UNIVERSITY OF CINCINNATI

September 8, 19 99

I, Vehbi A. Sanalan

hereby submit this as part of the requirements for the degree of:

Doctor of Education

in Curriculum and Instruction

It is entitled A National Survey of Teachers Trained in Image Processing for Teaching

Approved by:

Priyush Sevani

Janet K Bohren

Glenn Markle

Daniel D. Wheeler

A NATIONAL SURVEY OF TEACHERS TRAINED IN

IMAGE PROCESSING FOR TEACHING

A dissertation submitted to the

Division of Graduate Studies and Research
of the University of Cincinnati

in partial fulfillment of the
requirements for the degree of

DOCTOR OF EDUCATION (Ed.D.)

in the Department of Curriculum and Instruction
of the College of Education

1999

By

VEHBI AYTEKIN SANALAN

BS, Gazi University, Turkey, 1990
MS, Gazi University, Turkey, 1994

Committee Chair: Dr. Piyush Swami

ABSTRACT

A NATIONAL SURVEY OF TEACHERS TRAINED IN IMAGE PROCESSING FOR TEACHING

The purpose of this study is to enhance our knowledge of science instruction done through image processing . The outcomes of workshops organized by the Center for Image Processing in Education (CIPE) were analyzed. A randomly selected sample of 116 teachers was surveyed using a Web-based instrument. The results showed that most people attending workshops used IPT. The participants who used Image Processing for Teaching (IPT) program had more positive beliefs than those who did not use IPT. Users stated that they need advanced training about IPT and its applications on other subjects. A majority of participants believed that IPT was very useful for learning science. Image Processing for Teaching exploits a different way to teach science i.e. by using images, and both users and non-users thought it was a credible way to teach the concepts included in science curriculum. The most important obstacle for non-users was the technological equipment availability. Teachers with adequate access to computers reported that using IPT requires excessive amount of time. It is concluded that the software program used for IPT should be revised.

ACKNOWLEDGEMENTS

I thank my wife, Aynur Sanalan, for her endless support and encouragement. This dissertation would not be possible without her care, love and patience.

Dr. Piyush Swami, as a scientist and an advisor, established many things in my career and professional development. I thank him for motivating me from the beginning.

Thanks very much to my dissertation committee members, whose input and consultation were much valued in designing and carrying out this study.

Special thanks to Sharon Nichols, for her time and effort devoted to reading and editing the drafts my dissertation.

DEDICATION

I dedicate this study to my grandmother, Fatma Yilmaz, who always encouraged me to read, investigate and question. I would have never reached this point without her support.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

One of the major ways human beings learn is through visual means. Ambient conditions are sensed primarily by means of processing visual data. The theory by Nayar and Poggio (1996) posited that our senses are converted into visual images in our brains, and that the thinking process moves along by using imagery tools. What we perceive becomes items that run along visual information processing paths, or "streams". Hence, one of the ways to explore the human brain and discover how it processes information is to observe its behavior throughout an image processing application. In this sense, visual imagery represents not only the process of producing or using images and pictures, but also the way by which our brain processes information. Paivio (1971) stated that " ...visual information may be represented in a fundamentally different format from that used for linguistic information....images are represented quite differently from words, and mental images are analogue or 'picture-like' representations" (p.203). In short, his theory proposed that visual imagery is a way of thinking.

Another theory by Kosslyn, Behrmann and Jeannerod (1995) claimed that visual imagery is one of the best ways to recollect information. Many experimental studies (Avons, 1998; Brandimonte, Hitch & Bishop, 1992; Magnussen, Greenlee & Thomas, 1996; Marschark & Surian, 1992; Salthouse, 1995; Sharps & Price-Sharps, 1996; Tracy, Pabis & Kilburg, 1998) have shown convincing proof of how much easier it is to remember something when it is connected to visual images. The basic assumption behind those reports is that an important aspect of learning is the capacity to recollect after information is stored. According to Saunders, Wise and Golden (1995), four operations must occur in order for one to learn. The learner must choose the important information, and store it in memory. Then connections must be made between new information and prior knowledge. Finally, learners must identify what they have learned.

The visual information process is best utilized when learning a course of action. Of all the subjects, science requires the most visual cues to grasp the procedure as a system. As an example, people's understanding of water circulation in an ecosystem requires necessary information from physics, chemistry and biology. However, in the absence of imagery, knowing all these facts may not help one grasp the process as a whole. The problem is not the process complexity, but in the lack of visual imagery or process cues in the brain.

In 1990, several researchers (Greenberg, 1992) from Arizona State University decided to investigate the possibility of an educational application of a state-of-the-art image-processing program called the Image Processing for Teaching project (IPT). As they had hoped, digital image processing became a useful tool for learning science, especially for culturally diverse students. After 1992, the Center for Image Processing in Education (CIPE) was established, and experts began giving lectures and IPT workshops to teachers all over the country (Raphael & Greenberg, 1995). Since any feedback from these workshops was provided from the scant spontaneous reports from the teachers, the weight or outcomes of the workshops remained incomplete. Thus, the feedback was insufficient to make any generalizations about IPT. One teacher (Collins, 1995) wrote about her impressions of the workshop, saying, " Providing our students access to modern science tools and modeling their use daily can make a difference in our students' education and future" (p.58).

Regional and partly sponsored by the National Science Foundation (NSF), the IPT workshops were expanded to seven states by 1997. In the five-day long summer workshops which 2000 teachers from various schools attended (each workshop with 15-30 teachers), teachers learned to manipulate digital images, to associate them with science content, and to help students as they struggled with the new tool (CIPE, 1997; Greenberg, 1992). The teachers were also trained in new instructional techniques and technology as well as science content and image processing. Integrating this approach with existing science curriculum was also presented.

Research Questions

The following research questions probing the effectiveness of IPT workshops were chosen:

1. Do teachers use Image Processing for Teaching (IPT) when teaching science after they have experienced an IPT training program?

2. How valuable do science teachers think Image Processing workshops are to their professional improvement?
3. How do science teachers consider IPT (Image Processing for Teaching) as a science teaching tool?

This study will investigate how effective a group of teachers found IPT techniques and the Image Processing workshops, and how the workshops affected their professional improvement. The basic question is whether the science teachers made use of image processing techniques after undergoing an IPT training program.

Another aspect of this research question is how valuable the science teachers felt Image Processing Workshops were for their professional improvement and whether they considered Image Processing a valid teaching tool.

Statement of Problem

The review of the literature revealed few studies addressing 1) a thorough analysis of the Image Processing for Teaching program, and 2) the effectiveness of the IPT workshops for teachers. The Center for Image Processing in Education (CIPE) arranged for numerous workshops with thousands of science teachers around the US. These teachers learned how to use IPT as a tool to teach science. They were instructed in using image processing methods, and in manipulating images. According to the visual learning theory (Paivio, 1971), image processing is one of the most effective ways to teach science because scientific thinking uses imagery models to explain phenomena. However, to confirm this theory, the need exists to evaluate the outcomes of these workshops. In other words, we need to determine whether the participants are making use of what they learned.

In the literature, the issue of whether the outcomes of teacher training programs are properly evaluated is also a hotly contested issue (Dori and Barnea, 1994). The results of Dori and Barnea, and Rudolph and Preston's (1995) studies strongly suggest that the success of teacher training programs can only be measured from whether--or to the extent--the participants are using the elements of the program in their teachings.

Purpose of the Study

The purpose of this study is to enhance our understanding of the strength of in-service teacher education programs utilizing image processing software techniques, on teachers' effectiveness in teaching science. The results of this study can be used not only to understand the training outcomes, but also to assist in organizing future workshops. Another purpose is to measure the efficiency of image processing, and of teachers' computer usage in instruction.

The findings of this study can demonstrate whether in-service teacher education workshops affect teachers' implementation of Image Processing; if teachers' computer usage can affect the quality of science instruction, and if digital image processing can prove to be a useful tool for science instruction. Any positive indicators of the effectiveness of IPT can lead educators and school administrators to introduce image processing as a teaching tool.

What Is Image Processing?

Personal computers have recently been equipped with image processing software, such as MS Paint, PaintBrush, Adobe PhotoShop, etc. These are the types of software that an end-user makes use of in image processing functions. For example, one software program, Adobe PhotoShop, is used to manipulate digital photos while another, PaintBrush, is used to create digital images. Sometimes, word processors have been combined with some functions of image processing. Generated by word processor software, lines and shapes can be drawn right on the page. Acquired from an external source, digital image files can then be manipulated and saved on digital media. Digital image processing consists of obtaining an image, transforming it into a digital mode, and processing, editing and manipulating its visual features, such as color, contrast, sharpness and smoothness. Digital imaging also measures the distances, areas, angles, and particles in an image.

Images can also be acquired from scanners and digital cameras, or can be created by users. Computers translate these images into a matrix of dots or digits. Using image processing software, scientists utilize the visual data to bring out vital aspects of images. Image processing software is also used in advanced science applications, such as spacecraft research. It is not intended to be a computer assisted educational package. In other words, it is not designed to assist learners in grasping processes or facts in schools. Image Processing for Teaching as a computer assisted educational package, is designed, unlike the more complicated program, to teach science at the middle-school level.

In an Image Processing for Teaching package, the software program is the NIH-Image, an image-processing program developed by the National Institute of Mental, Health Research Services Branch. The software is a state-of-the-art image-processing program that forward thinking scientists use in their research. The academic subjects used in the program include astronomy, cell biology, medical X-ray photo analyses, and so on.

The NIH Image software can acquire, display, edit, enhance, analyze and animate images. It reads and writes TIFF, PICT, PICS and MacPaint files, and provides compatibility with many other applications, including programs for scanning, processing, editing, and publishing images. The software supports many standard image processing functions, including altering the contrast, making a density profile, smoothing, sharpening, detecting edges, filtering using a median, and changing the location with user defined-kernels. The distance between two points on the image can be measured. The image assists in gauging the area, mean, centroid, and perimeter of the regions of interest; performing automated particle analysis, and measuring path lengths and angles via special tools. Scale calibration on the image is supported to provide realistic area and length measurements. The density calibration is done with radiation or optical density standards, using user-specified units. The actual image can be lifted from various sources, such as digital cameras, scanners, video capture and other plug-ins, which are easily downloaded from the Web site.

How imagery can be used

Students can learn about science content while they are creating, editing, and analyzing images. Although using visual representations of content information has been espoused as an effective way to learn science (Sounders, Wise & Golden, 1995), there are other possibilities for using image processing as a teaching tool.

Usage in Science Instruction

Greenberg (1992) noted that, "As a species, we are visual learners" (p.14). Images can keep information in mind more powerfully than any verbal explanation can. It is for this reason that science textbooks are full of images and captions. The explanation of a science process is usually described on a still figure or in a photograph. Editing and engineering an image promotes more understanding than looking at this sort of still image. Stationary images are merely a source of information while created or edited images assist in producing knowledge. Scientists use image processing to explore and discover what cannot be seen with the naked eye; thus, Image Processing (IP) offers a constructivist medium that allows students to explore without restriction. Once students learn to use it, they can follow the path of discovery cutting-edge scientists still heed. The unlimited subjects include biomedicine, planetary exploration, environmental science, motion physics, and solid-state chemistry.

The IPT sourcebook offers a Macintosh version of the program, and provides some activities the teacher can carry out. As of 1999, a Windows™ version is available for downloading from the Web. The IPT sourcebook contains 350 pages of instructions, activities and teacher resources. Each activity includes a recommended grade level and objectives. Each step of the activity is described clearly for students. The location of image files on the CD-ROM is highlighted. The teacher's edition of the activities is subdivided into six sections, each of which is headlined by "Teaching Notes": Subjects, topics, goal, image processing objectives, notes and acknowledgements. These "Teaching Notes" assist teachers in planning or carrying out the lessons. The student activity sheet incorporates steps to carry out the learning process, and includes evaluation questions and activities (see Appendix B for a complete list of the activities).

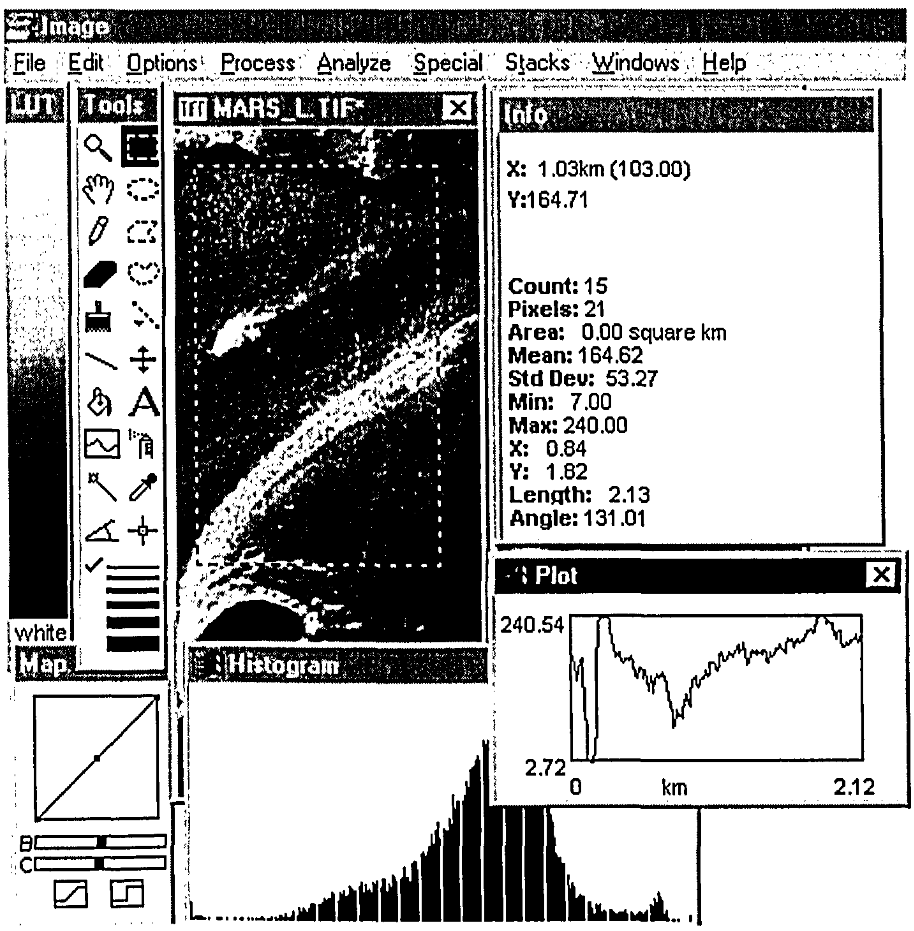
Two sample activities (images) are described briefly here to give an idea how IPT materials are used in the classrooms to teach the common concepts included in science curriculum. Figure 1 represents the screen capture of the activity "Mars 3-D", a lesson to teach erosional features on the surface of Mars. The students are expected to interpret this picture as being formed by flowing water.

Info window shows the x and y coordinates and mean number of pixels. This information can be used to make real measurements on the surface of the planet Mars.

Plot window portrays the pixel values on the picture corresponding to the gray levels. Higher values in plot window stand for brighter areas. Using the imaging tools, students can explore the patterns of erosion on the surface of Mars, and they can make a comparison with erosion on the Earth.

This activity can also be used to investigate the basics of the 3-D vision. There are two images in the package, one for the left eye, and another one for right eye. Using 3-D goggles -- provided in the IPT Sourcebook -- students understand how 3-D vision is possible.

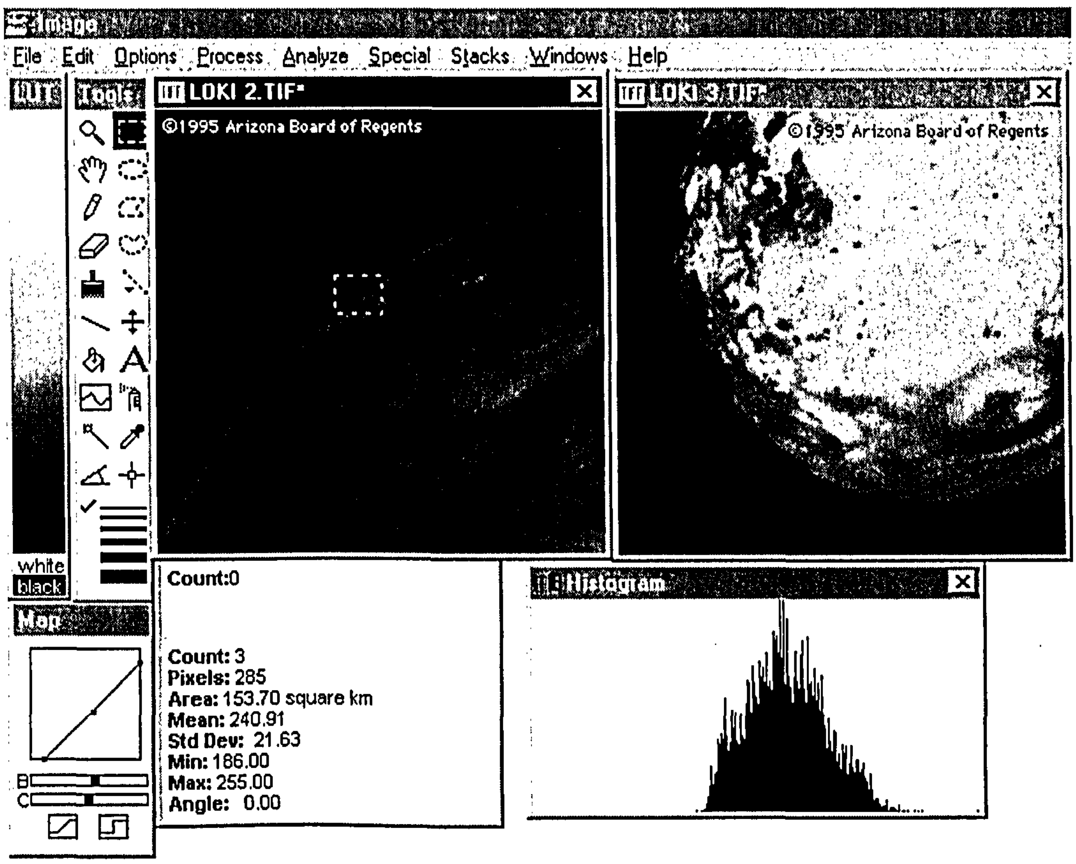
Figure 1. Screen-capture of activity: Mars in 3-D, Scion Image.



By doing these activities, students are able to see erosion in a realistic manner, and also follow some of the same procedures that actual researchers working with data from Mars have followed.

One other activity in the sourcebook is "Eruption Plumes of Io" (see Figure 2). In this activity, teacher uses image processing skills such as enhancing, measuring, labeling, scaling and rotating images. Students learn how to locate and identify volcanoes, how to rotate images mentally, and how to recognize patterns of different views of objects.

Figure 2. Screen capture of activity: Eruption plumes of Io, Scion Image.



First students find out the eruption in the picture, using image processing tools. The eruption occurs in the rectangular area (see Figure 2). Then they measure the height of eruption, and compare this value with other pictures in the package.

In a typical science classroom it is almost impossible for students to look at a volcano eruption in such detail. The teaching of volcano is generally confined to read about a few examples, build a model of a volcano, and perhaps see a film of lava flow. By using IPT materials teachers have a rich tool in hand that enables students to do detailed observations.

Teacher Effectiveness

Teachers play a vital role in teaching science through image processing. They are not only dealing with technology, but they are also facilitating student learning. Teachers help students learn the basics of using a computer, direct students as they practice, and guide them in exploring science content. Therefore, teachers should be trained in three basic areas: computer usage, image processing, and the image processing/science content link. The effectiveness of Image Processing (IP) in science teaching depends heavily upon the teacher's efficiency in using the above criteria. This study will investigate the effects of the workshops on these parameters.

Definition Of Terms

Access: A database software application by Microsoft™. It is used to create, edit and manage database files.

ASP ©: Active Server Pages © is a server-side scripting language produced by Microsoft ™ . It allows Web developers to use the functions of the Web server, Internet Information Server © developed by Microsoft™.

CIPE: Center for Image Processing in Education. Established in 1992, the CIPE is the major provider of IPT applications and materials.

HTML: Hypertext Markup Language. The digital code type that is used on the Internet. The documents on the Internet are written in HTML, and the documents can include pictures, multimedia files and links to other Web sites.

IPT: Image Processing for Teaching project.

Magno Stream: The neural activity generated by the processing of visual information. The magno stream plays an important role in the process of visual object recognition.

MRI: Magnetic resonance imaging. A method to analyze the responses of molecules and atoms and their behavior to a magnetic field. It is used to observe the structural and biochemical features of tissues.

NIH Image: An Image Processing program created by the National Institute of Health. The program is used to analyze the visual data gathered from a variety of sources: space observations, X-ray photos, satellite images and other visual scientific information.

Parvo Stream: One of two neural activities in the dorsal region of the brain. The parvo stream is produced by perceiving visual information.

PET: Positron emission tomography. A method to observe metabolic activities in the brain by radioisotopes.

PICT (PICS): A Macintosh-based digital image file format.

Scion Image: The Windows version of image processing software (NIH Image).

SPSS: Statistical Package for Social Sciences. SPSS is a software package used to analyze numerical data collected from social research. The company also produces helpful booklets that serve as a guide in designing research studies based on quantitative methods.

TIFF: A Tagged image file format. This program carries the specific code by which the image files are saved in digital form.

CHAPTER II

LITERATURE REVIEW

The review of the literature is divided into three points of view: image processing in science teaching, visual learning, and in-service teacher education. A summary of the findings can provide a final analysis.

Image Processing in Science Teaching (IPT)

As one of IPT's founders, Richard Greenberg (1992) reported important aspects and conclusions on IPT:

> ...[IPT] is an intrinsically 'constructivist' medium when used by students...IPT offers access to the extensive, original imaging data that has yet to be fully explored by the scientific community. This opens the door to true scientific discovery as students manipulate the data (p. 15).

The reports of teachers affirmed that IPT can eliminate common barriers to science learning for those with certain kinds of learning disability, especially attention disorders and low language proficiency (Raphael & Greenberg, 1995, p. 35). Raphael and Greenberg also found that IPT increased motivation in both male and female students from different cultural backgrounds. Many teachers reported that students with negative attitudes or behavior disorders had shown changes in demeanor after using image processing. Collins (1995) recounted her experiences of using IPT, and reported that the individualization in science made possible by IPT, could enhance students' self-esteem (p. 58). Finally, Greenberg stated that those teachers "...with enthusiasm, flexibility, and administrative acumen to introduce this fundamentally constructivist medium into their classrooms" (p.18) were most likely to use IPT effectively.

Teachers' creativity is one important ingredient to ensure the integration of IPT in science education. One of the science teachers who attended a workshop on IPT reported on her personal experiences: "...I had no efficient, vital or effective means to deliver [science content]... until I saw what was being done at the IPT project. Image processing was the answer to my students' needs" (p. 55). Collins (1995) reported that image processing provides digital lab opportunities, and both teachers and students can make better applications of science content via image processing.

Raphael (1995) found that lower achieving students can enhance their ability in image processing as well as in science knowledge and problem solving. One teacher's report, for instance, makes it plain that image processing is a very powerful tool to engage students in discovery, encouraging them to join in a constructivist science experience (Collins, 1995, p. 56).

Unfortunately, the Image Processing for Teaching program has not been discussed and evaluated broadly. This has occurred because few teachers who attend IPT workshops report back on their own experiences with the new knowledge, and so all we have are a few studies by the founders of the IPT program. This study can therefore add some missing pieces to the totality of information we have to date.

Visual Learning

Fifty years ago, it was found (Human Eye, 1999) that some of the cells in the retina of the human eye were stimulated by the appearance of light while other cells in the same area became excited when the light vanished. Still other cells responded to both events. As research on eyes and eyesight advanced, other types of cells were identified. Milner and Goodale (1995), for example, explained that cells are stimulated by movement, color, spatial location, and resolution. These cells conduct axons, which turn into bioelectrical pulses and end up in the parietal or the visual cortex where the visual stimulus is perceived. This perception records the features of the object, including contrast, color, depth, contour, shape and motion. Although the issue is still hotly argued, how and where questions on the issue have been gradually replaced by what and why questions (Humphreys & Bruce, 1989).

Unfortunately, although the physiology of the visual process has been adequately elucidated, we really don't yet know the cognitive processes and the neural mechanisms that determine how we "see" things in the absence of a physical stimulus.

If we waste time and energy perceiving an object all over again every time we see it, vision would not likely be a primary sense. Visual memory provides a very useful function: object recognition. A valuable goal of vision is to be able to instantly recognize the structures as belonging to familiar categories. For example, we can recognize a horse even if we have never seen the horse before. Humphreys and Bruce (1989) described the recognition process as a function of visual imagery as follows:

> ...one of matching a description of an object derived from an image, with one of a set of stored representations of the visual characteristics-'appearances'- of different kinds of subjects (p. 51).

Thus, an outside object having the same basic characteristics as an inside model can be recognized because of matching criteria. However, this observation brings up the question of how we describe things so they can be labeled. This recognition process includes a number of visual, semantic and verbal processes. These three areas will be discussed later in the paper under perceptual, and semantic classifications, and name retrieval, respectively.

One of the early theories of object recognition was conceived by Plato. He concluded that mental images are like impressions on wax templates, intended for future use. Contemporary psychologists believe that ideas are represented by mental images which accompany all thought processes while psychologists from the past maintained that "...all knowledge is ultimately represented in propositional format" (Humphreys & Bruce, 1989, p. 203).

Other imagery experiments (Shepard & Metzler, 1971) provided some proof in favor of the former claim. In a classic experiment involving eight male subjects, Shepard and Metzler showed each subject a pair of images and asked whether the images were the same. One image was a copy that was rotated over a period to wider angles, and at each angle change, the researchers measured the reaction time it took subjects to recognize similarities between the images. They found that the reaction time increased as the rotation angle widened. There was a linear relationship between decision time and angle degree. This experiment, and others after it provided the first important empirical evidence about cognitive abilities, especially in the areas of mental rotation and visual imagery. We know now that human beings use mental imagery to perform most of their everyday tasks, imaging objects in space all day long. What is imagery? According to Kosslyn, Behrmann and Jeannerod (1995), visual imagery is the act of processing visual information through mental functions when the stimulus does not exist.

From a neurophysiological point of view, two streams or cortical pathways of the visual information process have been identified: Discrimination of object and of location identification. Milner and Goodale (1995) proposed that these two functionally separated processes are located in different parts of the cortex, and are known as the ventral and dorsal projections of perception, respectively. Each cortical pathway (or stream) transforms incoming visual information and stores it in long term memory. Alivisatos and Petrides (1997) made a novel argument about the regions and functionality in the brain's visual cortex. PET and MRI data led these researchers to claim that face and object recognition activate different regions of the cortex.

As indicated earlier, visual object recognition occurs in three stages: perceptual classification, semantic classification and name retrieval. The perceptual classification stage involves matching a given view of an object to a stored representation of that object. This is the stage at which different views of the same object can be seen as similar, and distinct from other object categories (Milner & Goodale, 1995). The perceptual classification is the action primarily responsible for the ability to identify objects under various conditions.

The perceptual classification stage includes the complete perception of an image. The basic characteristics of the image are seen, and distinguished from the background vision. Object recognition begins at this point. Davies, Gilmore and Green (1995) demonstrated in their experiment that recognition of programming code cards by two groups of subjects -- experts and novices--were different. The researchers found that in the perceptual classification stage, experts used functional relationships to order cards while novices used syntax. The experiment also found that experts in this experiment proceeded to the semantic classification stage faster than novices. The perceptual classification phase sets up the semantic classification.

The semantic classification stage is the point at which the functions of a given object are retrieved from the semantic memory system. At this point, the object is recognized and matched with a concept that is already in the brain. Stark, Grafman and Fertig (1997) conducted an experiment using one subject who had difficulty in identifying large objects. The subject in the experiment was found to be better at recognizing objects than at stating names. The results of the Stark et al. study showed that the meaning and concept of an object is recognized before its name is retrieved. The semantic classification stage is followed by name retrieval.

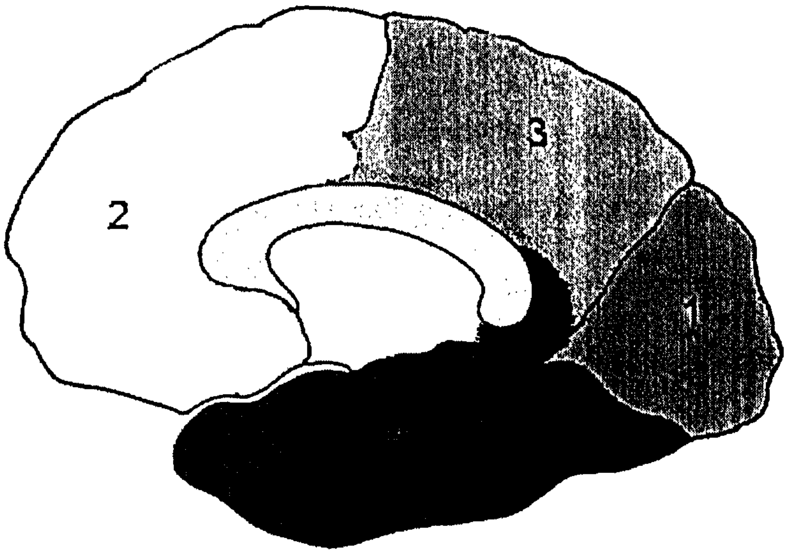
Name retrieval occurs when the name and mental image of an object is stored in short-term or long-term memory (Carter, Cushing, Sabers, Stein & Berliner, 1988). In an experiment with a patient with a visual recognition deficiency, Milner (1995) determined that the patient was unable to copy an image of an apple when it was placed before her, but could draw an apple from long term memory when asked. Presumably, the information coming from the magno channel had dominated the dorsal stream, and the parvo channel could not send any information to the dorsal stream. The parvo system deals with colors, contours and the surface properties of objects while the magno system is concerned with global spatial organization, and the elements of visual objects, such as edges and discontinuities.

Humphreys and Bruce (1989) proposed a schema for storing visual information. The schema consists of three main aspects: early visual processes, short-term visual store, and long-term visual store. The early visual processes have previously been explained under perceptual and semantic classifications, and name retrieval. Short-term visual store (STVS) can be understood as a "scratch pad," a viewer-centered buffer in which representations are constructed of the current surface layout and into which representations of recognized objects can be written from the store of structural descriptions, such as straight, vertical and horizontal, to name just a few. Ishai & Sagi (1997) found that STVS can be affected by long-term visual memory.

Several researchers have shown that visually stored information of objects was retained for longer periods than that for verbal descriptions (Avons, 1998; Brandimonte, Hitch & Bishop, 1992; Magnussen, Greenlee & Thomas, 1996; Marschark & Surian, 1992; Salthouse, 1995; Sharps & Price-Sharps, 1996; Tracy, Pabis & Kilburg, 1998), especially retention from long term visual memory. Sharps and Price-Sharps (1996) conducted an experiment to determine whether a simple mnemonic technique could be developed for the elderly. The sample consisted of 34 elderly adults, divided into three groups. The first group (the visual memory support group) was asked to use visual cues to help them remember everyday tasks while the second group (the notepad group) was encouraged to use a notepad to do the same. A third group was assigned to a control group and only recorded the instances when they forgot daily tasks. The results of the experiment showed that the visual memory support group forgot the tasks significantly fewer times than the notepad or control groups. The researchers concluded that effective mnemonic techniques using the visual information process theory had significant effects on memory in the older adults. Even though one can conclude that visual cues help only elderly adults remember efficiently, and that the results might not be valid for people from all ages, Salthouse (1995) searched the relationship between age-related memory tasks and visual information processing speed, and found scant evidence for age-related selectivity of the verbal versus visual information process. In other words, the help of visual representations for recollection is valid for people of all ages. Other researchers (Rolandelli, 1989; Olshansky, 1994) showed similar results: that pictures are stored in memory much longer than mere sentences and words.

Mental imagery not only assists in the retrieval of information, but also provides another helpful tool to process information from the world around us. Alivisatos and Petrides (1997) prepared a task in which subjects decided whether an image was a "normal" or a "mirror image". A second task required subjects to choose the correct upright position of an image. During these activities, a PET-MRI was taken, and the regions with activity were determined. The highest brain activity was found in the right hemisphere, in the medial frontal cortex. The researchers showed that the ability to rotate mental images is located in the parietal regions of the brain. These findings correlate with those of Williams, Rippon, Stone and Annett (1995) who also found that the parietal regions (see Figure 3) play an important role in mental rotation tasks. Both sets of researchers agreed that the right hemisphere is the part of the brain where visuospatial processing takes place.

Figure 3. Mid-sagittal view of human brain.



1: Occipital lobe; 2: Frontal lobe; 3: Parietal lobe; 4: Temporal lobe.

Gender differences may also influence the processing of mental images. De Lisi and Cammarano (1996) designed a study to find out whether computer game experience had an effect on mental rotation test results. They divided 110 male and female undergraduates into two groups. One mixed group operated a computer game that required the ability to rotate mental images while the other group operated a computer game restricted to a simple solitaire game. The researchers then gave a standard mental rotation ability test to both groups. They found that women in both groups outperformed men in the solitaire-only group. The researchers also reported that undergraduate subjects' computer use had an impact on their success in spatial ability, and that the gender differences in men and women's mental image rotation tasks were mitigated. That is, the gap between men and women's scores was not as wide as expected. As a covariant, regular computer use was correlated with their success on the mental rotation test. De Lisi and Cammarano failed to explain, however, why women who played solitaire only showed an unexpected increase in their mental rotation test results. One can conclude that rotating mental images is something that one can improve across various means throughout one's life.

Pinker (1997) cited vision as one of the reasons human beings have evolved and flourished. It is a crucial sense. We can perceive the color, depth and shape of objects; we can also imagine things even if they are not there. Today's scientific community spends a great deal of time looking at charts, graphs and photos which mean nothing to anyone but the experts in that particular field. Doctors, astronomers, chemists and many other professionals thus require a certain degree of experience to communicate with these images, and transform them into layman's language. This type of expertise requires knowing the language of those images.

In his preface to the Vision Research Journal, Hildreth (1998) presented some ways to recognize visual representations. He gave a short history of psychophysics, and claimed that knowledge of the complexity of these processes had advanced since the mid-80s. Research on object recognition shifted from a focus on shape, color, and movement to a focus on higher-level visual processing and recognition tasks. Hildreth also stated that while early studies in this area investigated the recognition of 3-D information, the newest evidence shows that recognition can be achieved just as quickly with the use of 2-D images. The complexity of visual processes has not been sufficiently explored, and necessitates further research. As the sequence involved in processing visual information becomes understood, we can better explain visual image processing at the level of neural mechanisms. In turn, we can use this emerging knowledge to improve our expert training programs so as to provide better instruction in exploring issues, such as medicine, chemistry, and astronomy.

According to Gauthier, Williams, Tarr and Tanaka (1998), it is surprisingly easy to become an expert in object recognition. Their study aimed to discover whether people could be trained to be experts in object recognition. The researchers chose 24 random participants, and divided them into two groups. The basic hypotheses underlying the study were that "...expertise may mediate many apparent dissociations that occur in visual recognition...and that tuning of a single kind of visual representation can subserve both novice and expert object recognition performance" (p. 2401). One group was trained to differentiate fictitious creatures named greebles by gender and family features. The authors noted that the genders could be differentiated on "...the basis of the orientation of appendages". The family features could be distinguished by the "...shape of the main body" (p. 2403). The other group received no training. The researchers called the exercise expert training, wherein participants received variable amounts of training until they reached a pre-specified criterion. The researchers set one criterion for all subjects in the first group and conducted a training session lasting two weeks, one hour a day. The criterion was the recognition of the two types of features on an individual and categorical level. The researchers found a significant difference in the number of correct answers by participants who were trained than by those who were not. The participants who had had specific training in recognition of fictitious creatures were significantly more accurate than the group of people who had not been trained. Gauthier et al. concluded that object recognition of imaginary creatures can be learned and expertise can be obtained. This was one of just a few research studies that have proposed training procedures to shape expertise in mental object recognition. However, the design is still an issue since the basic statistical assumptions lay on the borderline of violation. The researchers did not assign individual names to the greebles; therefore, they believed that the subjects only became experts in the identification of shape and direction, not in the greebles themselves. It is the researcher's opinion, on the other hand, that this experiment only trained a group in expert recognition of greebles, not in object recognition itself. The real importance of this study, however, was not in the results themselves, but in the training process. Becoming an expert in object recognition is tricky because it can be difficult to decide the best method of instruction to use and the criteria by which learners become experts.

Gauthier, Williams, Tarr and Tanaka (1998) found that this proposed technique would be helpful in training people with normal eyesight to become experts at object recognition. They stated that human beings are face recognizers, and the recognition of faces is on a more subordinate level than the recognition of other objects (p. 2401). However, a recent study by Hildreth (1998) pointed out that face recognition involves an absolute coordinate system, just as in any other object recognition task. Pinker (1997) stated that "..people learn objects by mentally describing the various arms and crossing [an absolute] coordinate system centered on the object " (p. 280). The training method proposed by Gauthier et al. might increase object recognition performance as well as develop better skills for face recognition.

According to Gauthier, Williams, Tarr and Tanaka (1998), the greeble study and the proposed neural network model have two major points in common:

> First, the small amount of gradient-decent learning incorporated in the learning rule constantly pushes the network to respond most strongly to trained exemplars. Second, individuating information is explicitly stored (via the two-letter individual level label) for each trained exemplar in its associated identification-layer pattern (p. 2424).

Recognition of shaded fictional images, as seen in the greeble study, has been shown to be learnable. Further, expertise can be established in object recognition. However, Gauthier et al. argued that the training caused participants to learn more about how to learn than provided visual expertise on any given task. As noted previously, trainees were significantly better at recognition than the novice participants, but

> ...experts may have acquired a psychological similarity space capturing the variation among Greebles in the training set, and became very good at extracting the

diagnostic information about any one Greeble that differentiated it from other members of the set (p. 2425).

The control group findings showed a pattern of not recognizing objects within subcategories. This difficulty may have laid in a basic ignorance of the subcategories. Another reason might have been due to the position of the stimuli. Any change in the angle of the picture, for instance, can create a difference in perception and recognition (Nial, 1997). As well, the research shows that object recognition depends heavily on prior information about that particular object (Alivisatos & Petrides, 1997; Gauthier et al., 1998). For example, expertise in object recognition is functional only for a known object. In other words, dog judges may not be able to tell the differences among bird species as well as they can among dog species.

According to Nayar and Poggio (1996), the learning process is usually more successful when "...simple learning techniques based on statistics, pattern recognition, neural networks, and function approximation" (p. 2) are used in applications. Although these authors call the technique "low-level learning", what Nayar and Poggio really mean is that computerized imagery poses an alternate way for deducing the concept from image information, rather than extracting it from the task at hand.

It is well known that a picture is worth a thousand words, and no further explanation is needed. Visualization is useful, and occasionally the only tool to improve the learner's ability to conceptualize the context. Several studies (Avons, 1998; Brandimonte, Hitch & Bishop, 1992; Magnussen, Greenlee & Thomas, 1996; Marschark & Surian, 1992; Salthouse, 1995; Sharps & Price-Sharps, 1996; Tracy, Pabis & Kilburg, 1998) have found that in almost every case, visual materials do enhance what and how the student learns. In short, though students can explain ideas they learned from the text, they may not be able to visualize and recognize it without the pictures. In a study by Mayer, Bove, Bryman, Mars, and Tapangco (1996), 56 college students were assigned to one of four groups. One group was taught about lightning, using illustrations with short summaries. The second group received the same instructions with a full text. The third group received only pictures and the fourth had no training. Afterwards, the researchers tested the groups' problem-solving skills. The results showed that the first group instructed with illustrations and a short summary, scored the highest in the problem-solving tasks. The researchers concluded that students perform better at problem-solving tasks when pictures are combined with short synopses of material. The researchers emphasized that just having a still picture is not a sufficient context for students to explain a concept verbally.

Every type of visual representation, including notes, drawings and diagrams, can be used to help students construct neural networks of information (Saunders, Wise & Golden, 1995). With this multifaceted approach, students are able to connect new information to previous knowledge. Thompson and Wiegman (1993) stated that visualizing can sharpen such science processes as hypothesizing or inferring. Students can learn, in other words, to take known information and "read between the lines".

Visualization also assists teachers in improving classroom management and science methods. The method keeps students interested and involved.

In-service Teacher Education

Teachers need to undergo training at periodic intervals to update their professional background. In their noteworthy study, Dori and Barnea (1994) stated that the self-efficacy of a science teacher can be "...enhanced through intensive, short term in-service programs" (p. 3). The programs not only remind the teachers of important science content, but also make them aware of the newest technological and pedagogical options for teaching. Dori and Barnea asserted that these programs should run continuously because teachers generally do not immediately apply the new knowledge from an in-service program. Teachers tend to implement these methods in small increments which means that substantial changes in their classroom instruction occur only after about two or three years (Dori & Barnea, 1994). Overall, the researchers found a positive attitude change in teachers' confidence, and in their willingness to use computers from the training. In fact, teachers recently began to use computers more in their instruction. However, it is not necessary for every teacher education workshop to result in positive changes in attitude towards science teaching and computer usage in the absence of certain conditions. At the minimum, these workshops should include the following essential conditions:

- The training environment should be comfortable and relaxing. Essential resources, materials and quality support should be provided.

- The equipment demonstrated and discussed should be inexpensive and easily obtainable.
- New strategies and opportunities should be demonstrated over a period of time so fellow teachers can discuss and get corrective and supportive feedback.
- A first-rate instructional team should manage the hardware, software and other materials, and make them readily available.
- The most successful instructional approaches should be represented (Rudolph & Preston, 1995).

Teachers become more effective in instruction when these essential elements are provided. It can be inferred that an adequately designed workshop is likely to foster a focus on science objects and science teaching via image processing since image processing as a visual learning tool can increase the understanding and use of science processes. After such a workshop, teachers can provide better opportunities, such as hands-on activities or computer applications, to their students so their attitudes toward science and their ability to problem-solve can be further enhanced by the new techniques and materials.

Summary

The literature review brought out two decisive points. First, science teachers are generally not exposed to computerized visual learning and teaching tools. Therefore, they are ineffective in using computers for instruction. Lehman (1994) claimed that in 95.5% of the schools, teachers use computers only for drill and practice. The problem lies in the fact that beyond in-service programs, teachers rarely find an opportunity to learn how to use computers in instruction (Lehman, 1995). This insufficient computer and software experience can hinder teachers from overcoming a common computer user dilemma: computer anxiety. Teachers become distressed if information, experience or support personnel are not available. Once beyond the insufficient training and "computer-phobia" issues, how the computers are used is also important to both teacher and students. Using computers for drill and practice makes them only as effective as textbooks and encyclopedias, the latter of which are dry and static. In neither media is there any interaction between the learner and the media. However, computers set up as interactive media create a dynamic relationship with the computer user which allows for alterations in the process of learning, according to the learners' ability.

Second, IPT is a new field of application in which little scholarly investigation has been done. Visual learning theory (Paivio, 1971) offers one clear perspective. The theory posited that using ocular representations can embellish classroom instruction. One can explicate from such an idea that implementing visual learning theory in the classroom includes using differing visual cues as instructional techniques, such as texts, illustrations, movies, animations and sounds. Image processing as a new technique could produce further value in visual learning theory with an appropriate combination of these media, but how these components should be combined is yet to be fully investigated. The same is true of the connection between the proper application of in-service programs and the suitable use of image processing. This study will examine how a series of workshops on image processing affected teachers' subsequent application of computers. The results of this study can be used to evaluate not only the benefits of using image processing techniques from the teachers' perspectives, but also shed light on the efficacy of the workshop series used by Center for Image Processing in Education (CIPE).

CHAPTER III

METHODOLOGY

This study is based on a survey that attempted to find out whether science teachers effectively used IPT in their classrooms after attending the workshops. A survey is considered a "snapshot" of current attitudes and behaviors. The data gathered from the survey can be in the form of counts, frequencies, attitudes, or opinions. A variety of methods can be used to analyze the survey data: statistical, descriptive or content analysis methods. Statistical methods involve the inferring of numerical values to compare means, variables or groups. Descriptive methods are used to characterize the data, using percentage, central tendency (mean, median, etc.), or variance. Content analysis is utilized for extracting a textual pattern, using pre-determined themes or keywords. Content analysis is used for open-ended responses in a survey. These survey packages effectively investigate interactions among variables. Even so, preparing questions and ensuring their validity requires a lot of careful attention (SPSS, 1995). Validity and reliability issues have to be handled carefully.

Validity refers to the extent to which an instrument measures whatever is intended. To be valid, a survey needs to be designed in such a way that the definitions of variables agree with what is measured. Generally, the decision on an instrument's validity is straightforward. One does not have to be an expert to determine validity. Given the theoretical definitions of a variable, the validity of a measure is predicated on the strength of the relationship between the theoretical and the operational definitions. If the theoretical definition does not match the operational definition, the instrument is not valid.

The reliability is the extent to which the instrument remains consistent across measures. That is, the rate and score of an item or response does not change according to the identity of the researcher, or the context of the experiment. Different scorers agree on the same results. With so-called 'indefinite scoring' (answers to open-ended questions) reliability is a concern because a response can be judged in a subjective way. The reliability of an instrument is measured through item analysis. The correlation between the items is calculated, and the mean correlation coefficient obtained. Item analysis in statistical packages yields reliability in the Cronbach alpha (α) value. If the instrument is reliable, the Cronbach's α will be high.

Instrument Development

This study is more a look at the past since the workshops (read: treatments) were held one to three years before the current study was done. The best way to scrutinize how teachers were affected by the workshops was to simply ask them. The survey method was chosen to investigate whether the selected teachers had used Image Processing for Teaching (IPT), and how they were affected by the techniques that the IPT workshops offered.

Content

Four different categories were extracted, based on the literature review, research questions and input from the committee.

Skills. This section determined whether the subjects felt their teaching skills were sharpened by the workshops. Shacar (1997) noted that teachers' self-efficacy, generated by sufficient background knowledge in their subject areas, increases teachers' ability to teach well. For example, teachers generally become more effective when they believe they possess adequate background knowledge on their subject. The belief that they would be more effective as a teacher can be one of the reasons affecting their use of IPT.

Equipment availability. Technological equipment and human resources are necessary tools for the computer-assisted instruction (CAI) technique to be implemented. Lehman (1994) noted that teachers tend to rarely use technology in their classroom when equipment is not readily available with technical support. As mentioned previously, it is important to supply assistance since computer anxiety can be reduced by providing adequate technical equipment with technical assistance personnel. However, even if the personnel is not available, if teachers feel comfortable with the technology, they will tend to employ it in their instruction.

The value of IPT. One of the reasons teachers use a new instructional tool is the teachers' belief about the new tool's instructional value. In order to implement IPT, teachers should be instructed in its educational applications as a new teaching technique. If the workshops on IPT are effective, teachers will respond to this idea more positively, but if they attach a low value to IPT, teachers will be less likely to employ the new technique in their classrooms.

Table 1

Item grouping

Item	Group letter	Group name
2. The IPT workshop provided me sufficient basic technical skills to use these materials in school.	A	Skills
3. I have difficulty in implementing IPT because I am not sufficiently trained in technology.	A	Skills
4. Technology involved in using IPT is complex and difficult to implement	B	Equipment
5. I have sufficient amount of equipment to implement IPT in my classroom.	B	Equipment
6. I am able to implement image processing in my classroom.	B	Equipment
7. Using image processing is worth the time and effort because it helps students' understanding of science concepts.	D	Curriculum
8. The science content covered by the IPT sourcebook is appropriate for my students' level of understanding.	D	Curriculum
9. The IPT sourcebook covers topics that are included in the science curriculum of my school.	D	Curriculum
10. The IPT sourcebook provides sufficient hands-on experience for science learning.	D	Curriculum
11. Image processing is an effective way to teach science.	C	Value of IPT
12. The IPT source book is easy to understand for implementing in the classroom.	C	Value of IPT
13. I feel good about using IPT materials in class.	A	Skills
14. The IPT materials are too advanced for my students.	C	Value of IPT
15. By learning computerized visualization techniques in the image processing workshops, I feel I can be more effective with my students.	A	Skills
16. Computerized visualization tools are useful for teaching science.	C	Value of IPT
17. Certain abstract concepts can be learned better when I teach them using IPT.	C	Value of IPT

Greenberg (1992) highlighted the worth of image processing techniques in general and outlined how IPT is implemented. When teachers feel that they can make effective use of IPT in instruction, they hold positive beliefs about it. Hence, one of the factors that affect IPT usage in classrooms is whether teachers see instructional value in the program.

Curriculum match. A new technology or instructional technique should sufficiently fulfill students' needs if it is to be implemented. The use of a new instructional technique depends on whether it can assist in achieving given educational objectives.

Using the above four categories, a set of 20 questions was compiled. The questions were revised, using the feedback from a pilot study, and the 16 questions were finalized for the instrument (Table 1). These 16 questions covered the research questions, "How valuable do science teachers think Image Processing workshops are to their professional improvement?", and "How do science teachers consider IPT as a science teaching tool?".

The instrument prepared for this study can be found in Appendix A. The first nine items were intended for demographic purposes. The questions about gender, years of teaching experience, and subjects taught assisted in identifying and clustering results. The first question in the second group of the survey answered the first research question, "Do science teachers use Image Processing for Teaching after they have gone through an IPT training program?" The question in the survey form read: "Have you ever used Image Processing in Teaching in classroom settings after you attended the workshop?". The participants were divided into two groups, based on 'yes' (users), and 'no' (non-users) answers to this question. Group one consisted of participants who used Image Processing for Teaching (IPT) in their classroom instruction, and group two consisted of those who did not.

The second group of questions determined how participants judged the value of IPT. These questions were created using the above four categories. The teachers' beliefs about IPT as a new instructional tool and a new technology were probed.

Another set of five questions was prepared for the research question " How do science teachers use Image Processing for Teaching (IPT)?" The contents of the IPT sourcebook were sequenced by increasing level of difficulty, and included four questions that yielded teachers' answers about the frequency with which they used Image Processing applications. One question about the usage of IPT was how frequently teachers used the IPT sourcebook. The aim was to determine the level of difficulty of the activities used in classroom, and the frequency with which they were employed. This part of the questionnaire (questions 18 to 22) provided information on teachers' actual use of IPT or image processing.

Open-ended questions provide detailed explanations for questions in the second and third group of items. This part provided information about how the subjects really felt about IPT and its implementation. The questions probed the difficulties; advantages and disadvantages, and the required resources for the implementation of IPT.

After a small-scale pilot study was carried out with 20 subjects, the questionnaire was finalized, using the results and feedback from a pilot study. The pilot study was designed to give highlights of the implementation of IPT after a local workshop. Twenty teachers from Cincinnati Public Schools had responded to a questionnaire after attending the IPT workshop. Three of them were selected for a personal interview. The results of the pilot study showed that 55 % of the teachers had used IPT in their classroom at least once after they attended the workshop. The second group of questions in the current study was developed, using these participant reports from the pilot study.

Validity and Reliability

The validity issue was addressed by using content validity procedures, The instrument was inspected by a group of experts familiar with the subject. They were asked to review the instrument independently to determine whether the instrument could provide the proper data for the research questions. Grouping items in four categories was also discussed and examined by the experts. The items were placed into four categories after reaching full agreement. Questions that showed disapproval were dropped from the final version. The item analysis provided the strength of the reliability measure (see Table 2). For the first 22 items, the Cronbach's α value was 0.91, a score which showed high reliability.

Table 2

Reliability measures for the items in the questionnaire

Item Numbers	Cronbach's α
2-17	0.91
18-22	0.86
Group A	0.79
Group B	0.61
Group C	0.81
Group D	0.82

Limitations

It is assumed that the participants would respond honestly and openly to the Web survey. Since the response rate was low, some bias might exist. The respondents in this study were likely to have more positive beliefs than the total population. The survey was carried out toward the end of the school year, hence the participants had already interest in the subject. Since the science teachers had willingly attended the IPT workshops, the participants in this study had a positive view about using technology and computers.

Sample

The current study sampled 500 teachers out of 2000 workshop alumni from the U.S., and two from Canada. The teacher sample was selected randomly. A random number was assigned to two thousand records in the database, and then the list was compiled in numerical order. Five hundred records were selected for the study. The demographic characteristics of teachers were gleaned from the questionnaire, and the database provided by CIPE (Center for Image Processing in Education). The database included the following information on workshop attendees: Gender, first name, last name, position, subject, work address, zip code, phone number and e-mail address. Of all the subjects, only 17 did not have e-mail addresses. Fifty-two percent of the respondents were male, and 48 % female. Another eight participants were from the IPT conference and the responses were gathered using the same questionnaire. Further discussion on the characterization of the sample is included in Chapter IV.

Data Collection Procedures

A self-prepared questionnaire was used as instrument, and the data analyzed through descriptive statistical methods. Each subject completed the same questionnaire independently. An Internet questionnaire form was prepared so that participants could fill out the questionnaire on the Internet, if available. The URL address was sent via e-mail with the questionnaire attached; the questionnaire was also sent via ground mail to subjects who failed to respond to the e-mailed form.

Internet surveys are relatively new to the research community. However, computer system professionals and businesses have recently begun to realize that using Internet survey methods reduces time and effort, and increases the effectiveness of surveys. Effectiveness represents time and design advantages. Web surveys give the researcher the flexibility to construct the design, according to the needs and type of the study. It requires less time in both the data collection and the analysis steps. By using Web forms, researchers can receive responses immediately, and subjects need less time to complete Web forms than paper and pencil surveys. In addition, Web forms can be composed, at little cost to researcher and participants. There are several methods for surveying user populations through the Internet.

Table 3

Comparative table of the Internet versus traditional surveys.

Web surveys[a]	E-mail surveys[b]	Traditional surveys
Quick response (point and click). Participants can put a checkmark, or select from a pull-down menu with a click.	Electronic typing is needed. Every response should be typed.	Handwriting is required. It causes problems due to different handwriting characteristics.
Structured responses can be provided. The type and length is consistent.	Layout may be changed due to differences in e-mail program configuration.	Control over structure is limited. The participant cannot be forced to enter uniform response.
The participant has a chance to review the responses. They can change the responses before sending.	Participants have no chance to review after sent. The final form of responses is not visible to them.	Changing responses causes problems, and analyzing the results can be difficult due to scrambles.
The design complexity can be reduced. Instructions can be on a separate page.	Design cannot be applied. Programs can change the design.	Design can be implemented, but consistency is not assured.
Survey can be dynamic. Choices can be arranged during the session.	Survey cannot be dynamic.	Survey cannot be dynamic
Time and space is flexible. Participants can fill the survey whenever and wherever the Internet connection is available.	Time and space is less flexible. Participants need to be on a computer with their e-mail is configured.	Time and space is not flexible. Further effort is required to send.
Internet connection is a requirement.	E-mail program has to be installed	No individual requirements

Notes. [a] Pitkow and Recker 1995. [b] Mavis and Brocato 1998.

One of the survey tools is e-mail. The researcher can post the questionnaire in an e-mail message to electronic newsgroups or send it to subjects by means of electronic mail servers. The e-mail usually includes survey questions; instructions on how to fill out the questionnaire, and how to send it. The survey form includes fill-in the blanks and multiple-choice questions.

Participants use their keyboards to type an X mark or fill in the blank; then they send it to the researcher. This kind of Internet survey carries certain advantages and disadvantages over the traditional kind.

One advantage of e-mail surveys is that, like other types of Internet surveys, e-mail surveys reduce time, effort and cost by using electronic forms of communication. A disadvantage is that e-mail surveys are not as flexible as World Wide Web (WWW) surveys, and thus, it can be difficult obtain uniform data (see Table 3).

Another Internet survey form is Web technology, which was the primary technique used in this study. The researcher converts questionnaires into a hypertext markup language (HTML) format. This document contains a Web form into which the text is entered and questions answered. Then the Web application software gathers the data and sends it to the server. The whole set is put into a file to be analyzed later. The file format can be a text, spreadsheet, or database. One of the advantages of using Web surveys is that few choices are provided for participants to select. This is important because the reliability of an instrument decreases as the choices for participants increase. Another advantage is that the data is uniform, and consistent across responses. Traditional surveys yield more divergent responses that require more time and effort to analyze, whereas Web surveys, with consistent responses across questions, take less time and effort. Thus, in the latter survey form, researchers can obtain structured and uniform data.

The data collection procedure employed in this study was the Web technologies, but the other methods were also used to inform the participants about the Web address of the questionnaire.

Data Analysis

The analysis methods in this study varied from descriptive to inferential to content analysis. In order to adequately answer each research question, a different analysis method was used for each. Descriptive statistical methods were the only way to analyze the demographic data. The percentages and means of the responses were calculated, and cross-tables were created, showing a summary of the data. Inferential statistical methods were used to compare groups of users with non-users. The analysis was completed by using ANOVA (analysis of variance). The assumptions and requirements of ANOVA were taken into account and presented in the results section. Finally, a content analysis was applied to the open-ended responses for analysis.

CHAPTER IV

DATA ANALYSIS

Introduction

The purpose of this study was to investigate whether science teachers used the Image Processing for Teaching program after they completing a week long training in its use. The categories identified on page 37 were selected, and the survey questions grouped, according to category. The survey was e-mailed to the subjects with the HTML form attached. The Web address from which the original Web form originated was also sent to participants. The researcher's ground mail address and phone numbers were included in the cover letter. To address ethical issues, a statement that assured anonymity was included in both formats -- the Web and the hardcopy. The results were collected through a Web application written in Active Server Pages (ASP), and were saved in an Access © database file. The complete code for the Web application is found in Appendix C. Each record was coded with a single key number. The data was analyzed using a variety of methods, including descriptive and comparative methods. With descriptive methods, subjects were identified by their basic characteristics, and with comparative methods, a difference was drawn between subjects who used IPT in their classrooms (users group) and those who did not (non-users group).

Sample

The initial sample size was, as noted previously, 458, a number which was randomly selected out of 2000 workshop alumni. Four hundred ninety-one had an e-mail address in the database. An e-mail message was sent to these 491 participants and a ground mail message was sent to the remaining 11. Of this, 40 participants responded by Web form in the first attempt, and 18 % responded by surface mail to the first message. Eight from postal mail and 208 from e-mail message were returned due to incorrect address. Then the researcher sent a surface mail message to 187 subjects, along with a cover letter. Of these 187 postal messages, nine were undeliverable due to incorrect address, and four people wrote back stating they were unwilling to participate. These latter records were not used. On the e-mail side, the second attempt was carried out with 257 e-mail messages, excluding the returned messages from a previous attempt. The response rates for this attempt were 8 % for e-mail (n=21), and 12 % for surface mail (n=22). A third message was then sent to 228 people of whom 2 % responded. The bounced and returned records were deleted from the database (see Table 4 for the sample summary).

Another 35 responses were gathered from the attendees of a conference about Image Processing for Teaching. Of these 35, there were 22 participants who were in the initial database. Eight participants were not in the database file and they were added. Four participants had already responded via email or surface mail, (duplicate responses) so these four responses were discarded.

Table 4

Summary of responses

Total Records	Responded	Decided Not to participate	Bounced (Not reached)	Non-respondent
508	116	14	50	328

The response rate for the entire sample was 28%. This is a notably low percentage for a hypothesis testing analysis. The response rate would not have increased by sending more messages to subjects because of circumstances beyond the researcher's control. The timing of the survey at the end of the school year reduced the number of responses. In addition, many of the e-mail addresses remained unused or unchecked for the same reason. Another parameter that might have affected the response rate could have been changes in Internet service providers, schools or addresses. Table 5 shows the changes in the response rate over time.

Table 5

The change in the response rate over the time

	E-mail (N=490)		**Ground mail (N=197)**	
	Response	Non-response	Response	Non-response
First attempt	40 (15 %)	239 (85 %)	3 (18 %)	9 (82 %)
Second attempt	21 (8 %)	236 (92 %)	22 (12 %)	156 (88 %)
Third attempt	5 (2 %)	223 (98 %)		
Total N	116			

The numbers in Table 5 did not add up to the total numbers because of duplication and insufficient addresses. The total number of responses from all attempts was 116 out of a working total of 458 participants. (50 people did not received the questionnaire through repeated procedure.

Representative Sample

Since the overall response rate was very low (28%), making a generalization using statistical tests is difficult. This barrier was overcome by investigating certain characteristics of the sample, such as participants' gender, location and subject area, and for the groups of respondents and non-respondents were not different for the given criteria.

First, the analysis was carried out by determining the geographical location of participants and calculating the percentages of subjects from each location. Then subjects were divided into two groups; one group consisted of subjects who responded, and the other group consisted of those who did not.

The same procedure was carried out for gender and subject area. Then the two groups were compared, using the test of variance. The analysis (see Table 6) showed that there was no significant difference between respondents and non-respondents. In other words, respondents and non-respondents were not statistically different in the region of the U.S. they resided in, their gender, and the subjects they taught. None of the probability (p) values was smaller than 0.05. One can infer from these results that the sample was representative for the whole data set of 508 people on the three criteria covered (see Table 6), even though the response rate was low.

The biggest difference between respondents and non-respondents was in the subject category, Administrative subgroup.

Table 6

Comparison of non-respondents with respondents

	Respondents	Non-respondents	F (p)
Location			
Northwest	20 %	17%	1.010 (0.497)
Southwest	35 %	36 %	
Northeast	41 %	42 %	
Southeast	3 %	5 %	
Gender			
Male	51 %	52 %	4.000 (0.295)
Female	49 %	48 %	
Subject			
Science	27 %	26 %	1.167 (0.428)
Math	9 %	10 %	
Administrative	13 %	18 %	
Biology	14 %	10 %	
Physics	14 %	14 %	
Art	3 %	7 %	
Computer	7 %	6 %	

The results of this study can be utilized within the limitations caused by the response rate. However, the survey produced valuable information that can be used to enlighten the effects of Image Processing for Teaching (IPT) programs on teachers.

Demographic Data

The answers for the first group of questions were analyzed through descriptive methods. The subjects were coded into seven categories (see Table 7 for frequencies).

Table 7

Frequency distribution of demographic data.

Item	Frequency	Percentage
Gender		
Male	59	51%
Female	57	49%
Degree		
Bachelor	26	23%
Masters	76	68%
Doctorate	10	9%
Grade		
K-5	9	8%
6-8	46	40%
9-12	50	43%
College	11	9%
Subjects		
Science	32	27 %
Math	11	9 %
Administrative	15	13 %
Biology	16	14 %
Physics	16	14 %
Art	3	3 %
Computer	8	7 %

The results showed that 51% of the subjects were male while 49 % were female. Those with bachelor degrees comprised 23% of the sample while those with master's and doctorates comprised 68 % and 9 %, respectively.

Most of the respondents taught 6th through 12th grades (83%), and more than half taught science. Their average teaching experience was 18.5 years, given a standard deviation of 8.7 years (see Table 8). The subjects' mean age was 45.6 years (with a standard deviation of 7.8). The subjects attended, on average, the workshops 2.1 years ago (with a standard deviation of 1.7).

Table 8

Mean and standard deviation of some demographic variables.

Variable	Mean	Standard Deviation
Age	45.6	7.8
Experience	18.5	8.7
Workshop attendance	2.1	1.7

Findings

The collection of data was organized through a Web form and through surface mail, and the data stored in a database file. SPSS software package was used to analyze the data.

The first results came from the first research question. Question one read: " Have you ever used image processing in classroom settings after you attended the workshop?". Seventy-seven percent of the participants answered "yes" to this question (see Table 9). The high percentage of positive response to this question indicates that more than three-quarters of the sample used Image Processing at least once, and only less than a quarter did not.

Table 9

The Percentages of participants

Users (%)	Non-users (%)
77	23

For the second group of questions (two through seventeen), a scale was generated to appraise the level of agreement. For items two through seventeen, the choices from strongly agree to strongly disagree were converted into response codes from 1 to 5 in decreasing agreement.

Table 10

The scale used to encode responses.

Abbreviation used in survey	SA	A	U	D	SD
Meaning	Strongly agree	Agree	Uncertain	Disagree	Strongly disagree
Code number	1	2	3	4	5

The mean was calculated for each question by adding the response codes for one question across subjects and dividing the sum by the number of respondents. The smallest mean value showed the greatest agreement. Using this same coding strategy, the mean and standard deviation for a second group of questions were calculated.

Table 11

Overall results about beliefs of participants toward IPT (Item 2-17)

	Mean	Standard Deviation	t	p
Non-users	2.55	0.77	5.022**	0.000
Users	1.90	0.67		

** significant at $p<0.01$

For questions two through seventeen, the mean for users was 1.90 (see Table 11) (SD = 0.67). Overall, these results showed that users seemed to have more positive beliefs about IPT and its implementation than non-users (M = 2.55, SD = 0.77).

Table 12 was generated from the responses of non-users. The researcher rank ordered the items from strongly agree to strongly disagree on the table. As can be seen from Table 12, the smallest mean in the non-user group belonged to the 16th item in the questionnaire. The item read as follows: “Computerized visualization tools are useful for teaching science”. Participants strongly agreed with this statement.

The mean of greatest disagreement for the non-user group was 3.48 (SD = 1.42) which was seen in item number six, a sentence: “I am able to implement Image Processing in my classroom”. The second greatest disagreement occurred on the item, “I have sufficient amount of equipment to implement IPT in my classroom”. The mean was 3.00 (SD = 1.49). This value is the response code for the choice “uncertain”, and it means participants do not agree with the statement.

Table 12

Non-users' responses to question two through 17.

	Non-users	
Question	M	SD
16. Computerized visualization tools are useful for teaching science.	2.11	0.70
2. The IPT workshop provided me sufficient basic technical skills to use these materials in school.	2.19	1.04
7. Using image processing is worth the time and effort because it helps students' understanding of science concepts.	2.26	0.90
11. Image processing is an effective way to teach science.	2.30	0.78
9. The IPT sourcebook covers topics that are included in the science curriculum of my school.	2.33	0.83
3. I have difficulty in implementing IPT because I am not sufficiently trained in technology.[a]	2.37	1.21
12. The IPT source book is easy to understand for implementing in the classroom.	2.41	0.84
14. The IPT materials are too advanced for my students.[a]	2.41	0.89
17. Certain abstract concepts can be learned better when I teach them using IPT.	2.42	0.76
4. Technology involved in using IPT is complex and difficult to implement.[a]	2.44	0.97
15. By learning computerized visualization techniques in the image processing workshops, I feel I can be more effective with my students.	2.48	1.01
8. The science content covered by the IPT sourcebook is appropriate for my students' level of understanding.	2.56	1.12
10. The IPT sourcebook provides sufficient hands-on experience for science learning.	2.63	0.97
13. I feel good about using IPT materials in class.	2.81	0.80
5. I have sufficient amount of equipment to implement IPT in my classroom.	3.00	1.49
6. I am able to implement image processing in my classroom.	3.48	1.42
(a) Numbers were reversed because of negative statement		

Table 13 shows the results of users' responses to the second group of questions. The strongest agreement seemed to be for the second item in the survey:

"The IPT workshop provided me sufficient basic technical skills to use these materials in school". Also, item 16 produced a close mean value to the second item.

The least agreement was found in the area of equipment availability: "I have sufficient amount of equipment to implement IPT in my classroom". The mean was 2.46 (SD = 1.33), meant that teachers did not completely agree with the statement.

Table 13

User's responses to questions two through seventeen.

	Users	
Question	M	SD
2. The IPT workshop provided me sufficient basic technical skills to use these materials in school.	1.54	0.69
16. Computerized visualization tools are useful for teaching science.	1.57	0.67
3. I have difficulty in implementing IPT because I am not sufficiently trained in technology.[a]	1.71	0.68
13. I feel good about using IPT materials in class.	1.75	0.77
7. Using image processing is worth the time and effort because it helps students' understanding of science concepts.	1.76	0.75
11. Image processing is an effective way to teach science.	1.76	0.78
17. Certain abstract concepts can be learned better when I teach them using IPT.	1.78	0.77
6. I am able to implement image processing in my classroom.	1.82	0.95
12. The IPT source book is easy to understand for implementing in the classroom.	1.90	0.80
15. By learning computerized visualization techniques in the image processing workshops, I feel I can be more effective with my students.	1.90	0.89
9. The IPT sourcebook covers topics that are included in the science curriculum of my school.	1.93	0.93
4. Technology involved in using IPT is complex and difficult to implement.[a]	2.02	0.99
8. The science content covered by the IPT sourcebook is appropriate for my students' level of understanding.	2.03	0.82
14. The IPT materials are too advanced for my students.[a]	2.08	0.97
10. The IPT sourcebook provides sufficient hands-on experience for science learning.	2.13	1.06
5. I have sufficient amount of equipment to implement IPT in my classroom.	2.46	1.33

Note. (a) Numbers were reversed because of negative statement

Further analysis on the mean comparison of grouped items was carried out using ANOVA. The four categories mentioned on page 37 were used to aggregate the means of each item. The results are presented in Table 14.

Table 14

ANOVA results

Grouped Items	Item No	Group	N	Mean	Std. Dev.	F	Sig.
A (Computer Skills)	2, 3, 13, 15	Non-users	27	2.47	*0.76*	29.57**	0.000
		Users	89	1.72	*0.58*		
		Total	116	1.90	*0.70*		
B (Equipment Availability)	4, 5, 6	Non-users	27	2.98	*0.94*	21.87**	0.000
		Users	89	2.10	*0.82*		
		Total	116	2.30	*0.92*		
C (Value belief)	11, 12, 14, 16, 17	Non-users	27	2.33	*0.53*	15.71**	0.000
		Users	89	1.82	*0.61*		
		Total	116	1.94	*0.63*		
D (Curriculum Match)	7, 8, 9, 10	Non-users	27	2.44	*0.83*	9.18**	0.003
		Users	89	1.96	*0.69*		
		Total	116	2.08	*0.75*		
Overall result						8.96**	0.000

Note. ** Significant at $p < 0.01$

As indicated in the above table, the users and non-users had significantly different responses to grouped items. Group B, which represented the technology concern, had the largest mean. The results showed significant differences among the users and non-users about the availability of equipment for their use. The homogeneity of variance was tested, and it is found that the assumption was not violated (Levene statistics 0.722, $p<0.397$).

The question, "How the teachers used IPT in their classroom", revealed the results in Table 15. Seventy-seven percent of participants used Image Processing techniques for only showing pictures related to the task at hand in classroom. Only 21% employed macros and automated analyses, which can be called as high level image processing techniques.

Table 15

Percentage of use and disuse of IPT

Type of Application	Percent of Use	Never Use (%)
Use of IPT Sourcebook	72	28
Using images in classroom	77	22
Creating images as classroom activity	68	32
Creating animations	61	39
Using macros and automated analyses	21	79

Another analysis was conducted, using the third group of questions in the survey form. As mentioned previously, this part queried the actual classroom use of Image Processing for Teaching. The choices for these five questions (18 through 22) were coded from one to four in decreasing frequency (see Table 16). The overall mean for this part was 3.22 (SD = 0.58).

The use of IPT focused on three types of applications (see Table 16): a) using images (77 %), b) Creating images (68 %), and c), Creating animations (61%). Only 21 % of the teachers were using macros and automated analyses. The IPT sourcebook usage was 72 % among the respondents.

Table 16

Analysis of questions 18-22

Type of use	More than two times per week (%)	More than once per week (%)	Less than once per week (%)	Never (%)	M	SD
Use of the IPT sourcebook	4	16	52	28	3.04	0.79
Use of digital photos, maps, images	6	19	52	23	2.91	0.82
Creating, drawing or editing digital images	5	13	50	32	3.07	0.81
Creating animations and image stacks	2	7	52	39	3.29	0.67
Writing macros and automated analyses	0	2	19	79	3.77	0.46
Overall					3.22	0.58

The correlation between the four categories on page 37 and the use of IPT in the classroom was sought which yielded the results in Table 17.

Table 17

Pearson Correlation matrix for four groups and use of IPT.

		A (Skills)	B (Equipment)	C (Value Belief)	D (Curriculum Match)
USE	Correlation Coefficient.	0.512**	0.466**	0.503**	0.423**
	Sig. (2-tailed)	0.000	0.000	0.000	0.000

Note. ** Significant at $p<0.01$

The strongest correlation was between the frequency of IPT usage, and teachers' concerns about their teaching skills. Items representing self-efficacy beliefs were closely correlated to frequency of IPT usage. The relationship between frequency of use, and the matching of IPT with curricular standards evidenced the weakest correlation coefficient (see Table 17).

The results of this study showed that there was no difference between male and female respondents on any of the responses. The analysis by subject taught produced no significant results on any item. The master's degree was the major academic degree among the respondents, but other degree holders were not significantly different in their responses. There was no significant correlation between age and IPT usage.

CHAPTER V

CONCLUSIONS, DISCUSSION AND RECOMMENDATIONS

Summary

The study was carried out to determine whether teachers used Image Processing for Teaching (IPT) in their classrooms after they had attended workshops conducted by Center for Image Processing in Education (CIPE). The sample (458 teachers) was selected randomly out of 2000 workshop alumni. A Web survey was employed and the Web address was mailed to them. The responses were gathered in a database file and analyzed using descriptive, statistical methods, and content analysis. The results showed that 77% of teachers had used IPT at least once. Many users reported that they need more equipment and technical assistance. They also suggested that the PC version of software, Scion Image, should be revised and made available to implement IPT effectively.

Another result was the need for new series of workshops where teachers can share their experiences and ideas on how to use IPT more effectively. They reported that they want to know more about how to bring IPT in line with their curriculum. The activities and images were selected for general curricular guidelines, and were unable to serve specific programs.

The respondents who did not use IPT exhibited three main reasons. First, the equipment was not available or inadequate. The number of computers in the classroom was insufficient or unavailable for the number of students. Second, the results showed that they were not proficient in using the computer technology and in troubleshooting. The use of IPT in classrooms requires ability to solve technological problems and teachers were not fully qualified to solve computer related problems. Especially during a class period, they were anxious about interruption of activity due to computer usage. This is one of the reasons that they hesitate to implement IPT in classroom.

The third reason was the lack of the curriculum match. The activities in IPT sourcebook were not completely adaptable with different curricular guidelines, or participants were inadequately instructed about the alignment.

IPT offers a constructive and collaborative media that combines with useful aspects from the visual learning theory. The workshops on IPT instructed teachers in the basic skills of underlying visualization techniques. However, not every teacher used image processing in classroom because of the obstacles created by equipment availability, lesson preparation time, and the adaptability of the curriculum.

Conclusions

The analysis of item one showed that a majority of the participants (77 %) had used Image Processing in Teaching (IPT) at least once in their classrooms. According to the analysis of this group (the users group), users responded more positively to questions two through seventeen ($M = 1.90$, $SD = 0.67$). This finding indicated that teachers who used IPT in their classroom had more positive beliefs toward Image

Processing techniques. The most positive belief was on item two, "The IPT workshop provided me sufficient basic technical skills to use these materials in school. ". Participants believed that the workshops were useful for their professional improvement, and they stated that they needed even more workshops in the future to ensure sufficient use of these materials. It was found that the subjects believed in the value of Image Processing techniques (M = 1.57, SD = 0.67). The open-ended answers also confirmed that using computerized visualization techniques were favored by the participants. They found IPT very useful for teaching science, getting students' attention, and covering a wide subject area. Teachers reported overall that IPT helped students stay on task, and learn at a deeper level.

Users of IPT

According to Table 15, 77% of participants used digital images in their classrooms. However, the percentage of IPT sourcebook and CD-ROM usage was only 72 %. This means at least five percent of the subjects used other sources for images and activities rather than the IPT sourcebook. Teachers may have used alternate sources because of the type of system on the computers. The open-ended answers suggested that teachers were not able to use the sourcebook and the CD-ROM since the CD-ROM would not work on IBM compatible computers. One teacher specifically reported in question 27 that the two reasons why he avoided using the sourcebook and CD-ROM were: " 1) Mac/IBM bugs frustrate novice users, 2) IPT instructions [are] not specific enough (Cookbook form) to teach basic lessons". Another reason for the avoidance was the availability of equipment and technical assistance. As noted earlier, Lehman (1994) claimed that equipment and technical personnel availability could be very effective for the teacher's use of technology. These findings parallel the literature review.

The analysis of open-ended comments pointed out that the users need to share ideas and activities in order for IPT to be more effective. These teachers stated that they could use the preplanned lessons well, but in order for them to create their own lessons, they needed more advanced regional workshops. In other words, teachers expected quality assistance for short-term implementation, and suggested anywhere from one to five days of training to gain expertise in this area. They expressed appreciation for the National Imaging Technology Education Conference (NITEC), but several teachers complained that the NITEC was not conveniently located for everyone. Time and location limitations did not allow them to attend conferences and improve themselves on Image Processing for Education.

Non-users

The results indicated that 23 % of the participants had not used Image Processing for Teaching after they underwent training in a workshop. The responses to questions two through seventeen showed an agreement on that computerized visualization techniques were useful for teaching science among non-users (see Table 12, M=2.11, SD=0.70). There also was an agreement in the belief that the IPT workshops provided sufficient technical skills to use these materials in school. The analysis, however, indicated clearly that the most disagreement occurred on the statement, "I am able to implement image processing in my classroom". Teachers believed that they were unable to use the IPT materials effectively in classroom instruction. The data analysis for understanding the reasons was carried out further by grouping items 2 to 17 dealing with equipment availability, computer skills, belief on value of IPT and curriculum match.

Equipment Availability. Since the second highest disagreement was on the statement about sufficient equipment availability (see Table 12; M=3.00, SD=1.49), it is clear that participants felt that the equipment required for implementing IPT was inadequate. Many teachers reported on open-ended questions that the basic problem was access to the computers. They said that the students had to work in groups because of an insufficient number of computers. In some cases, the teachers could not use IPT at all because the computers in the classroom were IBM compatible computers, and the material was created only for Mac. Although an IBM version of the program is available through the Web, there are two main reasons why teachers could not efficiently use the software:

First, the program had been converted from the version that was created exclusively for Mac computers. The conversion process hardly produces fully adaptable software, and the teachers reported lots of bugs crashing the network systems. As such incidents happened, they missed a significant period of using IPT because of the lack of trained personnel to troubleshoot.

The second reason was the lack of other sources (image files and activities), designed for IBM compatible computers. Even though teachers managed to run the software on an IBM machine, converting the image files and creating the activity sheets consumed too much time. The image files included in the CD-ROM were for Mac computers and IBM machines could not use those files efficiently.

Another obstacle in the equipment was the lack of peripheral devices. In the IPT workshops, teachers were trained in importing images from various sources. These sources include scanners, digital cameras, and video capture equipment. In this study, the participants reported that when they managed to run IBM versions of the program, they could import images, but they lacked the sources to create activities.

Skills. According to the results of ANOVA, the second largest mean was in the item group named "skills", but the mean value (2.47) was closer to the choice "Agree". Table 12 also shows in item 13, "I feel good about using IPT" a mean of 2.81 (SD = 0.80). However, the open-ended responses provided enough confirmation that teachers felt satisfied with what the workshop offered, in general. Further, item two, "The IPT workshop provided me sufficient basic technical skills to use these materials in school", with the mean of 2.11 (SD = 0.70) showed the strongest agreement among non-users. This finding showed that teachers were instructed sufficiently in the basic skills to use IPT. The disagreement in item 13 might be because of the equipment and software-related obstacles. Considering the correlation between teachers' beliefs about their skills and the frequency of use, (see Table 17 and Table 14), it can be inferred that the ones who had the greatest self-efficacy beliefs tended to use IPT more often. The problem at hand was that they did not feel confident in how to troubleshoot. Item three, "I have difficulty in implementing IPT because I am not sufficiently trained in technology, " resulted in weaker agreement than item two. The semantic difference between the two statements was caused by the word "basic". According to these results, the workshops were effective in training teachers about basic technological skills, but not in solving more complex technical issues that they faced (ones they reported in the open-ended responses) in the classroom.

Curriculum match. These items were included in the questionnaire to see how well teachers perceived IPT materials to match with their curriculum. According to Table 12 and Table 14 (M = 2.44, SD = 0.83), the suitability of IPT for participants' curriculum was uncertain. They believed, on the one hand, that using Image Processing was worth the time and effort because it helped students understand science concepts, but on the other hand, in open-ended responses, teachers' major concern was that prep time for IPT activities was too lengthy. The differing views could imply that using computerized visualization techniques meets students' needs, but that IPT materials as a tool for this purpose required additional effort not only for teachers, but also for students. One teacher reported that though students learned how to use computers for IPT applications, by the time when they used it again, the students had to study it all over again.

Two different opinions were expressed among non-users about the appropriateness of the activities in the IPT sourcebook. One group felt that the grade level listed in the sourcebook matched their students' level of understanding while another group felt that the material was too complex and the level of activities exceeded the grade level assigned to the material.

Another controversial point was whether there was value in the hands-on experience that IPT offered. In science curricula, hands-on activities are critical to learning most science concepts. It is a matter of debate whether Image Processing for Teaching provides hands-on experience at all. One definition of hands-on experience is "...direct practical experience in the operation or functioning of something" (Hands-on, 1999). In this sense, IPT activities that are directly related to image processing provide hands-on experience. Another definition holds that hands-on experience is "...concrete involvement with manipulative materials" (Markle, Tanveer, Hashmi & Swami, 1992, p. 180). The latter definition does not make clear whether image processing provides hands-on experience. However, it the researcher's opinion that context determines whether an image processing activity is considered as a hands-on activity. For instance, carrying out an activity about planets' surface structure, or an analysis of an X-ray image can be considered hands-on while using image processing to carry out an activity about motion is less likely to offer any hands-on experience. The results of this study showed that the teachers had the same confusion about IPT as a source of hands-on activities. They requested more training on IPT applications to create their own real-life experiences.

Value of IPT (Image Processing for Teaching). The non-users' point of view about IPT as an effective science teaching tool was positive. As indicated by the responses to item 16, "Computerized visualization tools are useful for teaching science", the mean showed the strongest agreement among non-users ($M = 2.11$, $SD = 0.70$). The open-ended responses also confirmed that teachers believed strongly that IPT had value as an instructional tool. Teachers also stated that "certain abstract concepts could be learned better" [participants' words] with IPT. The results showed that students' involvement improved when teachers used IPT to get across science concepts. It is noteworthy that even those who did not use IPT consider the materials to be very useful for teaching science.

Advantages and Disadvantages

The teachers' comments to open-ended items on the advantages and disadvantages of using IPT are summaries below.

Advantages:

- Exciting technology stimulates students' engagement in science concepts.
- IPT allows implementation of real life applications for math and science.
- Visualization promotes visually oriented learners.
- IPT techniques provide hands-on learning experience.

- IPT's wide applicability allows teachers to integrate different disciplines into a lesson.
- Computer and technology literacy can be provided.
- IPT promotes high level thinking skills.
- The content covered by IPT materials enhances the curriculum to some extent.
- IPT techniques help students manipulate imagery as a form of discovery. It allows students to actively engage in scientific research.
- IPT promotes collaborative learning experiences.

Disadvantages:

- IPT activities require considerable preparation time.
- IPT requires a specific type of equipment (Mac computers with CD-ROM drive) to be utilized.
- Materials are equipment-specific, and software bugs need correcting.
- IPT is a science-centered medium and integration with other areas (such as social studies) is not included with the sourcebook.
- IPT does not completely match with every aspect of the curriculum. It needs some adjustments and teachers sometimes do not feel confident enough to bring the program more in line with the curriculum.

Implications for Schools

The participants' reports and responses showed that IPT has an immense potential for science instruction. As a result of this study, there is evidence to claim that science instruction can be enhanced and enriched by using IPT materials. However, the results showed that the major problem in implementing IPT in classroom was the lack of equipment. As an implication for school administrators, the number of computers in classroom should be increased so teachers can make use of what they have learned in not only IPT workshops, but also in other in-service training programs on technology. Another implication from the results is that the curriculum standards should meet the need for the technological equipment in the classroom. IPT can be implemented best with the proper technology and assistance.

Even though this would mean a lay out of funds for equipping classrooms with computers, and training science teachers in the use of IPT, there is, however, a strong potential to bring about a significant positive change in the quality of experience and skills reassured by students. But the availability of equipment, attendance at workshops, and training of teachers, along with a discussion on curriculum alignment are a must before such change in science instruction can be expected.

Recommendations

The recommendations given below are based on the data and researcher's own experience with the Image Processing for Teaching materials. While most teachers who have been trained in the workshops have used these materials, certain obstacles need to be addressed for even wider and more frequent use. Recommendations are:

1. Almost every participant suggested further training in IPT. The participants felt that advanced workshops or assemblies where they could share their experiences with each other would improve their implementation of IPT.
2. Teachers need to be trained in not only image processing techniques, but also technical troubleshooting so that they can overcome the obstacles generated by software bugs to be able to use IPT effectively.
3. It is important for future advanced level workshops to be more regional and in close proximity.
4. Consideration should be given to holding one or two day workshops in specific subject areas where teachers focus on a better understanding of the certain type and discipline-based applications. Gaining expertise in a specific area would improve their management of IPT-driven lessons. The NITEC conference was very beneficial, but some teachers reported that they could not attend because of the cost and the location of the conference.
5. The updates for materials should be made available on the Web
6. Both versions of materials (Windows + Mac) need to be made available. Additionally, activities and image files need to be improved and debugged. The subjects' main complaint was the software; activity availability and IBM compatibility issues. Activities for Scion Image should be made available, the

program improved to have a better user interface, and compatibility with different image file formats.

7. The researcher had experienced in working with the material that there was a gap in what the activities provide, and how it can be used to instruct in specific curriculum or concept.

Recommendations for Further Research

1. A follow-up study for the impact of workshop on teachers in one school district. This type of study would eliminate problems of variety of curricula used in different school districts.
2. A comparative study of effectiveness of IPT images versus digitized images from other sources to show how learning affected by using a variety of sources.
3. An in-depth qualitative analysis on how teachers use these materials and how students interact with them.
4. A study to determine which models of in-service training programs (workshop, online course, and small, two-day workshops) in Image Processing for Teaching are effective.

REFERENCES

Alivisatos, B., & Petrides, M. (1997). Functional activation of the human brain during mental rotation. *Neuropsychologia, 35*(2), 111-118.

Avons, S. E. (1998). Serial item recognition of novel visual patterns. *Journal of Psychology, 89*, 285-308.

Brandimonte, M. A., Hitch, G. J., & Bishop, D. V. M. (1992). Verbal Recoding of Visual Stimuli Impairs Mental Image Transformations. *Memory & Cognition, 20*(4), p. 449-455.

Carter, K., Cushing, K., Sabers, D., Stein, P., & Berliner, D. (1988). Expert-Novice differences in perceiving and processing visual classroom information. *Journal of Teacher Education, 39*(3), 25-31.

CIPE (Center for Image Processing in Education) (1992). *Regional workshops* [On-line]. Available: http://www.cipe.com/ Workshops/workshop.html

Collins, F. (1995). Using image processing. *The Science Teacher 62*(3), 55-60.

Cozby, P. C. (1996). *Methods in Behavioral Research* (6th ed.). Mountain View, CA: Mayfield Publishing.

Davies, S. P., Gilmore, D. J., & Green T. R. G. (1995). Are objects that important? The effects of expertise and familiarity on the classification of object-oriented code. *Human Computer Interaction 10,* 227-248.

De Lisi, R., & Cammarano, D. M. (1996). Computer Experience and Gender Differences in Undergraduate Mental Rotation Performance. *Computers in Human Behavior, 12*(3), 351-361.

Dori, Y. J., & Barnea N. (1994). *In-service chemistry teachers training: The impact of introducing computer technology on teachers' attitudes*. Paper presented at the annual meeting of the National Association for Research in Science Teaching, Anaheim, CA. (ERIC Document No. ED 369646).

Eye, Human (1999). Encyclopedia Britannica. [Online]. Available: http://www.eb.com:180/bol/topic?artcl=109527&seq_nbr=1&page=n&isctn=2

Gauthier, I., Williams, P., Tarr, M. J., & Tanaka, J. (1998). Training 'greeble' experts: A framework for studying expert object recognition processes. *Vision Research, 38*, 2401-2428.

Greenberg, R. (1992). Scanning the images of science. *The Science Teacher 59*(8), 14-18.

Hands-on (1999). Encyclopedia Britannica. [Online]. Available: http://www.eb.com:180/cgi-bin/dictionary?va=hands-on

Hildreth, E. C. (1998). Models of recognition. *Vision Research, 38*, 2225-2228.

Humphreys, G. W., & Bruce, V. (1989). Visual cognition: computational, experimental and neuropsychological perspectives. Hove: Lawrence Erlbaum Associates.

Ishai, A., & Sagi, D. (1997). Visual imagery: Effects of short- and long-term memory. *Journal of Cognitive Neuroscience, 9*(6), 734-742.

Kosslyn, S. M., Behrmann, M., & Jeannerod, M. (1995). The cognitive neuroscience of mental imagery. *Neuropsychologia, 33*(11), 1335-144.

Lehman, J., R. (1994). Technology use in teaching of mathematics and science in elementary schools. *School Science and Mathematics 94*(4), 194-202.

Lehman, J., R. (1995). Microcomputers and the preparation of secondary science teachers: An eight-year follow-up. *School Science and Mathematics 95*(2), 69-77.

Magnussen, S., Greenlee, M. W., & Thomas, J. P. (1996). Parallel processing in visual short-term memory. *Journal of Experimental Psychology*, 22(1), p. 202-212.

Markle, G. C., Tanveer, S. A., Hashmi, K. A., & Swami, P. (1992). *Inexpensive Science Activities*. Multan, Pakistan: Aamir & Asim Publications.

Marschark, M., & Surian, L. (1992). Concreteness effects in free recall: The roles of imaginal and relational processing. *Memory & Cognition, 20*(6), 612-620.

Mavis, B. E., & Brocato, J. J. (1998). Postal surveys versus electronic mail surveys. *Evaluation & The Health Professions, 21*(3), 395-408.

Mayer, R. E., Bove, W., Bryman, A., Mars, & Tapangco, L. (1996). When less is more: Meaningful learning from visual and verbal summaries of science textbook lessons. *Journal of Educational Psychology 88*(1), 64- 73.

Milner, D. A., & Goodale, M. A. (1995). *The Visual Brain in Action.* New York: Oxford University Press.

Nayar, S., K, & Poggio, T. (1996). *Early Visual Learning.* New York: Oxford University Press.

Nial, K. K. (1997). 'Mental rotation', pictured rotation, and tandem rotation in depth. *Acta Psychologica*, 95, 31-83.

Olshansky, B. (1994). Making writing a work of art: Image-making within the writing process. *Language Arts 71*, 350-356.

Paivio, A. (1971). *Imagery and Verbal Processes.* New York: Holt, Rinehart and Winston

Pinker, S. (1997). *How The Mind Works.* New York: W.W.Norton & Company.

Pitkow, J. E., & Recker, M. M. (1995). Using the Web as a survey tool: Results from the second WWW user survey. *Computer Networks and ISDN Systems, 27*, 809-822.

Raphael, J. & Greenberg, R. (1995). Image Processing: A state-of-the-art way to learn science. *Educational Leadership 53*(2), 34-37.

Rolandelli, D. R. (1989). Children and television: The visual superiority effect reconsidered. *Journal of Broadcasting & Electronic Media 33*(1), 69-81.

Rudolph, S., & Preston, L. (1995). Teaching teachers: The elements of successful workshop design. *The Science Teacher 62*(6), 30-32.

Salthouse, T. A. (1995). Differential age-related influences on memory for verbal-symbolic information and visual-spatial information. *Journal of Gerontology, 50B*(4), 193-201.

Saunders, G. W., Wise, K. C., & Golden, T. S. (1995). Visual learning. *The Science Teacher 62*(2), 42-45.

Shacar, H., & Shmuelevitz, H. (1997). Implementing cooperative learning, teacher collaboration and teachers' sense of efficacy in heterogeneous junior high schools. *Contemporary Educational Psychology 22*(1), 53-72.

Sharps, M. J., & Price-Sharps, J. L. (1996). Visual memory support: An effective mnemonic device for older adults. *The Gerontologist, 36*(5), 706-708.

Shepard, R. N., & Metzler, J. (1971). Mental rotation of three-dimensional objects. *Science, 171*, 701-703

SPSS. (1995). *SPSS Survey Tips*. Chicago, IL: SPSS.

Stark, M. E., Grafman, J., & Fertig, E. (1997). A restricted 'spotlight' of attention in visual object recognition. *Neuropsychologia, 35*(9), 1233-1249.

Thompson, T. E., & Wiegman, B. A. (1993). Visualizing classroom instruction: Creating visual images for preservice teacher education. In: *Visual Literacy in the Digital Age: Selected Readings from the Annual Conference of the International Visual Literacy Association* 25th, Rochester, New York. (ERIC Document No. ED 370574).

Tracy, R. J., Pabis, M., & Kilburg, D. (1998). The effect of schematic context on mental imagery. *Imagination, Cognition & Personality, 17*(3), 191-214.

Williams, J. D., Rippon, G., Stone, B. M., & Annett, J. (1995). Psychophysiological correlates of dynamic imagery. *British Journal of Psychology, 86*(2), 283.

APPENDIX A

A National Survey of Teachers Trained in Image Processing

This questionnaire is designed to collect information on how teachers trained in image processing workshops have used this material in their schools. The first group of questions deals with your thoughts and experiences with computerized image processing as a teaching tool. The second group is open-ended questions. Please read the following statement and if you agree, sign the space provided:
"I agree to complete this questionnaire and allow researcher to use the data for research purposes. I understand that my name and personal identification will be kept confidential and not released on public reports". Signature:

____

Name:	Position title:
Age (Optional):	Gender: M / F
Subjects taught (1997-99): (Circle the ones where you use IPT):	
Grades taught (1997-99): (Circle the ones where you use IPT):	
When did you attend an image-processing workshop last time?	
Years of teaching experience:	Highest level of education degree attained:

Have you ever used image processing in classroom settings after you attended the workshop? ☐ Yes ☐ No

Please use the scale below to answer questions 1-8. State the extent of your agreement with the proposition using the following scale:

SA: Strongly agree; A: Agree; U: Uncertain; D: Disagree; SD: Strongly disagree	SA	A	U	D	SD
1) The IPT workshop provided me sufficient basic technical skills to use these materials in school.	☐	☐	☐	☐	☐
2) I have difficulty in implementing IPT because I am not sufficiently trained in technology.	☐	☐	☐	☐	☐
3) Technology involved in using IPT is complex and difficult to implement.	☐	☐	☐	☐	☐
4) I have sufficient amount of equipment to implement IPT in my classroom.	☐	☐	☐	☐	☐
5) I am able to implement image processing in my classroom.	☐	☐	☐	☐	☐
6) Using image processing is worth the time and effort because it helps students' understanding of science concepts.	☐	☐	☐	☐	☐
7) The science content covered by the IPT sourcebook is appropriate for my students' level of understanding.	☐	☐	☐	☐	☐
8) The IPT sourcebook covers topics that are included in the science curriculum of my school.	☐	☐	☐	☐	☐
9) The IPT sourcebook provides sufficient hands-on experience for science learning.	☐	☐	☐	☐	☐
10)Image processing is an effective way to teach science.	☐	☐	☐	☐	☐
11)The IPT source book is easy to understand for implementing in the classroom.	☐	☐	☐	☐	☐
12)I feel good about using IPT materials in class.	☐	☐	☐	☐	☐

13)The IPT materials are too advanced for my students.	❐	❐	❐	❐	❐
14)By learning computerized visualization techniques in the image processing workshops, I feel I can be more effective with my students.	❐	❐	❐	❐	❐
15)Computerized visualization tools are useful for teaching science.	❐	❐	❐	❐	❐
16)Certain abstract concepts can be learned better when I teach them using IPT.	❐	❐	❐	❐	❐

17) I use the IPT sourcebook for teaching science on average:

More than two times per week	More than once per week	Less than once per week	Never
❐	❐	❐	❐

I apply digital image processing in science teaching on average by:

		More than two times per week	More than once per week	Less than once per week	Never
19)	Using digital photos, maps, scientific or weather images	❐	❐	❐	❐
20)	Creating, drawing or editing digital images	❐	❐	❐	❐
21)	Creating animations and image stacks	❐	❐	❐	❐
22)	Writing calculation macros and automated analyses	❐	❐	❐	❐

23) What sources of images, other than what is supplied on the IPT CD-ROM, do you use in classroom? *Choose all applicable.*
❐ Internet ❐ Scanner ❐ Digital Camera ❐ Other applications ❐ None

24) I use IPT to teach primarily:
❐Biology ❐Chemistry ❐Earth Science ❐Physics/Physical Science

25) Have you designed your <u>own</u> lessons using digital images from other sources? ❐ Yes* ❐ No
*If yes, please provide a list of such lessons separately:

26) List top 5 activities from the IPT source book that you have found most useful:

27) What difficulties did you find in implementing image processing?

28) What kind of follow-up workshops, resources, etc. would be most useful in your implementation of image processing?

29) What are the advantages/disadvantages of implementing image processing in classroom?

30) Would you be available for a short personal interview over the phone? ❑ Yes* ❑ No

(*) If yes, phone number: ____________________ and preferred time: ________

31) Would you like to take part in an online chat session with the researcher concerning IPT? ❑ Yes* ❑ No

(*) If yes, please give your e-mail address: __________________________

32) Would you like to receive a copy of results of this research? ❑ Yes ❑ No

Thank you for your participation.

APPENDIX B

THE LIST OF ACTIVITIES INCLUDED IN THE IPT PACKAGE

1. Learning Image Processing
   - Stadium Pictures
   - Acme Detective Agency
   - Piecing Together the Past
   - Travel USA
   - Been There...Done That
   - Taking Out the Garbage
   - Thank For the Memory
   - Stacks and Stacks of Images
   - Makes My Head Spin
   - Gray+Gray+Gray=Color
   - Playing Tricks on Your Brain
   - Stretch It Out
   - The Plot Thickens
   - Picture This
   - Import/Export Business
   - Utopia Planitia
   - You Can Count On It
   - It's Only Logical
2. Biology
   - Alcohol and the Liver
   - Animal Hands
   - Animal Locomotion
   - Cancer Metastasis
   - Enlarged Heart
   - Enlarged Heart Cells
   - Inside the Knee
   - Neurons in 3-D
   - Out of Breath
   - Pain in the Back
   - The Pelvis Puzzle
   - Population Sampling
   - Rotating Axes
   - The Snake and the Rat
3. Chemistry
   - Avogadro's Number
   - Salt, Soda and Sand
   - Where Did the Ozone Go?
4. Earth and Space Science
   - All Shook Up
   - As the Rings Revolve
   - By Jove
   - Catch the Wave
   - Devil's Tower in 3-D

- An Eagle's Eye View
- Eruption Plums of Io
- Eyes in the Sky
- Gravitational Lenses
- It's Just a Phase
- January on Jupiter
- Jupiter Watch
- Mayday Mayday
- Mining the Moon
- Planet in a Shoebox
- Quakin' All Over
- Searching For Dark Matter
- Sizing up the Solar System
- Stars You Can't See
- The Storm That Ate South Carolina
- Water Water Everywhere

5. Math
    - Anti-terrorism Measures
    - Auto Designer
    - Cover Up
    - Don't Bug Me
    - Flower Garden Contest
    - Going in Circles
    - Incredibly Average Images
    - Polygon Patterns
    - Public Access
    - Quadrilateral Specs
    - Tessellating Tiles
    - The Travels of Andrew
    - Tree Ring Geometry
6. Physics
    - Basketball Ballistics
    - How Shocking
    - Io Physics
    - Picturing Forces
    - Roller Coaster
    - Wave Watching

APPENDIX C

COMPUTER ASP CODE TO STORE SURVEY RESULTS

```
<% Name=Replace(Request.form("name"),"'","'"):Position=Replace(Request.form("position"),"'","'")
Age=Request.form("age"):Gender=Request.form("gender")
Subjects=Replace(Request.form("subjects"),"'","'"):Subjects_ipt=Replace(Request.form("subjects-
ipt"),"'","'")
Grades=Replace(Request.form("grades"),"'","'"):Grades_ipt=Replace(Request.form("grades-
ipt"),"'","'")
Attend=Replace(Request.form("attend"),"'","'"):Exper=Replace(Request.form("exp"),"'","'")
Degree=Replace(Request.form("degree"),"'","'")
Q1=Request.form("q1"):Q2=Request.form("q2"):Q3=Request.form("q3"):Q4=Request.form("q4")
Q5=Request.form("q5"):Q6=Request.form("q6"):Q7=Request.form("q7"):Q8=Request.form("q8")
Q9=Request.form("q9"):Q10=Request.form("q10"):Q11=Request.form("q11"):Q12=Request.form("q
12")
Q13=Request.form("q13"):Q14=Request.form("q14"):Q15=Request.form("q15"):Q16=Request.form(
"q16")
Q17=Request.form("q17"):Q18=Request.form("q18"):Q19=Request.form("q19")
Q20=Request.form("q20"):Q21=Request.form("q21"):Q22=Request.form("q22")
Internet=Request.form("internet"):Scanner=Request.form("scanner"):Camera=Request.form("camera"
)
Other=Request.form("other"):None=Request.form("none"):Q24=Replace(Request.form("q24"),"'","'")
Q25=Replace(Request.form("q25"),"'","'"):Lessons=Replace(Request.form("lessons"),"'","'")
Q26=Replace(Request.form("q26"),"'","'"):Q27=Replace(Request.form("q27"),"'","'")
Q28=Replace(Request.form("q28"),"'","'"):Q29=Replace(Request.form("q29"),"'","'")
Q30=Request.form("q30"):Ph=Replace(Request.form("ph"),"'","'")
Times=Replace(Request.form("time"),"'","'"):Q31=Request.form("q31")
Email=Replace(Request.form("email"),"'","'"):Q32=Request.form("q32"):IpNumber=Request.Server
Variables("REMOTE_ADDR"):Set adConn=Server.CreateObject("ADODB.Connection")
adConn.Open "mydata"
SQLSt="INSERT INTO Incoming (NAME, POSITN, AGE, GENDER, SUBJECTS, SUBJECTSIPT,
GRADES, GRADESIPT,"
SQLSt=SQLSt & " ATTEND, EXP, DEGREE, Q1, Q2, Q3, Q4, Q5, Q6, Q7, Q8, Q9, Q10, Q11, Q12,
Q13, Q14, Q15, Q16, Q17, Q18, Q19,"
SQLSt=SQLSt & " Q20, Q21, Q22, INTERNET, SCANNER, CAMERA, OTHER, NONE, Q24, Q25,
LESSONS, Q26, Q27, Q28, Q29, Q30,"
SQLSt=SQLSt & " PHONE, TIMES, Q31, EMAIL, Q32, IPNUMBER) "
SQLSt=SQLSt & "VALUES ('" & Name & "', '" & Position & "', " & Age & ", '"
SQLSt=SQLSt & Gender & "', '" & Subjects & "', '" & Subjects_ipt & "', '" & Grades & "', '"
SQLSt=SQLSt & Grades_ipt & "', '" & Attend & "', '" & Exper & "', '" & Degree & "', '" & Q1 & "','"
SQLSt=SQLSt & Q2 & "', '" & Q3 & "', '" & Q4 & "', '" & Q5 & "', '" & Q6 & "', '" & Q7 & "', '"
SQLSt=SQLSt & Q8 & "', '" & Q9 & "', '" & Q10 & "', '" & Q11 & "', '" & Q12 & "', '" & Q13 & "', '"
SQLSt=SQLSt & Q14 & "', '" & Q15 & "', '" & Q16 & "', '" & Q17 & "', '" & Q18 & "', '" & Q19 & "',
'"
SQLSt=SQLSt & Q20 & "', '" & Q21 & "', '" & Q22 & "', '" & Internet & "', '" & Scanner & "', '" &
Camera & "', '" & Other & "', '" & None
SQLSt=SQLSt & "', '" &  Q24 & "', '" & Q25 & "', '" & Lessons & "', '" & Q26 & "', '" & Q27 & "', '"
```

```
SQLSt=SQLSt & Q28 & "', '" & Q29 & "', '" & Q30 & "', '" & Ph & "', '" & Times & "', '" & Q31 & "',
'"
SQLSt=SQLSt & Email  & "', '" & Q32 & "', '" & IpNumber & "')"
Set rsSurveySubmit=adConn.Execute(SQLSt)
if Err.Number<>0 then
        Response.redirect "http://oz.uc.edu/~sanalavi/error.html"
Else
        Response.redirect "http://oz.uc.edu/~sanalavi/thanks.html"
End if %>
```

APPENDIX D

COMMENTS TO OPEN-ENDED QUESTIONS

The following statements are the participants' own answers to the question 27:

"What difficulties did you find in implementing image processing?"

- Lack of equipment available to me and the level of students. I teach 9th grade IN-CLASS-SUPPORT.
- 1/2 of the students are special education and have reading and mathematics abilities of 4th - 6th grade.
- My school district uses networked pc's. When I attended the workshop you did not have a pc version. The last time I downloaded the pc version it still did not do the lessons in the book as well as the Mac version. It was very slow and often crashed the network.
- Finding enough machines to get students working in small enough groups so they each got hand-on time within a reasonable length of time.
- None
- Obtaining sufficient image capture devices.
- The PC version is still beta -- finding areas of objects, such as Enlarged Heart Cells, is still rather iffy.
- The main difficulty is the fact that we do not have a 30 station lab in which to take a class so that all students can be working. Without first instructing all kids how to do the IPT processes, my kids can't handle the independent working through of lessons.
- I have a cadre of 14 teachers who have been trained as trainers to provide training in Image Processing to our teachers. We have had a few classes with teachers and the greatest difficulty is finding the time for teachers to use it on a consistent basis
- Gearing to various grade levels. The people who create the curriculkum do not understand children well.
- I only have access to one PC in my classroom. I was given software for Mac but I have a PC. I tried to get software for my PC but am asked to pay extra for it so I never persued it more.
- I know it's a beta version, but the software has some bugs.
- Capturing video fast enough to be useful
- Time to infuse it into the curriculum
- Enough machines in one room to teach it

- Not enough math activities appropriate for Algebra
- There is quite a bit of training kids need before they are comfortable enough to use the program and learn the science without focusing too much on learning how to use the program.
- The Windows version received at Level II Training could never be loaded.
- The lessons (or at least some of the questions within) range from "oversimplistic" to vague to very difficult. (But that's OK, I can and do frequently write my own questions
- Time to prepare, remembering how to use the software, availability of computers
- It does not work well on the IBM/IBM Clone PC
- I am looking for a new, updated verson
- Lack of digital camera
- more computers (I have 2 and only 1 is hooked up to the internet.)
- lack of a scanner
- lack of time for explortation and planning
- overhead projector hooked to the computer
- tv access to computer
- More Technology Equipment
- I do not have enough TIME in my 24-hour days to carry out all my routine classroom activities plus add and develop more and more new activities. (Science teachers do all the same things that French teachers and math teachers do, and then we also must set
- time to experiment hands-on with them
- Finding time to get into our computer lab.None with image processing.
- Since I do not teach science, I find it difficult to justify the time needed to use this type of program. I believe with additional training and some review of integration techniques I would be able to find a way. I am currently working to learn.
- I use a scanner quite a lot for students to load images for their projects. With the color images each seems to have its own LUT so when the students attempt to create a stack, first by copying and pasting their images on one window for sizing purpose.
- No major difficulties
- I haven't tried.
- Not enough computers with NIH imaging to have several groups work on the same problem.
- Having enough time to teach all concept areas and teach use of new technology.
- Sometimes I have difficulty opening images and finding how to trouble shoot
- Computer Memory Problems
- Access to enough computers- I use eight in my classroom.

- How can I center images exactly so than photographs taken with the digital camera will be exactly the same size?
- The software for image processing is old and needs to be updated!!! It is Mac based and I have PC computers. Also, there should be several file formats instead of the limited amount (2?). Other image processing software work on 16 bits and not 8 bits s
- I teach 3rd grade and many of the lessons are too difficult for my students. So, I've adapted some and made up my own.
- too complex; too many things to remember in terms of using the software
- not enough class time to work with students.
- students need more independent projects to utilize their skills.
- no time
- Getting a hold of computers when I need them. I also just changed schools and they use IBM (I used to use Macs) This has lead to
- new challenges with the IBM version of NIH Image as well as my unfamiliarity with the PC format.
- For my students it is difficult for them to do this level of work. My honors students did fine but the rest seemed to be a bit disinterested because the concept went over their head
- Enough time for class and preparation
- computer lab availability
- there is not enough geared for chemistry
- We are not able to get the correct version of Image PC on our computers. I only have the original beta version on CD-ROM. We have received floppy from IPT but they did not work and we do not download from internet into my computer. I have worked on the pr
- No technology in classroom
- Content was science oriented, not social studies, but with proper technology I could have adapted some of it
- Sometimes too time consuming
- I have MAC dist but a PC
- Time
- Each teacher in my school has certain areas of "advertized" expertise.Other teachers were chosen to use Image processing as their area of expertise.
- Not enough PC in lab or classroom I can use. I used it with students as independent learning after school.
- IBM
- lack of technology in former school.now that I am in a school with good technology resources, i do not have the time as I am a computer resource teacher.

- I feel image processing is a strong tool, I wish we could ise it in our district but there isn't enough mac to go around. when a pc version comes out I will use it. I feel art and science go hand in hand.
- I wish I had more than one computer to do it with.
- finding,/attaining the necessary technology at our school
- time from the regularly assigned
- no follow up and refresher course, no core group to communicate with and correspond on a regular basis such as alist serve
- It is mainly teacher driven- the sheets for exercises are not always user friendly and are too long
- sometimes they only focus on looking at something or finding

- constructivistically speaking I find the exercise sheets too lock step oriented and too te
- We were using a beta edition for PC and it rarely worked correctly in our system.
- There is an acute shortage of computer hardware available to the students for classroom use. This severely limits the image processing that is available to the students for instruction.
- No major difficulties

- None
- I need better computers and money for the software for the GIS and since it has been over a year, I need to attend another workshop.
- Time, I need more time during the school year. I needed to stay very late getting it set up for my students in the computer lab.
- availability of technology
- My students are L.D. students and it was difficult for them to follow all the directions required.
- For myself I needed a bit more explanation in the directions, or perhaps visual aids would have helped me feel more comfortable using the product.
- Originally, a lack of computers. Now, lack of time to understand well enough to implement.
- none
- Getting enough equipment with sufficient memory.
- Mac/IBM bugs frustrate novice users
- IPT instructions not specific enough (Cook book form) to teach basic lessons
- Correlation withTexas Essential Knowledge & Skills (TEKS)
- Some times it was hard for the students to follow.

- First, I had to teach the tools of the program necessary for use with each activity. Since I use Image Processing only around six times per school year, students need a review of tool use each time we do an activitiy.
- Sometimes student complain about using the computer. These are the same studetns who generally complain about using traditional labs.
- we have technical difficulties at our school. We can't load all image on all machines.
- Curriculum structure = amount of time allowed to cover content
- Remembering the steps
- not enough time - more than I teacher using lab computer at a time
- Time
- Students are not well prepared to work on computers
- insufficient computers
- Mostly hardware issues not connected to CIPE
- Initially it was access to computers. That is no longer a problem. Now the problem is taking time to decide what things to remove from the curriculum to be replaced by IP activities.
- number of computers
- older students are intimidated by computers and image processing
- Initially - computer access(in the 1st year of implementation)
- Now I have more computers
- getting access to the computer lab in a regular basis
- completing labs and lectures to attain the creative explorations
- students do not have computer accesss at home
- IPT Materials were difficult for elementary students & had to be adapted
- Finding time to collect my own data sets
- Not enough computers with NIH imaging to have several groups
- work on the same problem.
- Having enough time to teach all concept areas and teach use of new technology.
- Some times I have difficulty opening images and finding how to trouble shoot

Comments to the question 28: "What kind of follow-up workshops, resources, etc. would be most useful in your implementation of image processing?"

- I would like to see a pc format workshop and materials. I think the images used for the lessons should have been a free upgrade for pc users.

- Refresher workshops, articles in the newsletter about foundations/organizations that are "friendly" to image processing projects.
- I am attending an advanced workshop this summer.
- I attend the national imaginf conference yearly
- Keying Imaging in specifically to the AP Biology Curriculum.
- Work on creating images and anlyzing them.
- I can use the preplanned lessons well. What I don't know how to do is use IPT to put in my own information. Quite frankly, I don't know what kind of information I should put in. I would like to see how other people use IPT other than just using the prepared lessons.
- We currently have an"Implementation Class" where teachers come back and share/problem solve what they have done in Image Processing.
- Mini workshops taught by great teachers, not the official trainers.
- A place to go when you experience a problem and can't solve it on your own.
- Amusement park physics applications
- Just plain old time to work on things, with qualified assistance around.
- Sample Math activities for Algebra I and higher.
- It hadn't been completed the last time I checked.
- Downloading of different material off of the internet and
- using it in the program.
- Since traditional training sessions must be aimed at the bulk of the class and each participant will work at a different rate and be interested in different uses of the imaging techniques, there is inevitably some wasted time, regardless of the proficiency.
- time to collaborate with other teachers and develop lessons
- 1 or 2 day refresher classes
- More in-depth workshop into my specific area.
- Administrators need to be encouraged to allot EXTRA PLANNING TIME for teachers who are serious (and dependable) about implementing image-processing.
- some workshops in my area of Montana
- More images.
- Any review or refresher course would be great, but I would like to see how this tool could work together with my subject matter area and other tools to provide my students with a richer educational experience. Can it work with GIS technology?
- I would like to find other ways to use the program such that students use it to create projects.
- Hearing about new applications

- Help how to's, index
- Additional lessons, More advanced applications, updated versions of image disks.
- A workshop that would encourage use of cross-curriculum techniques to tie science with other content areas besides math would encourage others like myself to use these programs in other curriclum areas.
- Until you update the software, not much unless you want to use other products that are out. I'd like to evaluate and learn to use other good quality software. I'd also like a tie in to scientific research and find out how they are using it on a day to d
- Workshops to get ideas for activities for lower grade students.
- I would need to start all over with instructors and working PI software
- integrating IPT in existing classroom materials.
- sharing work with other IPT users.
- My biggest thing is getting started and seeing how other teachers make use of the technolgy. How they have been able to overcome many of the obsticles, new lessons they have developed. We are our own best resources, but we don't have the time and energy.
- More that gave specific time to work on the lessons that we could use in our classroom
- A satclass would be good
- summer sessions are always the best
- I probably would not use it
- until I have technology available, none would be helpful
- more lessons to use. have them online for downloading
- workshop went too fast. Instructor assumed too much of participants computer literacy. group was too large. application of programs or ideas were not appropriate.
- advanced IPT training
- workshop get-togethers with people who use it in the classrom (teacher who are close by)
- n/a currently
- unknown
- I want to go to the conferebce this year as I would be inspired, I hope.
- our school is PC based, we hae requested software but last time I checked the web is isn't available.
- Refreshen courses
- a sourcebook of activities by science class (ie biology, chemistry, physics etc.)
- workshops focusing on each area mentioned above
- I dont know what is available

- website
- list serve
- 1800 number
- regional gathering od users
- curriculum integration
- Many students in middle school do not have the prerequisite skills and knowledge or background of geology, astronomy etc. I am attempting to merge NIH use with other factors in my
- Project S.I.M. (Simulations, Interdisciplinary
- Need another beginning course
- Hearing about new applications
- I am attending an advanced workshop this summer.
- Probably most of us have done the few we feel most comfortable with, it would be great to attend another session and get new ideas.
- More repetive exercises
- Practice using the product
- Perhaps more visual cues, or important teacher directions written in a different color or highlighted.
- One day tune-up, just before school starts in Fall.
- Directly relate CIPE/IPT to TEKS
- The use of 3D images in the lessons.
- Additional activites geared for middle school use and training in how to develop more of my own activities. Sources of images that are useful for classroom purposes.
- Methods of digital video capture
- N/A - I provide follow - up & development
- The annual conferences are very beneficial - exchange of ideas
- An occasional review & procedures would be helpful and may be macro workshop
- Time to work on develooping and/or modifying existing activities for my needs
- Periodic workshop
- more in depth questions of lessons, and a quick ref. card for student use
- Exchange of lessons/activities/images with other IP using teachers, such as NITEL conference
- Suggestions of where/what kind of supplements are helpful and not that costly
- scanners that work well
- find web sites
- sources for students/faculty/school grants

- The NITEC conferences and becoming an instructor served as sufficient follow up for me.