exposed to visuals in the mediated instruction.

The statistical analysis for the Audio Mode is shown in the ANCOVA summary in Table 5.
Testing the Null Hypothesis 3

The Null Hypothesis 3 in this study is stated as follows:

Ho 3: There will be no interaction effect among the presentation methods, the audio modes, and the GEFT scores when learners are exposed to visuals in the mediated instruction.

The overall ANCOVA procedure was conducted in testing the Null Hypothesis 3. The statistical analysis shows that the interaction between the GEFT and the PM (GEFT*PM) is significant, $F (2, 132) = 3.72, p < .05$. Also, both terms of the interaction are significant: (1) the PM, $F (2, 132) = 5.88, p < .01$; and (2) the GEFT, $F (1, 132) = 22.09, p < .001$. The analysis indicates that there is an interaction between the GEFT and the PM. Therefore, this study rejects the Null Hypothesis 3.

This analysis indicates that an interaction is present when the effects of the GEFT (reflecting subjects' ability to disembed hidden figures) on the posttest (reflecting subjects' knowledge of the presented concept on the performance test) change at the different levels of the presentation method when learners are exposed to visuals in the mediated instruction.

The statistical analysis for the Interaction is shown in the ANCOVA summary in Table 5. Then, steps are taken to further investigate the interaction effect in the following paragraphs.
<table>
<thead>
<tr>
<th>SOURCE</th>
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<th>MS</th>
<th>F</th>
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<tbody>
<tr>
<td>AM</td>
<td>4.6664</td>
<td>1</td>
<td>4.6664</td>
<td>1.04</td>
</tr>
<tr>
<td>PM</td>
<td>52.7086</td>
<td>2</td>
<td>26.3543</td>
<td>5.88 **(a)</td>
</tr>
<tr>
<td>PM*AM</td>
<td>17.1367</td>
<td>2</td>
<td>8.5683</td>
<td>1.91</td>
</tr>
<tr>
<td>GEFT</td>
<td>99.0734</td>
<td>1</td>
<td>99.0734</td>
<td>22.09 ***</td>
</tr>
<tr>
<td>GEFT*AM</td>
<td>0.6301</td>
<td>1</td>
<td>0.6301</td>
<td>0.14</td>
</tr>
<tr>
<td>GEFT*PM</td>
<td>33.3712</td>
<td>2</td>
<td>16.6856</td>
<td>3.72 * (b)</td>
</tr>
<tr>
<td>GEFT<em>PM</em>AM</td>
<td>9.5290</td>
<td>2</td>
<td>4.7645</td>
<td>1.06</td>
</tr>
<tr>
<td>ERROR</td>
<td>591.9551</td>
<td>132</td>
<td>4.4845</td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>805.3055</td>
<td>143</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note:
*  \[ p < .05 \]  
** \[ p < .01 \]  
*** \[ p < .001 \]

PM = Presentation Method  
AM = Audio Mode  
GEFT = Group Embedded Figures Test  
"* *" = The Symbol for Interaction

(a) Omega-Squared = .054  
(b) Omega-Squared = .030

Table 5: ANCOVA Summary Table for the Posttest as a Function of the Presentation Method and the Audio Mode with the Group Embedded Figures Test: The Overall Test.
1. Examining the Interaction

Since an interaction between the GEFT and the PM was determined in the previous analysis, a simplified ANCOVA procedure with the elimination of non-significant terms was conducted. This ANCOVA procedure solely focused on PM, GEFT, and GEFT*PM in order to examine the interaction in detail. The statistical analysis for the Presentation Method is reported as follows: \( F (2, 138) = 5.75, p = .004 \). A summary of this ANCOVA is reported in Table 6.

Also, a chart (See Figure 7) has been generated to screen how the presentation methods interacted with different degrees of capability to disembed hidden figures represented by the GEFT scores. In this chart, a three-lined disordinal interaction is found. This interaction picture unveils rich information about using different visuals for different categories of learners. The three lines in the interaction chart represent (1) Animation, (2) Still-visuals, and (3) No-visuals, respectively. Then, these three lines were further analyzed in the next step.
<table>
<thead>
<tr>
<th>SOURCE</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM</td>
<td>51.7671</td>
<td>2</td>
<td>25.8835</td>
<td>5.75  ** (a)</td>
</tr>
<tr>
<td>GEFT</td>
<td>122.7265</td>
<td>1</td>
<td>122.7265</td>
<td>27.28 ***</td>
</tr>
<tr>
<td>GEFT*PM</td>
<td>34.8828</td>
<td>2</td>
<td>17.4414</td>
<td>3.88  * (b)</td>
</tr>
<tr>
<td>ERROR</td>
<td>620.9322</td>
<td>138</td>
<td>4.4995</td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>805.3055</td>
<td>143</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note:
*   $p < .05$
**  $p < .01$
*** $p < .001$

PM = Presentation Method
GEFT = Group Embedded Figures Test
" * " = The Symbol for Interaction

(a) Omega-Squared = .053
(b) Omega-Squared = .032

Table 6: ANCOVA Summary Table for the Posttest as a Function of the Presentation Method and the Group Embedded Figures Test: Examining the Interaction.
Figure 7: The Interaction between the Presentation Method and the GEFT.
2. Removing the Interaction from the Analysis of Covariance Model

In this phase, steps were taken to break down the interaction. To do this, the interaction effect (GEFT*PM) was first removed. Hence, an ANCOVA procedure focusing only on the GEFT and the PM was conducted. The statistical analysis for the Presentation Method is reported as follows: \( F(2, 140) = 4.12, p = .0182 \). A summary of this ANCOVA is reported in Table 7. The means and least squares means are reported in Table 8.

In contrast to the interaction chart, a "no-interaction-effect" chart was also developed. This chart (See Figure 8) shows that Animation is superior to Still-visuals and No-visuals—Animation is located in a higher position. Whereas, Still-visuals and No-visuals are grouped together in a lower position. The ranking is described as follows: (1) Animation (High), (2) Still-visuals (Medium), and (3) No-visuals (Low). Also, the correlation between the GEFT scores and the posttest scores is reflected in this chart by the three presentation methods.
<table>
<thead>
<tr>
<th>SOURCE</th>
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<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM</td>
<td>38.6406</td>
<td>2</td>
<td>19.3203</td>
<td>4.12* (a)</td>
</tr>
<tr>
<td>GEFT</td>
<td>110.6840</td>
<td>1</td>
<td>110.6840</td>
<td>23.63***</td>
</tr>
<tr>
<td>PM 1 VS 2</td>
<td>20.4496</td>
<td>1</td>
<td>20.4496</td>
<td>4.37*</td>
</tr>
<tr>
<td>PM 1 VS 3</td>
<td>34.9960</td>
<td>1</td>
<td>34.9960</td>
<td>7.47**</td>
</tr>
<tr>
<td>PM 2 VS 3</td>
<td>2.0143</td>
<td>1</td>
<td>2.0143</td>
<td>0.43</td>
</tr>
<tr>
<td>ERROR</td>
<td>655.8150</td>
<td>140</td>
<td>4.6843</td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>805.3055</td>
<td>143</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note:
* $p < .05$  PM 1 = Animation
** $p < .01$ PM 2 = Still-visuals
*** $p < .001$ PM 3 = No-visuals
(a) Omega-Squared = .036

Table 7: ANCOVA Summary Table for the Posttest as a Function of the Presentation Method and the Group Embedded Figures Test: Without the Interaction.
<table>
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<tr>
<th>GROUP</th>
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<th>MEAN</th>
<th>SD</th>
<th>LSMEAN</th>
<th>STD ERR</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM1</td>
<td>50</td>
<td>8.1400</td>
<td>2.1853</td>
<td>8.1219</td>
<td>0.3061</td>
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<tr>
<td>PM2</td>
<td>48</td>
<td>7.1041</td>
<td>1.8362</td>
<td>7.2066</td>
<td>0.3131</td>
</tr>
<tr>
<td>PM3</td>
<td>46</td>
<td>7.0000</td>
<td>2.8828</td>
<td>6.9127</td>
<td>0.3196</td>
</tr>
</tbody>
</table>

**LSMEANS TEST**

**GROUP**

<table>
<thead>
<tr>
<th>PM1</th>
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<th>PM3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PM1</td>
<td>*</td>
<td>**</td>
</tr>
<tr>
<td>PM2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PM3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note:
* $p < .05$  
** $p < .01$

PM 1 = Animation  
PM 2 = Still-visuals  
PM 3 = No-visuals

Table 8: Means and Least Squares Means for the Posttest by Presentation Methods: Without the Interaction.
Figure 8: The Correlation Between the GEFT Scores and the POSTTEST Scores, Represented by the Three Presentation Methods (When Interaction Effect Is Removed).
3. Separating the GEFT Scale into Two Categories

Since the interaction point is located at the Mean score (4.9) on the scale of the GEFT scores, there is a need to further investigate subjects' posttest performance from the two ends in the continuum of the GEFT scores, especially when no interaction effect is involved. This investigation may provide in-depth information judging from the perspectives of Field-Dependence (FD) and Field-Independence (FI).

Therefore, the scale of the GEFT scores was separated at the point "5," an integer representing the GEFT Mean score, into two categories: GEFTCAT1 and GEFTCAT2. Subjects whose scores are lower than and equal to 5 (0 - 5) in the GEFT scale belong to the GEFTCAT1. Subjects whose scores are higher than 5 (6 - 18) in the GEFT scale belong to the GEFTCAT2. Then, the data in each category were analyzed separately without the influence of the interaction effect.
4. Analyzing the Simple Effects of the Presentation Method

An ANCOVA procedure including the two GEFT categories was conducted to compare the simple effects at each level of the Presentation Method. The results of the ANCOVA and the planned pairwise comparisons were then used to test the Null Hypothesis 1.

A. Simple Effects in Category One

In Category One (GEFTCAT1), the statistical analysis shows that significant differences do exist among the three presentation methods, $F (2, 86) = 5.23, p < .01$. Therefore, this study rejects the Null Hypothesis 1 in GEFT Category One.

This analysis indicated that in GEFT Category One these component single-factor treatments (animated-visuals, static-visuals, and no-visuals) of the Presentation Method have different impacts on scores on the performance test of knowledge of the presented concept when learners are exposed to visuals in the mediated instruction.

Then, three planned pairwise comparisons were conducted to analyze the differences among the three levels of the PM. The results are reported as follows:
(1) The first comparison "Contrast PM 1 vs 2" shows that PM1 is not significantly different from PM2, $F_{(1, 86)} = 1.09, p > .05$.

(2) The second comparison "Contrast PM 1 vs 3" shows that PM1 is significantly different from PM3, $F_{(1, 86)} = 10.18, p < .01$.

(3) The third comparison "Contrast PM 2 vs 3" shows that PM2 is significantly different from PM3, $F_{(1, 86)} = 4.56, p < .05$.

Hence, the pairwise comparisons in the GEFTCAT1 showed that (1) Animation is not significantly different from Still-visuals. However, (2) Animation is significantly different from No-visuals. Also, (3) Still-visuals is significantly different from No-visuals.

It is meaningful to learn that Animation is in the highest position in the GEFTCAT1 chart. Also, Animation and Still-visuals are close to each other. No-visuals is in the lowest position—it is distant from both Animation and Still-visuals.

In other words, when the interaction is removed and the other independent variable "Audio Mode" is ignored, Animation and Still-visuals are not different from each other in GEFT Category One. However, both Animation and Still-visuals are useful presentation methods in comparison to no visual presentation at all. Hence, the analysis in GEFT Category One supports the use of visuals in the mediated instruction.
The results of the analyses for the GEFTCAT1 are reported in Table 9. The Means and the adjusted Least Squares Means of the posttest scores are reported in Table 10. For visual examination, data are also plotted in Figure 9.

B. Simple Effects in Category Two

In Category Two (GEFTCAT2), the statistical analysis shows that no significant difference exists among the three presentation methods, $F(2, 50) = 1.93, p > .05$. Therefore, this study fails to reject the Null Hypothesis 1 in GEFT Category Two.

This analysis indicated that in GEFT Category Two these component single-factor treatments (animated-visuals, static-visuals, and no-visuals) of the Presentation Method have no different impacts on scores on the performance test of knowledge of the presented concept when learners are exposed to visuals in the mediated instruction.

Even though no significant difference exists among these three levels of the PM, planned pairwise comparisons were still conducted in order to investigate the insight. The results are reported as follows:

1. The first comparison "Contrast PM 1 vs 2" shows that PM1 is not significantly different from PM2, $F(1, 50) = 3.81, p > .05$. 

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(2) The second comparison "Contrast PM 1 vs 3" shows that PM1 is not significantly different from PM3, $F (1, 50) = .48, p > .05$.

(3) The third comparison "Contrast PM 2 vs 3" shows that PM2 is not significantly different from PM3, $F (1, 50) = 1.47, p > .05$.

Hence, the pairwise comparisons in the GEFTCAT2 showed that (1) Animation is not different from Still-visuals at the edge of the significance-testing level, $F (1, 50) = 3.81, p = .056$. Again, (2) Animation is not significantly different from No-visuals. (3) Still-visuals is not significantly different from No-visuals either.

In the GEFTCAT2 chart, the ranking of the three levels differs from that in the GEFTCAT1 chart. Even though (1) Animation is higher than Still-visuals, the two levels become most distant within the three levels. Whereas, (2) Animation excels No-visuals only by a narrow margin—they become more adjacent to each other within the three levels. More importantly, (3) No-visuals outperformed Still-visuals even though the difference is not significant.

In other words, when the interaction is removed and the other independent variable "Audio Mode" is ignored, the three presentation methods have no significant differences in GEFT Category Two. Hence, the analysis in GEFT Category Two reveals an important message regarding different learning styles (i.e., FD vs. FI) in the mediated instruction.
The results of the analyses for the GEFTCAT2 are reported in Table 11. The Means and the adjusted Least Squares Means of the posttest scores are reported in Table 12. For visual examination, data are also plotted in Figure 10.

<table>
<thead>
<tr>
<th>SOURCE</th>
<th>SS</th>
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<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM</td>
<td>44.1472</td>
<td>2</td>
<td>22.0736</td>
<td>5.23 **(a)</td>
</tr>
<tr>
<td>GEFT</td>
<td>35.7909</td>
<td>1</td>
<td>35.7909</td>
<td>8.48 **</td>
</tr>
<tr>
<td>PM 1 VS 2</td>
<td>4.5863</td>
<td>1</td>
<td>4.5863</td>
<td>1.09</td>
</tr>
<tr>
<td>PM 1 VS 3</td>
<td>42.9463</td>
<td>1</td>
<td>42.9463</td>
<td>10.18 **</td>
</tr>
<tr>
<td>PM 2 VS 3</td>
<td>19.2621</td>
<td>1</td>
<td>19.2621</td>
<td>4.56 *</td>
</tr>
<tr>
<td>ERROR</td>
<td>362.8846</td>
<td>86</td>
<td>4.2195</td>
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</tr>
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<td>TOTAL</td>
<td>431.6000</td>
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Note:
* $p < .05$
** $p < .01$
(a) Omega-Squared = .082

PM 1 = Animation
PM 2 = Still-visuals
PM 3 = No-visuals

Table 9: ANCOVA Summary Table for the Posttest as a Function of the Presentation Method and the Group Embedded Figures Test: In the GEFTCAT1.
<table>
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<th>GROUP</th>
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<th>STD ERR</th>
</tr>
</thead>
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<td>7.6666</td>
<td>1.7681</td>
<td>7.6794</td>
<td>0.3750</td>
</tr>
<tr>
<td>PM2</td>
<td>31</td>
<td>6.9354</td>
<td>1.8427</td>
<td>7.1272</td>
<td>0.3747</td>
</tr>
<tr>
<td>PM3</td>
<td>29</td>
<td>6.1724</td>
<td>2.7133</td>
<td>5.9542</td>
<td>0.3887</td>
</tr>
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</table>

**LSMEANS TEST**

<table>
<thead>
<tr>
<th>GROUP</th>
<th>PM1</th>
<th>PM2</th>
<th>PM3</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM1</td>
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<td>**</td>
<td></td>
</tr>
<tr>
<td>PM2</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>PM3</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note:
* $p < .05$  
** $p < .01$  

PM 1 = Animation  
PM 2 = Still-visuals  
PM 3 = No-visuals  

Table 10: Means and Least Squares Means for the Posttest by Presentation Methods in the GEFTCAT1.
<table>
<thead>
<tr>
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<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM</td>
<td>20.4039</td>
<td>2</td>
<td>10.2019</td>
<td>1.93</td>
</tr>
<tr>
<td>GEFT</td>
<td>30.5942</td>
<td>1</td>
<td>30.5942</td>
<td>5.79  *</td>
</tr>
<tr>
<td>PM 1 VS 2</td>
<td>20.1160</td>
<td>1</td>
<td>20.1160</td>
<td>3.81</td>
</tr>
<tr>
<td>PM 1 VS 3</td>
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<td>2.5161</td>
<td>0.48</td>
</tr>
<tr>
<td>PM 2 VS 3</td>
<td>7.7658</td>
<td>1</td>
<td>7.7658</td>
<td>1.47</td>
</tr>
<tr>
<td>ERROR</td>
<td>264.1910</td>
<td>50</td>
<td></td>
<td>5.2838</td>
</tr>
<tr>
<td>TOTAL</td>
<td>314.3703</td>
<td>53</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note:
* $ p < .05$

PM 1 = Animation
PM 2 = Still-visuals
PM 3 = No-visuals

Table 11: ANCOVA Summary Table for the Posttest as a Function of the Presentation Method and the Group Embedded Figures Test: In the GEFTCAT2.
<table>
<thead>
<tr>
<th>GROUP</th>
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<th>MEAN</th>
<th>SD</th>
<th>LSMEAN</th>
<th>STD ERR</th>
</tr>
</thead>
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<tr>
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<td>20</td>
<td>8.8500</td>
<td>2.5807</td>
<td>8.8900</td>
<td>0.5142</td>
</tr>
<tr>
<td>PM2</td>
<td>17</td>
<td>7.4117</td>
<td>1.8391</td>
<td>7.4101</td>
<td>0.5575</td>
</tr>
<tr>
<td>PM3</td>
<td>17</td>
<td>8.4117</td>
<td>2.6706</td>
<td>8.3662</td>
<td>0.5578</td>
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**LSMEANS TEST**

<table>
<thead>
<tr>
<th>GROUP</th>
<th>PM1</th>
<th>PM2</th>
<th>PM3</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PM2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PM3</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note:
PM 1 = Animation
PM 2 = Still-visuals
PM 3 = No-visuals

Table 12: Means and Least Squares Means for the Posttest by Presentation Methods in the GEFTCAT2.
Figure 9: The Simple Effects of the Presentation Method in the GEFTCAT1
(When Interaction Effect Is Removed).
Figure 10: The Simple Effects of the Presentation Method in the GEFTCAT2 (When Interaction Effect Is Removed).
Testing the Null Hypothesis 4

The Null Hypothesis 4 in this study is stated as follows:

Ho 4: There will be no relationship between the scores measured by the Group Embedded Figures Test (GEFT) and the scores measured by the performance test (the posttest) for those learners who receive the mediated instruction.

A PROC CORR PEARSON procedure was conducted in testing the Null Hypothesis 4. The statistical analysis shows that the Pearson product-moment correlation coefficient is significant ($r = .37, p < .001$). Therefore, this study rejects the Null Hypothesis 4.

This analysis indicates that there is a "positive and moderate" relationship (Davis, 1971) between the scores measured by the GEFT and the scores measured by the posttest for those learners who receive the mediated instruction. In other words, as subjects' GEFT scores increase in this study, their posttest scores also increase in a moderate manner. This relationship is reflected in both Figure 6 (i.e., The Linear Trend of the Data Set) and Figure 8 (i.e., The Correlation between the GEFT Scores and the POSTTEST Scores).

Also, it is meaningful to examine the statistics among the six treatment groups. The significant statistics showed the following:
(1) For the Audio-no-visuals group (AN), the relationship is also "moderate" 
\( r = .40, p < .05 \). It ranks second among all the treatment groups.

(2) For the Control group (SN), the relationship is "substantial" \( r = .65, p < .001 \). It has the highest coefficient of correlation compared to any other treatment groups.

This examination discloses further information to interpret the 
effectiveness of mediated instruction–learning style as an important factor in 
mediated instruction.

The results of the correlation analysis can be seen in Table 13.
<table>
<thead>
<tr>
<th>SCORES</th>
<th>O-G</th>
<th>AA-G</th>
<th>AS-G</th>
<th>AN-G</th>
<th>SA-G</th>
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<td>O-P</td>
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Note:
* $p < .05$
*** $p < .001$

O = Overall  P = Posttest scores
G = Group Embedded Figure scores
AA = Audio-animated-visuals group  SA = Silent-animated-visuals group
AS = Audio-static-visuals group  SS = Silent-static-visuals group
AN = Audio-no-visuals group  SN = Silent-no-visuals group

Table 13: Summary Table of the Correlation Analysis between the Group Embedded Figures Test Scores and the Posttest Scores.
SUMMARY

At the beginning, descriptive statistics about the posttest and the GEFT were reported. Also, the linearity of the data was verified by the Trend Analysis. Then, four null hypotheses were tested at the alpha level of .05. General findings are summarized in the following paragraphs.

1. In testing the Null Hypothesis 1 concerning the difference among the presentation methods, the statistical analysis is reported as follows: $F (2, 132) = 5.88, p = .0036$. Since there is an interaction between the GEFT and the PM, this hypothesis was tested later in the analysis of the interaction (Ho 3).

2. This study fails to reject the Null Hypothesis 2 concerning the difference between the audio modes.

3. This study rejects the Null Hypothesis 3 concerning the existence of the interaction between the posttest scores and the GEFT scores.

   Hence, this three-lined disordinal interaction was first screened. Then, the data set was separated into two categories (GEFTCAT1 and GEFTCAT2) and analyzed without the interaction to determine the simple effects of the presentation methods.
In the GEFTCAT1, a significant difference does exist. Therefore, this study rejects the Null Hypothesis 1 in GEFT Category One. The results indicated that (1) Animation and Still-visuals have no significant difference; (2) Animation is significantly different from No-visuals; and (3) Still-visuals is also significantly different from No-visuals.

In the GEFTCAT2, no significant difference exists. Therefore, this study fails to reject the Null Hypothesis 1 in GEFT Category Two. However, this analysis reveals an important message regarding different learning styles (i.e., FD vs. FI) in the mediated instruction.

4. This study rejects the Null Hypothesis 4 concerning the relationship between the GEFT scores and the posttest scores. The analysis shows that there is a positive and moderate relationship between the two factors. The control group yields the highest coefficient of correlation among all the treatment groups.
CHAPTER 5

SUMMARY, DISCUSSION, IMPLICATIONS, AND RECOMMENDATIONS

SUMMARY

The primary purpose of this study was to investigate the effectiveness of visual presentations, especially animation, for concept learning. Theories of visual learning were incorporated into this study, including Vygotsky's notion of Concept Formation, Paivio's theory of Dual Coding, and Gibson's notion of Visual Motion. The Media ZPD Model was developed to portray how concepts are formed in the Zone of Proximal Development.

A pilot test was first conducted in order to secure the accuracy and usability of the instruments. Then, one hundred and forty-four 5th-grade students were observed in an experiment in the spring of 1996. The subjects who participated in this study were from elementary schools in the urban and suburban areas of Columbus, Ohio.
The Design and Implementation

The design includes two independent variables: Presentation Method (PM) and Audio Mode (AM). Within the Presentation Method, there are three levels: Animated-visuals, Static-visuals, and No-visuals. Within the Audio Mode, there are two levels: Audio and Silent. Combining the two independent variables yields six different treatments. Through randomization, the subjects were assigned to one of the six treatment groups. The Silent with No-visuals treatment group served as the control group.

Before the experiment, the Group Embedded Figures Test (GEFT) was given. Scores on the GEFT were used as the covariate to control for variability which could not be controlled experimentally. In the experiment, variations of a video segment, "Cube," that displayed the concept of the relationship of the volume of a cube to its edge, were employed for the visual presentations. Visuals and audio were presented in six different ways for the six treatment groups as described above. After presenting the treatment, a posttest was administered. Scores on the posttest were used as the dependent variable. Then, data were analyzed by SAS® computer software. The Analysis of Covariance (ANCOVA) procedure and the Correlation (CORR) procedure were used to do the statistical analysis.
The Results of Analysis

The statistical analysis showed that there is no difference, $F(1, 139) = 0.72$, $p > .05$, between the two audio modes (Audio and Silent) when learners are exposed to visuals. Also, the analysis showed that there is an interaction, $F(2, 132) = 3.72$, $p < .05$, between the GEFT scores and the posttest scores. Then, this interaction was broken down into two categories (i.e., GEFT CAT1 and GEFT CAT2). The data in each category were analyzed separately.

In the GEFT CAT1, significant differences do exist, $F(2, 86) = 5.23$, $p < .01$, among the presentation methods. Planned pairwise comparisons indicated that (1) Animation and Still-visuals have no significant difference; (2) Animation is significantly higher than No-visuals; and (3) Still-visuals is also significantly higher than No-visuals. In the GEFT CAT2, no significant difference exists, $F(2, 50) = 1.93$, $p > .05$, among the presentation methods.

There is a positive and moderate relationship ($r = .37$, $p < .001$) between the scores measured by the Group Embedded Figures Test (GEFT) and the scores measured by the performance test (the posttest) for those learners who receive the mediated instruction.
DISCUSSION

The Impact of Audio

The analysis indicates that the audio modes (Audio and Silent) have no different impacts on scores on the performance test of knowledge of the presented concept when learners are exposed to visuals in the mediated instruction. Hence, audio in this study is not proven as an effective complement of presenting visuals.

The findings in this study are consistent with the picture-superiority comparisons in early studies. According to Paivio and Csapo (1969), recalled pictures exceeded concrete words and abstract words. Paivio (1991) further indicated that picture superiority under free recall conditions can best be explained in terms of an additive contribution of pictorial and verbal memory codes, in which the contribution of the former being decidedly greater than that of the latter (p. 99). In their studies, words basically referred to verbal texts (read by eyes) instead of auditory narrations (heard by ears). However, in this study the notion of picture-superiority in the two-channel coding system is evidenced. Hence, the results of this study accord with Paivio's Dual-coding Theory.

The findings in this study are in conflict with those of Mayer and Anderson's (1991) in which they maintained that "Animations Need Narrations." They found that the word-with-pictures group outperformed the words-before-
pictures group. They (1992) added that pictures and words were most effective when they occurred contiguously in time or space. In their experiments, the narration in spoken language was similar to the audio narration in this study. However, the findings in this study are different from theirs. This study found that audio does not make any significant difference in visual learning. The result of this study might be attributed to the impact of visual images that provides the primary information in the learning process.

In many cases, audio narration has been considered as an important part of the viewing experience (e.g., May & Lumsdaine, 1958; Travers, 1967), especially in video and film presentations. Although pictures may carry the main teaching burden (Hoban & van Ormer, 1950), audio narration still can help viewers grasp the content and construct a new meaning. The reasons that resulted in no measured impact of audio may be: (1) the narration may have been too short; or (2) the narration may need to be repeated more than twice. Hence, future studies should investigate the effects of auditory (sound) parts of visual presentations when more auditory variables (e.g., narration, music, sound effects, or content, etc.) are considered. Learners from different populations (e.g., different age groups, learning styles, or cultural backgrounds, etc.) should also be included for further investigations of audio impact.

The Interaction Between the GEFT and the PM

The analysis indicates that an interaction is present when the effects of the GEFT (reflecting subjects' ability to disembed hidden figures) on the posttest
(reflecting subjects' knowledge of the presented concept on the performance test) change at the different levels of the presentation method when learners are exposed to visuals in the mediated instruction.

In this study, a Group Embedded Figures Test (GEFT) was first administered to measure subjects' ability to find a simple form when it is hidden within a complex pattern. The purpose of this procedure is to determine the perceiving tendencies (i.e., Field-dependent mode or Field-independent mode) of each subject. Witkin et al. (1971) noted that "In a field-dependent mode of perceiving, perception is strongly dominated by the overall organization of the surrounding field, and parts of the field are experienced as 'fused.' In a field-independent mode of perceiving, parts of the field are experienced as discrete from organized ground" (p. 4). According to Witkin et al., "extremely high correlations have been found between the (visual) EFT situation and both tactile and auditory disembedding tasks" (p. 5). Hence, the GEFT is an important instrument to reflect learners' disembedding ability in visual and auditory learning.

After the testing, the GEFT yields a score reflecting learners' perceptual style—Field Dependent (FD) or Field Independent (FI). The lower the GEFT score a learner receives, the more field-dependent he/she tends to be. The higher the GEFT score a learner receives, the more field-independent he/she tends to be. In the analysis, the interaction point (i.e., the GEFT mean score) serves as a relative midpoint. It divides subjects into two parts (GEFTCAT1 and GEFTCAT2) on the GEFT scale. The left part (GEFTCAT1) represents the performance of FD learners. The right part (GEFTCAT2) represents the performance of FI learners.
Clearly, the impacts of the presentation methods on the two sides of the interaction point are different.

In the GEFTCAT1, significant differences do exist among the presentation methods. The analysis shows that (1) Animation is not significantly different from Still-visuals. However, (2) Animation is significantly higher than No-visuals. Also, (3) Still-visuals is significantly higher than No-visuals. In the GEFTCAT2, no significant difference exists among the presentation methods. Although Animation is not significantly different from Still-visuals, for FD learners, it is clear that both Animation and Still-visuals yield higher scores than No-visuals treatment. Hence, this study supports Vygotsky's notion of Mediated Function in which signs can be used as tools in concept formation.

The findings regarding the Animation effect in this study are in conflict with some other significant studies (e.g., Reed, 1985; Rieber, 1990, 1991b; Mayer & Anderson, 1991, 1992; Park & Gittelman, 1992; Large et al., 1995; Williamson & Abraham, 1995). These studies generally reported that animated graphics are superior to static graphics and no graphics. However, the approaches of these studies are somewhat different. Often, Animation in these studies was used with texts and practice activities in computer-assisted learning environments. Whereas, this study intended to exclude other factors and only investigated the effect of Animation. Hence, this study may provide experimental evidence of pure Animation effect.

The findings regarding the Animation effect in this study are congruent with some non-significant ones. For instance, King (1975) made a comparison of
three combinations of text and graphics for concept learning and found no significant differences. Caraballo (1985) studied the computation of area of geometric shapes in an animated instruction and reported that no significant difference existed. Rieber (1989) studied an animated lesson teaching Newton's law of motion by using elementary students and found no significant difference. Also, Stancil and Melear (1991) used a Flexibility of Closure Test (Ekstrom et al., 1976) in studying paper and cube interventions preceded by animation. Their findings indicated that the differences were not significant when subjects' ability to disembed hidden figures was considered. According to Towers (1994), the difference between text-plus-animated and text-only groups was not significant. He further supported the positive effects on the use of static illustrations. These studies used different designs to investigate the effect of animated images, and these studies share similar findings with this study.

The findings of the present study continue in the tradition of finding that different modes of stimuli have no measured impact on concept learning, even though casual observations of learners in real situations suggest that they do. Thus, the researcher might consider the following possible reasons in investigating the effect of animation that resulted in no measured impact.

1. The treatment may not have been long enough.

The presentation time of the animation was only one minute long. Even though this animation was played twice, it could be still too short to provide enough visual impact. This could be reflected in the significance-testing of the presentation methods ($F = 3.81, p = .056$) for the Field-independent learners.
2. **The instrument could be too short.**

   The number of items in the performance test was limited by the length of the treatment time. Although the 15 items were developed with appropriate considerations, more items may be needed in measuring students' learning.

3. **The narration may have been too short.**

   The content was embedded in the narration. However, the narration was also restricted by the presentation time of the visuals. It could be too short to provide in-depth verbal messages relevant to the subject matter. Hence, this could explain why there was no measured impact in investigating the effect of audio.

4. **Presentation may not have been visually-animated enough.**

   The degree of movement and attraction of this animation may be not salient enough. The impact of animation could be significant if more dynamic movements and attention-gaining techniques were utilized.

5. **No texts and illustrations were presented.**

   Descriptive texts and illustrative symbols were not presented on the screen when visuals were displayed. Hence, the impact of animation could be lower because students did not have enough learning cues. Texts and symbols that help explain the visuals may be necessary.

6. **Only one presentation was given.**

   Since only one presentation was given in the experiment, explanation and feedback were not available. Students could have difficulties understanding the
concept and reflecting their knowledge on the performance test. Hence, instruction may enhance the effectiveness of animated learning.

The conjectures above suggest some possible reasons that could result in no measure of animation impact in this study. However, the viewing of animation is often accompanied by various activities or exercises in classroom settings. Also, verbal descriptions (e.g., narration and texts) and symbolic illustrations (e.g., arrows and blinking marks) are usually included in the presentations. Hence, the way this animation was presented—without texts and illustrations—could help determine the pure animation effect. If an animation were presented with teaching activities and additive visual effects, the impact of instruction which includes animation could be significant. This is because "the context in which the film is presented to the audience" could influence the impact of animated instruction (Hoban & van Ormer, 1950).

According to Hoban and van Ormer, presentational strategies, whether lecture or linear media, when used alone have been demonstrated to be less effective than when activities (interaction, feedback, question and answer, exercise, problem-solving, etc.) are included in the instruction. Similarly, Vygotsky's (1978, 1986) notion of scaffolding in the Zone of Proximal Development can also be reflected not only by the assistance from teachers (adults) and students (peers) but also by the effect of media use (function of mediation). The combined impact—learning—is derived from this kind of context. Hence, how animation is presented plays an essential role in instruction.
In addition, some attributes of animation, implied in these possible reasons, could be worthy of investigation. Understanding the attributes of animation is as important as planning a suitable context for visual learning. For instance, Mayton (1990) did an animation study and reported that the use of animation can be beneficial under certain conditions. More importantly, he found that a significant impact on retention is associated with animated dynamic processes. It is meaningful to learn that the impact of animation is more obvious on the delayed memory than on the instant recall. For visual literacy, the degree of Field Dependence and Field Independence is one of the most important style measures. Hence, the inclusion of the learning style (i.e., FD vs. FI) is an essential approach to investigating students' perceiving tendencies in visual concept learning. This approach can increase the understanding of learners' cognitive perspectives in animated instruction.

After the experiment in this study, subjects had an opportunity to review all types of visual presentations. A brief discussion was held after this viewing. Most subjects positively expressed their viewing preference for the visuals presented in "Animation Method" and "Audio Mode." They felt that viewing and listening to the animation presentation was an interesting experience. Their responses in the discussion seemed to imply that animation could help gain attention and increase motivation in the process of learning. Therefore, the use of animation may have latent influence, derived from subjects' attitude, preference, and so forth, other than just the pure effect of animation. The latent influence may serve as a motivational factor in the process of learning and definitely deserves educators' attention.
Therefore, the findings in the present study offer empirical evidence for educators—the information about a learning style in relation to the use of animation in educational practices. It is clear that learners' characteristics are so important that educators should not ignore them.

The Relationship Between the GEFT and the Posttest

The analysis indicates that there is a "positive and moderate" relationship ($r = .37, p < .001$) between the GEFT scores and the posttest scores when learners are exposed to visuals in the mediated instruction. In other words, as subjects' GEFT scores increase in this study, their posttest scores also increase in a moderate manner.

For SN group (the control group), the relationship is "substantial" ($r = .65, p < .001$). It has the highest coefficient of correlation compared to any other treatment groups. This correlation indicates that their posttest scores only reflect their prior knowledge of disembedding hidden figures without any effect from the presented concept. Thus, the importance of prior knowledge in concept learning can be reflected in this analysis.

This study shares a similar view with Rieber's (1991a) findings, in which he noted that the external representations of instruction (animated displays) may unwittingly contribute to both scientific accuracies and scientific misconceptions. In this study, previous analysis found that, for those who have prior knowledge of disembedding hidden figures (FI learners), the use of visuals may hinder their
learning. Again, this correlation analysis shows that, for FI learners, the No-visuals group yields the highest correlation. Combining these two findings, the use of visuals for FI learners definitely deserves educators' special attention.

In general, this correlation analysis indicates that there is a positive and moderate relationship between the GEFT scores and the posttest scores. Hence, it is necessary for school teachers to take students' learning styles into consideration when mediated instruction is implemented.

IMPLICATIONS

Based on the above findings, this study made the following implications regarding the use of visuals in mediated instruction.

1. **Visuals Are Effective for Fifth-Graders**

   Witkin et al. (1967) indicated that "field dependence in the 10-24 year period" is evident. In this study, most subjects are 11 or 12 year old (fifth-graders). Although their GEFT Mean score was 4.98, the Mode is still 1. Sixty-two and a half percent of the subjects have scores below the mean score. These statistics demonstrate that most subjects in this study are FD learners. Based on
these findings, this study infers that the use of visuals can be effective for 5th-grade students.

2. Both Animation And Still-visuals Are Useful Presentations

The statistical analyses found that each visual type is significantly higher than No-visuals when students are learning a visual concept in the mediated instruction. Based on these findings, this study infers that visuals, both Animation and Still-visuals, can be useful presentations for visual concept learning.

3. FI Learners Need Special Instructional Arrangements

For FI learners, the analysis shows that the use of media may not be helpful. The scores of the No-visuals group (the control group) reflect that FI learners can learn better without visuals. Moreover, if visuals were used, FI learners' performance can be lowered to the level of (1) Animation or (2) Still-visuals.

Based on these findings, the researcher infers that the interaction in this study was caused by those learners who are strongly Field-independent in learning style. They already have the skill of disembedding hidden figures. Therefore, they can easily learn the presented concept without the assistance of
any media. Hence, special arrangements for FL learners in teaching and learning are necessary.

4. Basic Visual Skills Are Essential to Visual Concept Learning

This study found that there is a positive and moderate relationship between the GEFT scores and the posttest scores. That is, learners' prior knowledge of disembedding hidden figures is associated with their performance in visual learning. Based on Vygotsky's notion, students' ability for visual learning may function as a basic (spontaneous) concept in the Zone of Proximal Development. This ability is interrelating with a new (scientific) concept introduced. "As they meld . . . scientific concepts come to life and find a broad range of applications" (Daniels, 1996, p. 11). Then, learning occurs. This notion is delineated in the Media ZPD Model in Figure 1. Therefore, this study infers that improving students' basic visual skills can lead to better performance in learning new concepts.
RECOMMENDATIONS

Future Research

Based upon the information found in this study, recommendations are made for further studies. They are addressed in the following paragraphs.

1. Build Other Types of Cognitive Styles as Factors in Media Study

This approach can investigate how learners process the information given to them. As a result, the way they construct new meaning and make sense out of it can be interpreted. The results will be valuable messages for teachers, media producers, and instructional designers.

2. Include Audio as a Factor in Animation Study

The factor "Audio" can include narration, background music, special sound effects, and so forth. Literature that supports "verbal" contributions refers mainly to words in text form. However, verbal contributions in auditory form also play an important part in visual presentations. This approach will provide an important message for media producers.
3. Investigate Learners' Attitudes in Animation Study

After the experiment in this study, most subjects positively expressed their preference for the visuals presented in "Animation Method" and "Audio Mode." Hence, it is meaningful to investigate whether or not the learners' attitude (e.g., Appeal, Like or Dislike, etc.) toward animation can serve as a motivational factor in mediated learning. This approach can provide deeper insight, either qualitatively or quantitatively, into animated instruction.

4. Divide Subjects into FI and FD Groups in Future Studies

Since FI learners differ from FD learners in perceiving and processing messages, different treatments may cause different impacts in each group. The results for each experimental group might yield important information for comparisons. The findings will be beneficial to teachers as well as media producers.

5. Replicate This Study with Different Samples

To obtain consistent and in-depth knowledge about children's learning with animation, it is necessary to include more children in future studies. This approach can provide more knowledge on different subject matters, such as ethnography, demography, geography, socio-economical status, and so forth.
6. Approach Other Activities of Learning in Animation Study

In mediated instruction, the ways of implementing activities are essential. Therefore, many activities in mediated instruction employed in classroom settings deserve researchers' further attention. These activities can be viewing and reviewing, viewing with or without teacher's explanation or assistance, viewing with or without practice, and so forth. The findings in investigating these activities will also provide valuable information for educational practices.

Educational Practices

Based upon the information found in this study, recommendations are made for educational practices. They are addressed in the following paragraphs.

1. Using Appropriate Teaching Methods

To employ appropriate teaching methods, school teachers need to determine learners' perceiving tendencies (e.g., FI or FD) before teaching. For FI learners, teachers may provide such activities as self-paced learning, problem-solving strategies, and relevant exercises. For FD learners, the use of media is recommended. Teachers can assist students by increasing (Scaffolding) or decreasing (Fading) different levels of support (Dillenbourg, 1996, p. 170).
2. Producing Appropriate Teaching Materials

Media producers need to make appropriate products for their consumers. Since most elementary students are FD learners, media producers should consider using less complicated graphics or building relevant stories in visuals to enhance learning. Also, media producers may consider building challenging questions and review segments in visuals to maintain FI learners' motivation and correct their "incomplete and often inaccurate understanding of the domain" (Kozma et al., 1996, p. 43).

3. Developing Alternative Activities

According to Smith et al. (1992), "information from cognitive style measures is relevant only when considered with regard to particular learning tasks" (p. 47). Instructional designers may consider different activities for different types of learners. Activities such as "thinking aloud, hands-on practice, and peer teaching, etc." can be implemented simultaneously for different learners. In many courses, students can learn through comparing and sharing their ways of knowing with others.
4. Improving Students' Visual Literacy Abilities

Visual literacy can be defined as "the ability to comprehend and create information that is carried and conveyed through imagery" (Considine & Haley, 1992, p. 14). Since visuals are used in most forms of teaching materials, the ability to comprehend and create information from visuals is vital to learning. Cochran (1995) noted that "visuals are a language which people need to learn." Better ability in visual learning could benefit both FI and FD learners. It is necessary for educators to help students improve their visual literacy abilities.

CONCLUSION

The general findings in this study show that, for most subjects (5th-graders), animation can be used as a tool for concept learning. However, it is necessary to point out that a student's learning style plays an essential part in the effectiveness of mediated instruction.

For Field-dependent (FD) learners, Animation is not significantly different from Still-visuals. Since most elementary students are FD learners, both Animation and Still-visuals are effective media for most elementary students. For Field-independent (FI) learners, different ways of presenting visuals have no significant differences. However, the difference between Animation and Still-visuals has reached the edge of significance-testing level, $F (1, 50) = 3.81, p =$
056. The analysis further shows that inappropriate use of media could hinder FI students from learning. Hence, these findings provide important information for school teachers and media producers.

Since visuals are widely used in educational materials, the ability to acquire information from visuals is vital to learning. Adopting Vygotsky's notion in the Media ZPD Model, this ability could function as a basic (spontaneous) concept interacting with a new (scientific) concept in learners' Zone of Proximal Development. As a result, learning occurs. Therefore, for better performance, it is necessary to improve students' prior visual learning abilities.

Nevertheless, learning with Animation is inevitably affected by such latent factors as: (1) students' aptitudes, (2) students' exposure to animation programs in television and movies, and (3) students' experiences in producing computer animation in schools and at home. It is difficult to determine the effect of animation to the exclusion of these latent factors. However, this study was conducted with an expectation—to increase understanding of the use of animation for quality education.
For Your Information:

1. The volume of a figure or a solid means the number of cubic units that can be placed inside the figure or the solid.

2. Look at the following cube, to provide an answer to the statements or questions below.

I. Multiple Choice Questions:

1. The number of cubic units contained in a cube is called:
   (A) area  (B) volume  (C) length  (D) weight.

2. The amount of space occupied inside this cube is called:
   (A) width  (B) height  (C) area  (D) volume.
3. _________ A cube has how many edges?
   (A) 6   (B) 8   (C) 10   (D) 12.

4. _________ Each face of a cube is:
   (A) a rectangular shape   (B) a diamond shape
   (C) a triangular shape   (D) a square shape.

5. _________ A cube has how many measurements?
   (A) 1   (B) 2   (C) 3   (D) 4.

6. _________ How can you find the volume of a cube using these measurements?
   (A) add them   (B) subtract them
   (C) multiply them   (D) divide them.

7. _________ What happens to the volume of a cube if its height is doubled and its length and width remain the same?
   (A) same   (B) double   (C) triple   (D) quadruple.

8. _________ There is a small cube with 1 inch on each side. If each side of this small cube is doubled, what will be the volume?
   (A) 2 cubic inches   (B) 3 cubic inches
   (C) 6 cubic inches   (D) 8 cubic inches.

9. _________ A small cube measures 2 inches on each side. To fill in a cubic box measuring 4 inches on each side, how many small cubes do you need?
   (A) 4   (B) 6   (C) 8   (D) 16.
10. There is a 3-layer square cake measuring 6 inches on each side. If the top-layer is cut off, then, what will be the shape of this cake? (A) cubic (B) circular (C) rectangular (D) triangular.

II. See and Tell Graphic Questions:

11. Which of the following figures is a cube?

(A)  
(B)  
(C)  
(D)
12. Which of the following images illustrates "Width x Length x Height"?

(A) 

(B) 

(C) 

(D) 

13. Which answer applies to the following figure?
(A) 1 x 1  (B) 1 x 1 x 1  (C) 2 x 2  (D) 2 x 2 x 2.
14. How many small cubes are contained in the following large cube?

III. Drawing Question:

15. In the following space, draw a cube on this sheet.
APPENDIX B

FRAMES OF THE STILL-VISUALS
APPENDIX C

THE NARRATION OF THE VISUAL PRESENTATIONS
"Cube Animation" Script

**Media:** Video, Audiotape

**Length:** One Minute

**Narration:**

Introducing your basic cube.

It has length, and width, and height.

Twice the length,
Twice the width,
Twice the height,
And you have whole lot of cubes.

It's two cubes long,
It's two cubes wide,
It's two cubes high.

One, two, three, four, five, six, seven, eight;
Eight, that's how many cubes you have,
When you double length, and width, and height.
APPENDIX D

ORAL AND WRITTEN INSTRUCTIONS
ORAL AND WRITTEN INSTRUCTIONS

Activities for Non-participants:

1. Discuss with teacher in advance for the best arrangement.
2. Have teacher start non-participants on their own projects before the experiment begins.

Instruction for Participants:

Hello, everyone! My name is Mike Lee. I am a student at Ohio State University. I am so happy to be here. Today, we are going to do something different in our math class. So, let me tell you what we are going to do.

Sometimes, we watch videos (or listen to cassette tapes) in our class. It's a fun way to learn. Many students think videos (or cassette tapes) can help them understand the ideas and stories their teachers taught them in class. I happen to be a video producer. So, I want to know how videos (or cassette tapes) can help you learn.

Today, I will let you watch a video (or listen to a cassette tape). Before and after watching (listening), you get to answer some short questions. It is not a quiz. It has nothing to do with your grade or score. It is just your response to
that video (tape). Your response is very important, since it can tell me how to make better video programs for everybody to watch. With your help, I will make better video programs for other students. Maybe your friends will get to watch them. Then, everybody can learn things quick and easy. So, let's work together on a better video.

There will be three things to do today.

First, there will be a hidden figure test. It is not a math test. So, don't worry about it. It is just a pattern test. In the test book, find a SIMPLE FORM OR FIGURE hidden within a complex pattern. Try to find the simple form in the complex figure; trace the simple form in pencil. Is it the SAME SIZE, in the SAME PROPORTIONS, and FACING IN THE SAME DIRECTION as when it was alone?

Second, we are going to watch a short video (or listen to a cassette tape). This video (or cassette tape) is about 1 minute long. Try to understand everything in the video (cassette tape). I think you will like it.

Third, there will be a short test after you watch the video (or listen to the cassette tape). The test has true or false questions, multiple choice questions, see and tell graphic questions, and a drawing question. The questions in the test will be from the video (or cassette tape) that you are going to watch (or listen to). Give an appropriate answer to each question. I think all of you can answer those questions very easily.
When you finish the second test, you are done. But, stay where you are.
Follow your teacher's instructions. Your teacher will tell you what to do.

I am sure everyone who sees my future videos will appreciate what you have done here today. So, your response tells me how to make a better video.
You have done a great job today. Thank you very much!
APPENDIX E

HUMAN SUBJECTS REVIEW COMMITTEE'S LETTERS OF APPROVAL

174
RESEARCH PROTOCOL:

96B0110 THE USE OF ANIMATION AS A TOOL FOR CONCEPT LEARNING, John C. Belland, Hung-Liang Lee, Educational Policy and Leadership

was presented for review by the Behavioral and Social Sciences Review Committee to ensure proper protection of the rights and welfare of the individuals involved with consideration of the methods used to obtain informed consent and the justification of risks in terms of potential benefits to be gained, the Committee action was:

X APPROVED WITH CONDITIONS

CONDITIONS/COMMENTS:

Subjects were deemed NOT AT RISK and the protocol was unanimously APPROVED WITH THE FOLLOWING CONDITIONS:

1. Provide the Committee with a copy of the letter of solicitation to the participating school, formatted as follows:
   a. Print on OSU letterhead,
   b. Identify the investigators by name, title, and OSU affiliation,
   c. Include signature blocks for both investigators, include: signature, title, OSU affiliation and telephone number.

2. Provide the Committee with a letter of support, printed on school letterhead and signed by the principal/administrator, from the participating school.

3. Revise the consent form as follows and forward a copy to the Committee:
   Describe the activity that will be provided for non participating students.

4. Revise the oral script as follows and forward a copy to the Committee:
   Describe the activity that will be provided for non participating students.

COMMENT: The Committee wishes to compliment the researcher on the fine presentation of the proposal.

The Committee suggests that the researcher allow the students the opportunity to provide oral assent.
If you agree to the above conditions, PLEASE SIGN THIS FORM IN THE SPACE PROVIDED BELOW AND RETURN WITH ANY ADDITIONAL INFORMATION REQUESTED TO THE HUMAN SUBJECTS REVIEW DESK, 300 RESEARCH FOUNDATION, 1960 KENNY ROAD, CAMPUS, within one week. Upon such compliance, the approval form will be mailed to you. (In case of a deferred protocol, please submit the requested information at your earliest convenience. The next meeting of the Committee will be two weeks from the meeting date indicated above.)

Date 4/5/76

[Signature]

Signatures of principal and co investigator

HS-025A
Rev. 3/92
(Conditions/Comments)
Research Involving Human Subjects

ACTION OF THE REVIEW COMMITTEE

With regard to the employment of human subjects in the proposed research protocol:

96B0110 THE USE OF ANIMATION AS A TOOL FOR CONCEPT LEARNING, John C. Belland, Hung-Liang Lee, Educational Policy and Leadership

THE BEHAVIORAL AND SOCIAL SCIENCES REVIEW COMMITTEE HAS TAKEN THE FOLLOWING ACTION:

___ APPROVED ___ DISAPPROVED
___ x __ APPROVED WITH CONDITIONS* ___ WAIVER OF WRITTEN CONSENT GRANTED

* Conditions stated by the Committee have been met by the Investigator and, therefore, the protocol is APPROVED.

It is the responsibility of the principal investigator to retain a copy of each signed consent form for at least three (3) years beyond the termination of the subject's participation in the proposed activity. Should the principal investigator leave the University, signed consent forms are to be transferred to the Human Subjects Review Committee for the required retention period. This application has been approved for the period of one year. You are reminded that you must promptly report any problems to the Review Committee, and that no procedural changes may be made without prior review and approval. You are also reminded that the identity of the research participants must be kept confidential.

Date: March 8, 1996

Signed (Chairperson)
February 27, 1996

Linda K. Meadows
Research Foundation Vice President
Research Development/Management
OSURF Administration
304 Research Foundation
1960 Kenny Road
CAMPUS

Dear Linda:

This is to inform you that Dr. John Belland does have the approval of the department to serve as the Principal Investigator for Hung-Liang Lee, #400-17-0639, and his human subjects project.

If you need additional information you can reach me at the number above.

Sincerely,

Beverly M. Gordon
Professor Beverly M. Gordon, Chairwoman

BMG/nd

cc: J. Belland
H. Lee

PROGRAM AREAS

PROCESS AREAS
Curriculum and Instructional
Development
121 Ramirez Hall
914-292-1741

Educational Administration
NH Ramirez Hall
914-292-7761

Higher Education and
Student Affairs
NH Ramirez Hall
914-292-7786

Human Services
121 Ramirez Hall
914-292-5681

Institutional Design
and Technology
121 Ramirez Hall
914-292-5672

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February 28, 1996

Professor Beverly M. Gordon  
Chairperson  
College of Education  
Department of Educational Policy and Leadership  
29 West Woodruff Avenue  
CAMPUS

Dear Professor Gordon:

This letter is to confirm that Dr. John C. Belland, Emeritus Professor of Educational Policy and Leadership, is authorized to serve as Principal Investigator on the Hung-Liang Lee project #400-17-0639.

My best wishes to Dr. Belland in his research endeavors.

Sincerely,

Linda K. Meadows, Ph.D  
Vice President for Research  
Development and Management

cc:  John C. Belland  
     Hung-Liang Lee
APPENDIX F

THE LETTER TO THE PARENTS AND THE CONSENT FORM

180
April 3, 1996

Dear Parents:

This letter is to ask for your permission to include your child in our research project. As educators, my advisor (Dr. John C. Belland, Professor at the Ohio State University) and I understand that it is important to use educational media to help students learn fundamental concepts. For this reason, Dr. Belland and I are conducting a study on the effects of media use for concept learning. The purpose of this study is to determine the effects of an animation presentation in helping students develop a mathematical concept. The procedure is to present a video (1 minute long) in a mathematics class introducing a basic mathematical concept.

Your child's participation is voluntary. Your child is free to withdraw at any time. We assure you that your child will not be identified by name or by any other significant features in this research project. The results of this study will be used for academic purposes only.

We hope you will grant us permission to include your child in this important research project. Let us know your response by sending us your consent form in the enclosed envelope. Again, we appreciate your time and assistance in this research project.

Sincerely,

Dr. John C. Belland
(Professor, Department of Educational Policy and Leadership, the Ohio State University)
Tel: (614) 292-5181

Mr. Hung-liang Lee
(Graduate Student, the Ohio State University)
Tel: (614) 268-2119
CONSENT FOR PARTICIPATION

I consent to _______________________________________________________
(Student's Name)
participation in the research entitled: "The Use of Animation as a Tool for Concept
Learning," conducted by Dr. John C. Belland and Mr. Hung-liang Lee.

I understand that the purpose of this study is to determine the effects of an instructional
animation presentation in helping students develop a mathematical concept. The
procedure is to present a video (1 minute long) in a mathematics class introducing a basic
mathematical concept. My child will view this presentation and answer questions
regarding the video. The results of this study will be used for academic purposes only.
The entire process will take approximately 30-40 minutes to complete.

I acknowledge that there will be no risk involved in viewing such an instructional video
demonstrating a basic mathematical concept. Also, I acknowledge that my child's
participation will not affect his/her academic record. I understand that my child is free
to withdraw at any time and to discontinue participation in this study.

If I do not sign this form, my child will work on another project under the supervision of
the classroom teacher.

Finally, I acknowledge that I have read and fully understand this consent form. I sign it
freely and voluntarily.

Signed: ____________________________
(Principal Investigator)
Dr. John C. Belland
(Professor, Department of
Educational Policy and Leadership,
the Ohio State University)
Tel: (614) 292-5181

Signed: ____________________________
(Parent's Signature)
Mr. Hung-liang Lee
(Graduate Student,
the Ohio State University)
Tel: (614) 268-2119

Date: ________________

Signed: ____________________________
(Co-investigator)

Program Areas
Curriculum and Instructional
Development
121 Ramsayer Hall
614-292-5181

Educational Administration
301 Ramsayer Hall
614-292-7700

Higher Education and
Student Affairs
301 Ramsayer Hall
614-292-7700

Humanistic Foundations
121 Ramsayer Hall
614-292-5181

Instructional Design
and Technology
229 Ramsayer Hall
614-292-4871
APPENDIX G

THE LETTERS TO THE COLLEGE OF EDUCATION,
THE OHIO STATE UNIVERSITY
March 4, 1996

Dear Miss Hardin:

I have already submitted my request to the Human Subjects Committee on March 1, 1996.

Once my research is completed, I will provide the school district with a copy of the results.

Please submit my proposal to the Groveport Madison School District for review.

Best wishes!

Sincerely yours,

Hung-liang Lee

(Graduate Student, Department of Policy and Leadership, the Ohio State University)
Dear Miss Harding:

This letter is to thank you for recruiting participants for our research project.

To study mediated instruction, Dr. Belland and I are currently conducting a research project entitled "The Use of Animation as a Tool for Concept Learning." With your assistance, we were able to visit the schools that you arranged for us and administer our experiments. Now, we have obtained students' responses and completed data gathering for this study.

During the experiment, we felt that those students who participated in this study were so cooperative. Especially, the principals and classroom teachers of the participating schools were so helpful. Their assistance was of great importance for this study.

This study could not be accomplished without your support. Therefore, we wish to express our sincere appreciation to you for your assistance.

Sincerely,

Dr. John C. Belland
(Professor, Department of Educational Policy and Leadership, the Ohio State University)
Tel: (614) 292-5181

Mr. Hung-liang Lee
(Graduate Student, the Ohio State University)
Tel: (614) 258-2119
APPENDIX H

THE LETTERS TO AND FROM THE PARTICIPATING SCHOOLS

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Sr. Shawn Fitzpatrick, Principal  
Holy Spirit Elementary School  
4382 Duchene Lane, Columbus, OH, 43213  

Dear Sr. Fitzpatrick:

This letter is to ask for your permission to include the fifth graders in your school in our research project.

As educators, my advisor (Dr. John C. Belland, Professor at the Ohio State University) and I understand that it is important to use educational media to help students learn fundamental concepts. For this reason, Dr. Belland and I are conducting a study on the effects of media use for concept learning. The purpose of this study is to determine the effects of an animation presentation in helping students develop a mathematical concept.

The procedure is to present a video (1 minute long) in fifth graders' mathematics classes introducing a basic mathematical concept. Students will view this instructional presentation and answer questions relevant to the video. The entire process will take approximately 30-40 minutes to complete. We will analyze their responses to investigate the instructional effectiveness of animation.

In the process of viewing the video and taking tests, we will take necessary steps to protect your students' safety and rights. Also, the results of this study will be used for academic purposes only.

We feel that your help is important because your school is a quality representative in curriculum and student performance. We hope that you will grant us permission to include your students in this research project. Again, we appreciate your support.

Sincerely,

[Signature]

Dr. John C. Belland  
(Professor, Department of Educational Policy and Leadership, the Ohio State University)  
Tel: (614) 292-3181

Mr. Hung-hiong Lee  
(Graduate Student, the Ohio State University)  
Tel: (614) 268-2119
May 6, 1996

To Whom It May Concern:

Mr. Hung Liang Lee performed his research project, "The Use of Animation as a Tool for Concept Learning" to our fifth grade students at Holy Spirit Elementary School.

Prior to the experiment, he met with me to arrange a date, time and explain what would take place. He also came back and met with Mr. Kevin Gieg, the fifth grade math teacher.

We found him to be very thorough and did a fine presentation.

Sincerely,

Sr. Shawn Fitzpatrick
Sr. Shawn Fitzpatrick, OP
Principal
May 17, 1996

Dear Sr. Fitzpatrick:

This letter is to thank you for supporting our research project.

To study mediated instruction, Dr. Belland and I are currently conducting a research project entitled "The Use of Animation as a Tool for Concept Learning." With your permission, we were privileged to include your students in this project. Now, we have obtained students' responses and completed data gathering for this study.

During the experiment, we felt that those students who participated in this study were so cooperative. Especially, the classroom teacher, Mr. Kevin Gieg, was so helpful. His assistance was of great importance for this study.

This study could not be accomplished without your support. Therefore, we wish to express our sincere appreciation to you for your assistance.

Sincerely,

Dr. John C. Belland
(Professor, Department of Educational Policy and Leadership, the Ohio State University)
Tel: (614) 292-5181

Mr. Hung-liang Lee
(Graduate Student, the Ohio State University)
Tel: (614) 268-2119
April 3, 1996

Dear Mrs. Heisek:

This letter is to ask for your permission to include the fifth graders in your school in our research project.

As educators, my advisor (Dr. John C. Belland, Professor at the Ohio State University) and I understand that it is important to use educational media to help students learn fundamental concepts. For this reason, Dr. Belland and I are conducting a study on the effects of media use for concept learning. The purpose of this study is to determine the effects of an animation presentation in helping students develop a mathematical concept.

The procedure is to present a video (1 minute long) in fifth graders' mathematics classes introducing a basic mathematical concept. Students will view this instructional presentation and answer questions relevant to the video. The entire process will take approximately 30-40 minutes to complete. We will analyze their responses to investigate the instructional effectiveness of animation.

In the process of viewing the video and taking tests, we will take necessary steps to protect your students' safety and rights. Also, the results of this study will be used for academic purposes only.

We feel that your help is important because your school is a quality representative in curriculum and student performance. We hope that you will grant us permission to include your students in this research project. Again, we appreciate your support.

Sincerely,

Dr. John C. Belland
(Professor, Department of Educational Policy and Leadership, the Ohio State University)
Tel: (614) 292-5181

Hung-liang Lee
(Graduate Student, the Ohio State University)
Tel: (614) 268-2119
May 16, 1996

Mike Hung-Liang Lee
557 Stinchcomb Dr.
Apartment 8
Columbus, Ohio 43202

Dear Mr. Hung-Liang Lee:

This letter is in response to your request to include the fifth grade students at Cassingham in a research project for your studies at the Ohio State University. The request was approved prior to your visit on Wednesday, May 8.

During your visit, students participated in a pretest which was followed by a one-minute exposure to a math concept presented auditorially and/or visually. This was followed with an activity sheet which measured the effectiveness of the presentation.

We appreciated the opportunity to participate in your study on the effects of media for concept learning. We would be very interested in the results of your study as they become available. Thank you.

Sincerely,

[Signature]

Barbara B. Heisel
Principal
Mrs. Barbara Heisel, Principal
Cassingham Elementary School
250 South Cassingham, Columbus, OH, 43209

Dear Mrs. Heisel:

This letter is to thank you for supporting our research project.

To study mediated instruction, Dr. Belland and I are currently conducting a research project entitled "The Use of Animation as a Tool for Concept Learning." With your permission, we were privileged to include your students in this project. Now, we have obtained students' responses and completed data gathering for this study.

During the experiment, we felt that those students who participated in this study were so cooperative. Especially, the classroom teachers: Mrs. Mary McMullen, Mrs. Molly Davis, and Mr. Tom Griffin, were so helpful. Their assistance was of great importance for this study.

This study could not be accomplished without your support. Therefore, we wish to express our sincere appreciation to you for your assistance.

Sincerely,

Dr. John C. Belland
(Professor, Department of Educational Policy and Leadership, the Ohio State University)
Tel: (614) 292-5181

Mr. Hung-liang Lee
(Graduate Student, the Ohio State University)
Tel: (614) 268-2119
Dear Mrs. Crabtree:

This letter is to ask for your permission to include the fifth graders in your school in our research project.

As educators, my advisor (Dr. John C. Belland, Professor at the Ohio State University) and I understand that it is important to use educational media to help students learn fundamental concepts. For this reason, Dr. Belland and I are conducting a study on the effects of media use for concept learning. The purpose of this study is to determine the effects of an animation presentation in helping students develop a mathematical concept.

The procedure is to present a video (1 minute long) in fifth graders’ mathematics classes introducing a basic mathematical concept. Students will view this instructional presentation and answer questions relevant to the video. The entire process will take approximately 30-40 minutes to complete. We will analyze their responses to investigate the instructional effectiveness of animation.

In the process of viewing the video and taking tests, we will take necessary steps to protect your students’ safety and rights. Also, the results of this study will be used for academic purposes only.

We feel that your help is important because your school is a quality representative in curriculum and student performance. We hope that you will grant us permission to include your students in this research project. Again, we appreciate your support.

Sincerely,

Dr. John C. Belland
(Professor, Department of Educational Policy and Leadership, the Ohio State University)
Tel: (614) 292-5181

Mr. Hung-liang Lee
(Graduate Student, the Ohio State University)
Tel: (614) 268-2119
April 20, 1996

Behavioral and Social Sciences
Human Subjects Review Committee (HSRC)
The Ohio State University
Columbus, Ohio 43210-1177

To Whom It May Concern:

This letter is to state my support of Mr. Hung-liang Lee's and Dr. John C. Belland's research "The Use of Animation as a Tool for Concept Learning." Our fifth grade math students will be participating.

Sincerely,

Mrs. Margaret Crabtree
Principal
Dear Mrs. Crabtree:

This letter is to thank you for supporting our research project.

To study mediated instruction, Dr. Belland and I are currently conducting a research project entitled "The Use of Animation as a Tool for Concept Learning." With your permission, we were privileged to include your students in this project. Now, we have obtained students' responses and completed data gathering for this study.

During the experiment, we felt that those students who participated in this study were so cooperative. Especially, the classroom teacher, Mrs. Marian Georgenson, was so helpful. Her assistance was of great importance for this study.

This study could not be accomplished without your support. Therefore, we wish to express our sincere appreciation to you for your assistance.

Sincerely,

John C. Belland
Professor, Department of Educational Policy and Leadership, the Ohio State University
Tel: (614) 292-5181

Hung-liang Lee
Graduate Student, the Ohio State University
Tel: (614) 268-2119
April 3, 1996
Mrs. Janet Nungesser, Principal
Saint Phillip Elementary School
1555 Elaine Road, Columbus, OH, 43227

Dear Mrs. Nungesser:

This letter is to ask for your permission to include the fifth graders in your school in our research project.

As educators, my advisor (Dr. John C. Belland, Professor at the Ohio State University) and I understand that it is important to use educational media to help students learn fundamental concepts. For this reason, Dr. Belland and I are conducting a study on the effects of media use for concept learning. The purpose of this study is to determine the effects of an animation presentation in helping students develop a mathematical concept.

The procedure is to present a video (1 minute long) in fifth graders' mathematics classes introducing a basic mathematical concept. Students will view this instructional presentation and answer questions relevant to the video. The entire process will take approximately 30-40 minutes to complete. We will analyze their responses to investigate the instructional effectiveness of animation.

In the process of viewing the video and taking tests, we will take necessary steps to protect your students' safety and rights. Also, the results of this study will be used for academic purposes only.

We feel that your help is important because your school is a quality representative in curriculum and student performance. We hope that you will grant us permission to include your students in this research project. Again, we appreciate your support.

Sincerely,

Dr. John C. Belland
(Professor, Department of Educational Policy and Leadership, the Ohio State University)
Tel: (614) 292-5181

Mr. Hung-liang Lee
(Graduate Student, the Ohio State University)
Tel: (614) 268-2119

Program Areas
Curriculum and Instructional Development
121 Ramseyer Hall
614-292-5181

Educational Administration
311 Ramseyer Hall
614-292-7700

Higher Education and Student Affairs
311 Ramseyer Hall
614-292-7700

Humanistic Foundations
121 Ramseyer Hall
614-292-5181

Instructional Design
and Technology
202 Ramseyer Hall
614-292-4872
May 13, 1996

We at St. Philip School are proud to be a part of on-going research in the field of education. We believe that being on the cutting edge of new educational developments and investigation is important. It is with pleasure that we allow our Fifth Graders to participate in the current project entitled "Use Of Animation As A Tool For Concept Learning", through Dr. John Belland and Mr. Hung-Liang Lee, as we support this study.

Janet J. Nungesser
Principal
This letter is to thank you for supporting our research project.

To study mediated instruction, Dr. Belland and I are currently conducting a research project entitled "The Use of Animation as a Tool for Concept Learning." With your permission, we were privileged to include your students in our project. Now, we have obtained students' responses and completed data gathering for this study.

During the experiment, we felt that those students who participated in this study were so cooperative. Especially, the classroom teacher, Miss Kimberly Magraf, was so helpful. Her assistance was of great importance for this study.

This study could not be accomplished without your support. Therefore, we wish to express our sincere appreciation to you for your assistance.

Sincerely,

Dr. John C. Belland
Professor, Department of Educational Policy and Leadership, the Ohio State University
Tel: (614) 292-5181

Mr. Hung-liang Lee
(Graduate Student, the Ohio State University)
Tel: (614) 268-2119
April 3, 1996

Miss Susan Rieger, Principal
Asbury Elementary School
5127 Harter Boulevard, Columbus, OH, 43232

Dear Miss Rieger:

This letter is to ask for your permission to include the fifth graders in your school in our research project.

As educators, my advisor (Dr. John C. Belland, Professor at the Ohio State University) and I understand that it is important to use educational media to help students learn fundamental concepts. For this reason, Dr. Belland and I are conducting a study on the effects of media use for concept learning. The purpose of this study is to determine the effects of an animation presentation in helping students develop a mathematical concept.

The procedure is to present a video (1 minute long) in fifth graders' mathematics classes introducing a basic mathematical concept. Students will view this instructional presentation and answer questions relevant to the video. The entire process will take approximately 30-40 minutes to complete. We will analyze their responses to investigate the instructional effectiveness of animation.

In the process of viewing the video and taking tests, we will take necessary steps to protect your students' safety and rights. Also, the results of this study will be used for academic purposes only.

We feel that your help is important because your school is a quality representative in curriculum and student performance. We hope that you will grant us permission to include your students in this research project. Again, we appreciate your support.

Sincerely,

Dr. John C. Belland
(Professor, Department of Educational Policy and Leadership, the Ohio State University)
Tel: (614) 292-5181

Mr. Hung-liang Lee
(Graduate Student, the Ohio State University)
Tel: (614) 268-2119
May 15, 1996

Dr. John C. Belland
Department of Educational
Policy and Leadership
29 W. Woodruff Avenue
Columbus, OH 43210-1177

Dear Dr. Belland,

We have agreed to allow Mr. Hung-liang Lee to include the fifth graders at Asbury Elementary in his research project.

We understand the importance of research, especially in the area of student achievement and curriculum implementation. We were happy to assist in Mr. Lee's efforts.

Sincerely,

Susan R. Rieger, Ph.D.
Principal

cc: Mr. Hung-liang Lee
Dear Miss Rieger:

This letter is to thank you for supporting our research project.

To study mediated instruction, Dr. Belland and I are currently conducting a research project entitled "The Use of Animation as a Tool for Concept Learning." With your permission, we were privileged to include your students in this project. Now, we have obtained students' responses and completed data gathering for this study.

During the experiment, we felt that those students who participated in this study were so cooperative. Especially, the classroom teachers, Mrs. Carol McGonigal and Mrs. Jennifer Chatfield, were so helpful. Their assistance was of great importance for this study.

This study could not be accomplished without your support. Therefore, we wish to express our sincere appreciation to you for your assistance.

Sincerely,

John C. Belland
(Professor, Department of Educational Policy and Leadership, the Ohio State University)
Tel: (614) 292-5181

Hung-liang Lee
(Graduate Student, the Ohio State University)
Tel: (614) 292-5119

May 17, 1996
REFERENCES


Cambre, M. A. (1984, January). Children's preferences and information acquisition in reaction to four film animations in science. Paper presented at the annual meeting of the Association for Educational Communications and Technology, Dallas, TX.


Harding, A. (1990). The relationship of logical thinking and disembedding ability to a conceptual shift using a physical science concept. Doctoral dissertation, Ohio State University, Columbus, Ohio.


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