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ABSTRACT

Meteorology, the science of weather and weather conditions, has traditionally been taught via textbook and rote demonstration. This study was intended to determine to what degree utilizing technology in the study of meteorology improves students' attitudes towards science and to measure to what extent technology in meteorology increases higher-level thinking skills. Two groups, treatment (n=120) and traditional (n=126), of sixth-grade science students were presented meteorology using differing technologies, activities, and methods. The traditional method of lecture, notes, reading, answering textbook questions, demonstrations, and activities were presented to the traditional group. Instruction and practice using technology was given to the treatment group. Both groups were measured by a chapter test and an attitude survey. The data suggested that technology properly infused in the setting in which it was administered improves attitude and increases understanding. An appendix contains treatment group lesson plans. Contains 25 references. (MKR)

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Technology and Meteorology

Raymond F. Taggart

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Submitted to the Graduate School
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CHAPTER 1

INTRODUCTION

Few factors impact human existence so pervasively as does weather. The devastating fury of Hurricane Andrew, the unchecked power of a cresting Mississippi River, a relentless artic blast paralizing the northeast coast: these are the stuff of docudramas more stirring than the "man-made" caused by human error. But beyond the headlines and the feature stories of suffering and endurance lies a simple truism. Weather influences the ebb and flow of everyone's daily existence.

How we live, work and play - in short, who we are and who we will become is directly shaped by the forces of weather. We may never experience a raging typhoon, but who hasn't forgotten to close the window on the car? Obviously any factor as dynamic as weather has a "natural" attraction; any force so universal should be explored, understood and respected. Climate is the message and school should be its medium.

Meteorology, the science of weather and weather conditions, has traditionally been taught via textbook and rote demonstration. According to Brown and Rodriquez (1992), "the hard sciences continue to be taught in a passive mode, using a textbook-driven curricula." Consequently, while many students become test-savy, few leave a traditionally taught science course with the ability to "feel" number-temperature relationship, in other words, to connect learning with life experiences. Even fewer exhibit higher-level reasoning skill: the competence to predict future consequences from current, climatic conditions.

Many studies have already proven that the proper use of technology in the classroom leads to deeper levels of student understanding. In their "Cognitive Flexibility Theory," Spiro and Jehng (1990) contend that traditional instruction which relies solely on linear media (i.e. textbooks and lectures) does not promote higher level thinking skills as does properly infused technology. By employing techno-dynamics, the constantly changing structure of complex subject matter can be presented in a problem solving mode despite irregularities.

Weather satellite imaging is a compelling example of current technology applied to the classroom. Brown and Rodriquez (1992) argue that "the hands-on, computer-oriented and visual nature of satellite direct broadcast has proven to be a highly effective means of teaching technical subjects and enhancing technical literacy" (pp.42-43).

The critical need to move from a textbook-rooted curriculum to a technology-driven one is the rationale for this research project. While it's evident that each curricula format yields different teaching styles, what is less clear are the contrasting results in student attitude and achievement that each curriculum produces. The objective of this research is to clarify those contrasting results.

Statement of Problem

Does using technology in the study of meteorology improve attitude toward science and increase higher-level thinking skills among grade 6 students?

Purpose of Study

This study has a two fold purpose. First, it is intended to determine to what degree utilizing technology in the study of meteorology improves student attitude towards science. Second, its goal is to measure to what extent technology in meteorology increases higher-level thinking skills.

Limitations of Study

Treatment prior to the study is considered connected and, therefore, only students who were registered for the entire school year were included in the treatment and traditional groups. Variant location may limit the study since the measurement instruments were administered in different classroom settings. While results of this study cannot be generalized to apply to other populations, reenactment of these procedures may further broaden the significance of this research. Currently the results apply only to sixth grade science students at a specific work site.

Assumptions

Based on the limitations noted, the principle threats to the internal validity of this research are mortality and location. Extraneous variables include prior experiences with other technologies and/or science courses. However, since the use of weather satellite ground station monitoring and internet interactive access is a frontier instructional medium in the public schools, the chance of previous student exposure is virtually nonexistent. Also assumed after an extensive search into the school scheduling policy is that grade 6 student teams are, in fact, heterogeniously grouped and do reflect the Florida Schools 1992-93 School Report.

Definition of Terms

Technology: satellite receiver and station, video cameras, lab equipment, telecommunications and computer stations.

Attitude: the positive or negative student reaction based on instructional formatting as indicated by the Attitude Survey (Fisher, 1973).

Higher-level Thinking Skills: objectives measured by the content instrument Chapter 10 Test (Emilian, Knight & Handwerker, 1989).

Application: learner demonstrates the ability to use and apply information by relating it to new situations.

Analysis: learner classifies information by dividing it into its component parts.

Synthesis: learner connects formerly unrelated elements of information to create a unique whole.

Evaluation: learner exercises judgment and weighs outcomes by applying established criteria. (Bloom, 1956).

Justification of Study

Compared to other industrialized nations, science educaton in the United States lags dismally behind. Consequently, one of Blueprint 2000's primay goals, as stated by the Federal Coordinating Council for Science, Engineering, and Technology, is that "U.S. students will be first in the world in science and mathematics achievement"(p. 12). Undergirding the national agenda, the state of Florida is actively involved in a "systematic and comprehensive effort to increase the productivity of public school students . . . through developing, testing and implementing technology-based system of schooling" (Culler, 1994, p. i - 22).

According to the Florida Commission on Reform and Accountability Report in 1992 it is no exaggeration that "the Twenty-First Century, with all its promise and challenge, is rapidly approaching bringing with it ideas and visions and devices so incredible that we cannot today dare to imagine them" (p. 3). Nor is it a hollow prediction that "our state and national economies and quality of life are at risk as we approach the year 2000" (p. 5) because the U.S. populace is scientifically at-risk. In response to a state-wide and national concern over a technologically literate citizenry, this study finds its justification.

Since "citizens need new and higher level skills" (p. 5), our survival as a nation depends on people who can put knowledge to work. The need is evident and the state of Florida had adopted specific goals to meet the challenge. Consequently, this research project adresses Standards 3.1-3.9 of Goal 3, Student Performance Blueprint 2000. Furthermore, it incorporates "The Science For All Students" five reoccurring, embedded themes - Patterns, Change and Stability, Systems and Interractions, Health and Well Being, and Science, Technology and Society - that provide a unifying structure. These themes integrate science disciplines by demonstrating to students the dependent nature of "the real world" on scientific discovery. In addition to addressing the Blueprint 2000 standards, this research study corresponds to the "Forces That Shape the Earth" objectives in Science For All Students, The Florida K-12 Science Curriculum Framework.

CHAPTER 2

REVIEW OF THE LITERATURE

Weather is an essential element of human existence. It affects everything that occurs on our planet in every region of our world. In fact, climate often determines economic systems as it influences political ones. From the clothes that have developed to battle the elements, to the games that can be played outdoors, " weather affects our well being, our economy, our national security, our pocket book " (Mogil , 1989 , p. 3).

Any factor this significant to humanity must be learned in school. " There is no reason that with a little weather knowledge you, your students and their families can't fight back [against weather's negative effects]" (Mogil , 1989 , p. 3). The consequences of weather can range from discomforting to catostrophic. The same weather system that leaves one feeling bad because of pressure changes can produce violent storms destroying property and human life. Millions of dollars are spent every year in the United States alone for property damage from weather related influences. To " fight back ", one must be able to predict the effects of weather. The old adage holds true: " Knowledge is power " but today knowledge requires technology.

Modern meteorology relies heavily on data comparison and satellite imaging. Weather satellite imaging gives visible and infrared pictures of earth and its atmosphere: polar orbiting satellites give a view from 450 miles and geostationary satellites from 22,500 miles. The primary difference between these two systems is in resolution and area covered. The higher up, the less the resolution and the greater the area covered. Large weather systems are easily observed by geostationary satellites, tracking air masses and their fronts across the United States. Polar orbiting satellites also cover large areas, but not the entire United States in one pass. Closer to the earth, their resolution is better and more localized. For either geostationary or polar orbiting all visible images correspond to visible light. But " visible light " has a different meaning to the research scientist than it does to the conventional photographer.

A satellite image, however, records not only reflected energy but emitted energy (heat), that allows one to distinguish among land masses, bodies of water, vegetation, and atmospheric conditions. By comparing reflected (visible) and emitted (infrared) energy with the data collected from the ground and with the upper level atmospheric measurements periodically throughout the day and night, forecasting has become a more exact science.

Traditionally, due to lack of technological resources and /or proper teacher training, schools have presented meteorology in an information - only mode rather than a dynamic exercise in data collecting, imaging analysis, and prediction. Access to technological resources and training has always been a major obstacle. " The hard sciences continue to be taught in a passive mode, with teachers using textbook-driven curricula " (Brown & Rodriguez, 1992 , p.42). Teachers have been trained to present information to students in a rote manner; therefore, using technology creates problems in education as " the vast majority of educators remain untrained in the use of such systems to display images " (Brown & Rodriguez , 1992 , p.42).

Even when given tools and training, there is little evidence that using technology does in fact enhance or facilitate the higher-level thinking skills necessary to compare data or to make accurate predictions. Examples of technology that provide access to difficult content learning " in the convential school system " (Bork , 1990 , p. 12) are still currently being defined. " Technology itself provides nothing but potential " (Brunner , 1990 , p. 12); it is up to the classroom teacher to help students integrate high quality learning experiences through using technology currently available to them.

There is support however, based on the work of Spiro and Jehng (1990) related to the " Cognitive Flexibility Theory ". Traditional learning which relies on linear media such as textbooks and lectures (Spiro & Jehng , 1992 , p. 163), does not transfer higher level thinking skills as completely as does technology properly used. Weather satellite imaging is an example of technology that if effectively integrated to the curricula will stimulate higher level thinking skills. Studying images is considered to be a hard science, " hands-on, computer-oriented, and visual nature of satellite direct broadcast has proven to be a highly effective means of teaching technical subjects and enhancing technological literacy " (Brown & Rodriguez , 1992 , pp.42-43). It also provides an avenue for potential scientific and commercial applications.

Satellite imaging and its commercial, educational, and governmental application is only going to increase as the world moves farther into the Information Age. In the beginning, " Trios 1, the world's first weather satellite launched by NASA in 1960 " (Haggerty , 1989 , p. 98) provided images that were unrefined and lacked much detail. The progression of technology led to Automatic Picture Transmission (APT). When NASA launched Trios 8 in 1963, " this development made satellite images directly and immediately available to anyone willing to make the moderate investment in an APT ground station " (Haggerty , 1989 , p. 98). In 1975 NASA technicans developed the " Digital Scan Converter " (Haggerty , 1989, p.98) and in 1988 the company " Satellite Data Systems Inc . " (Haggerty , 1989 , p.99) used the original NASA work to build commercially the WeatherFax System currenty being used for this Action Research report.

Landsat satellites are the first commercial venture of remote sensing and are operated by Earth Observation Satellite Company (EOSAT). They orbit the earth in polar orbits with 438 miles of altitude. They make 14 and 9/16th's complete orbits in a 24-hour period and cover every square mile of the earth every 16 days (Staff , EOSAT , 1989 , pp.1-7). Data from Landsat comes in visible and infrared images much as the NOAA weather satellites. Currently the images are used for " mining, oil, seismic, plate tectonic, hydrology, cartography, land use planning, disaster assessment and emergency planning " (Staff , EOSAT , 1989 , pp. 1-7). Resolution is far superior to NOAA satellites and interpreting them is far more complex. The process is similar though and the experience and understanding gained from interpreting weather satellites is readily transferable to the commercial interests of EOSAT.

Perhaps the most compelling part of this technology is its ability to involve students. " The need to involve students' participation in the design and analysis ...has never been more urgent " (Itzkan , 1994, p. 60). One teacher extolled the educational benefits and expressed it well: "Whether due to a malfunction of the antenna , antenna motor, preamp, cable, receiver, or printer or due to an error in the computer, each break down challenged us to use science in solving practical problems " (Martin , 1989 , p. 17).

Ideally, science classes use the problem solving method everyday in learning. Problem solving works best if there is a personal involvement, a connection to the problem. The images are transmitted into the classroom daily for the students to see and they connect them to the weather conditions outside the classroom. Weather systems are naturally powerful and provide teachable moments. Hurricane Emily came at the right time and propelled the use of imaging from natures photography " pretty pictures " to an understanding of complex systems in order to predict a tropical storms movement and devasting effects. In short " students become more involved in their own learning as a multimedia progam about hurricanes expands the traditional classroom " (Floyd , 1991 , p. 6).

As personal predictions are made real, data comparison and imaging become extremely important tools. Studying meteorology with data comparison and satellite imaging actually incorporates the five domains of science education: " knowing & understanding, exploring & discovering, imagining & creating, feeling & valuing, and using & applying " (McCormick & Yager , 1989 , pp.47-48). The intent of this research project is to determine if using technology does improve attitude about science thereby helping increase the aquisition of higher-level thinking skills.

CHAPTER 3

METHODOLOGY

The quantitative method of research was chosen in order to contrast methods of instruction. Two groups of sixth grade science students were measured using the same instruments. Sense student learning is dependent on student attitude toward the instructional technique the purpose of this study is to determine if a technology-driven curriculum improves student attitude thereby facilitating higher-level understanding in meteorology among Grade 6 science students.

Subjects

The setting for this research is a school located in Central Florida. This school has an approximate student population of 1440 students grades 6 through 8. The sample is a convenience sample consisting of 120 students in the treatment group and 126 students in the traditional group. To control further the limitations of this study, only students who were registered for the entire school year were included in the measurement.

The demographics according to the Florida School Report 1992-93 are 79.1% White, 11.3% Black, 7.2% Hispanic, 2.1% Asian, .3% Indian. It is a suburban school setting with the convenience sample being heterogeniously grouped and reflecting the Florida School Report.

Prior Treatment

Prior to the begining of the study, the treatment group was presented meteorology using various technologies, activities, and methods. Students were introduced to live satellite images transmitted into the classroom on the first day. Using the satellite computer, the students compared three sets of data: actual outdoor temperature and precipitation, cloud temperature transmitted from the satellite to the classroom, and actual temperature and precipitation transmitted from the Florida School Weather Network (FSWN) over the Florida Information Resource Network (FIRN) with a classroom in Santa Rosa County. Treatment group students formed clouds in a bottle, determined relative humidity, dew point, and took barametric pressure. To identify cloud types charts were constructed and a video portfolio was eventually produced. The game " Predict The Weekend Weather " was played all year long. With students having mastered the basics of meteorology through technology, treatment began.

Treatment Protocol

Chapter 10 (Emiliani, Knight ,& Handwerker , 1989) of the Earth Science textbook is entitled Weather. Both the treatment and traditional groups received the performance objectives from Chapter 10 with differing instructional techniques. A traditional method of lecture, notes, reading, answering textbook questions, demonstrations, and activities were presented to the traditional group. On the other hand, instruction and practice using technology was given to the treatment group. As a form of closure, the treatment group further used the technology to present the objectives to the class and teacher. A lesson plan is included in Appendix A.

The treatment consisted of coupling the Blueprint 2000 standards with all of the technological resources available to make accurate predictions of future weather events. Students used the satellite tracking program to predict when the Polar Orbiting Satellites would pass over so that images could be captured and current pictures compared with previous ones. Telecommunications via FIRN were used to contrast temperature and precipitation readings of other schools involved with FSWN, the previous days satellite images, and the USA Today Weather Page.

The interactive internet program "BLUE-SKIES" (Sampson, 1994) was used to accurately determine cold and warm fronts with the " Interactive Weather Map "; to compare the " 24 Hour Satellite Movie " with the following: the USA Today Weather Page, FSWN reports, and the previous days satellite images. To use the " Interactive Map " to compare humidity precipitation, temperature and wind speed and direction of cities in the United States for predictions of tomorrows weather.

"BLUE-SKIES" was also used in conjunction with the weather satellite, the textbook, and media center resources on CD-Roms to gather information for group written /visual reports, on different types of violent storms. These reports were presented to the class. The program was also compared with the lab activities to show relationships between laboratory activities and actual hands-on research.

Not to mislead the reader and to clarify actual procedures, a key point needs to be made. Technology stations handle only one team of 4 students at a time. FIRN and "BLUE-SKIES" use the same phone line so that the station can be used for either network, but not simultaneously. The weather ground station can track satellites, receive transmissions, display saved images for temperature calibrations and colorizations, to map geopolitical areas, but as with FIRN and "BLUE-SKIES", not simultaneously.

Therefore, the treatment was presented in stations rotating daily as students worked in cooperative groups. Whenever possible, images were printed to free up technology for greater efficiency. Predictions from previous days were compared at the begining of class and reflective discussions were held to correct future forecasts. Closure was achieved at the end of each class by standard means. Prediction using class posted readings were made followed by making summaries written in their weather portfolios.

Finally, as preparation before the final test, Chapter 10 of the Earth Science textbook was divided up into sections; each station group presented its section to the class complete with the explanation of the relveant technology used. The test and attitude survey was then administered.

Data Collection and Analysis

The quantitative data consists of two measurement instruments. An attitude survey, and the Chapter 10 Test. Both treatment and traditional groups were given one class period to take both the content test and attitude survey. They were allowed to use notes and the textbook to answer the test questions. The data is quantitative and standard measurements will be used. Mean, standard deviation, t-test, and percentage of correct responses for comparison of higher-level understanding questions will be compared.

Instrumentation

The attitude survey administered was developed by Fisher (1973) to reliably discriminate between groups of students. The instrument is scored using a likert -type rating scale. The respondents must mark " one answer per category " (Fisher , 1973 , p. 647), and answers are weighted 5,4,3,2,& 1, respectively. The number 5 is assigned to the answer which, if checked, would reflect a judgement favorable to the treatment.

The attitude survey consists of 20 questions with a maximum of 100 points (5 x 20) and a minumin of 20 points (1 x 20). When scored, it indicates whether or not there is a favorable attitude toward the treatment. The way the survey is weighted will allow for comparison between the two groups.

The Chapter 10 Test includes questions directly from of the chapter (knowledge and comprehension) as well as content questions testing higher-level understanding of the chapter. Chapter 10 Test consists of 30 questions, 10 of which have been identified as requiring higher-level understanding in order to be answered correctly . Questions 4, 25, & 30 require application of higher-level thinking skills. Questions 3, 10, 26 part 1, & 29 demand students analysis. Synthesis is tested in question 28 and questions 6, 26 part 2 , & 27 involve an evaluation skill. Each level of Bloom's Taxonomy higher-level thinking questions will be evaluated seperately and compared to ascertain to what degree higher-level thinking was increased.

CHAPTER 4

ANALYSIS OF DATA

The data was collected in order to attempt to test the research question. Does using technology in the study of meteorology improve the attitude and increase higher-level thinking skills of Grade 6 science students?

Descriptive Data

There were 126 students in the traditional group and 120 students in the treatment group. The attitude survey (Fisher , 1973 , p.648) is a 20-item, 5-point likert-type scale that was used to measure student attitude. A t-Test was preformed to determine if significance exists.

The first analysis compared the attitude of the 2 groups to indicate student attitude concerning the use of technology in the study of meteorology. Data from the 2 groups are reported in Table 1:

Table 1
Attitude Survey

	N	M	SD	T - value	P
Treatment Group	120	73.9	9.08	9.19	0.05
Traditional Group	126	61.2	11.82		

The mean of the treatment group is 12.7 rating points higher than the means of the traditional group. The average score per survey item on the 5-point scale was 3.7 for the treatment group and 3.1 for the traditional group (5 points was the highest score possible). Overall, the treatment group scoring on the attitude survey was more favorable than the traditional group. As Table 1 indicates, there is a reliable difference between the groups mean at the $p < .05$ level. T value shows a significance between the two groups.

The second part of the research question examined higher-level thinking skills. Chapter 10 Test (Emiliani, Knight, Handwerker, 1989) is a 30 question test that presents questions using knowledge, comprehension, application, analysis, synthesis, and evaluation using Blooms Taxonomy (Bloom , 1956) as a higher-level thinking skills measurement. Each question has a weight of 1 with the highest possible score being 30.

A t-Test was completed to insure validity of the test for the 2 groups and to check for overall difference between them. The results are presented in Table 2:

Table 2

Chapter 10 Test

	N	*M*	*SD*	*T* - value	*P*
Treatment Group	120	23.44	4.63	10.02	0.05
Traditional Group	126	17.4	4.65		

Inspection of the table reveals that the mean of the treatment group is 6.02 (20.06%) higher than the mean of the traditional group. The standard deviation indicates the variability of both sets are closely matched and is a normal distribution comparison. The t-Test contrasting the means of the two groups reveals a reliable difference ($p < .05$). The *T* value showed significance between the two groups does exist.

Ancillary Data

Having validated the higher-level thinking skills test between the 2 groups a further analysis is necessary to answer if, in fact, higher-level understanding was increased. Ten questions were identified for comparison. Application, analysis, synthesis, and evaluation were compared and the percentage of correct responses are reported for each group (126 in the traditional group and 120 in the treatment group). Table 3 lists the percentages of correct responses for tests of higher-level understanding.

Table 3

Higher Level Understanding

	Percentage of Correct Responces			
	Application	Analysis	Synthesis	Evaluation
Treatment Group	78.6%	67.2%	51.7%	66.9%
Traditional Group	49.7%	44.8%	16.7%	54.2%

An examination of the data reveals that the treatment group showed higher percentages than the traditional group, 28.9% higher correct responses in the understanding of application questions: 22.4% difference in analysis: 35% difference in demonstrating synthesis: and, a 12.7 % difference in the understanding of evaluation questions than the traditional group.

The combined percentages of higher-level thinking questions support the research question. Interest in comparing specific questions from the attitude survey was considered, but due to time constraints , a complete analysis will be part of a further study. Averages and then percentages from frequency distribution of correct responses can be misleading. With the exception of question 26 part 1 (an analysis) and question 27 (an evaluation) the percentage of correct responses was higher for the treatment Group. Table 4 lists the data from these questions.

Table 4

Inconsistent Findings

	26 part 1	26 part 2	27
Treatment Group	27.5%	64.2%	87.5%
Traditional Group	38.1%	49.2%	88.2%

Inspection of the Table reveals that the treatment group had a combined response for question 26 of 91.7% and the traditional group 87.3%, a slight difference. Overall though, to get part 2 of the question correct the students need to know part 1, therefore the difference is still greater for the treatment group. Question 27 shows a 0.7% higher score for the traditional group and is to close in distribution to determine anything other than to note the closeness to maintain the integrity of this study.

CHAPTER 5

DISCUSSION AND RECOMMENDATIONS

CONCLUSIONS

Whether or not applying specific technology (satellite imaging) to the study of meteorology among Grade 6 science students improves student attitude toward science and increases higher-level thinking skills was the original research question. Data from both measuring instruments proves conclusively that technology properly infused in the setting in which it was administered improves attitude and increases understanding. First, results from the attitude survey administered to the treatment group displayed a significant increase over the results from the traditional group. Second, the treatment group's scores for the content and higher-level thinking skills also showed a significant rise over the traditional scores as a 20.06% difference existing between the means. Also, there was a marked increase in the treatment group's overall scores; both the highest and lowest scores were superior to those of the traditional group. Given these findings, the conclusion is an obvious one -- infusing technology in the study of meteorology does improve student attitude and increase higher-level thinking skills of this population of Grade 6 science students.

DISCUSSION

As satellites pass over earth-bound receivers and automatic picture signals come into range, the ground station emits a beeping sound. This beeping continues until the signal is strong enough to trip the noise setting threshold and is then converted from analog into a digital signal. At this point, the image begins to appear on the computer screen.

From day one, students (and researcher) were intrigued by the immediate, live images projected from space into the classroom. Their curiosity peaked, they naturally wanted to use the satellite and asked probing questions about its operation. The researcher, more than willing to seize a teachable moment, introduced the study of meteorology that was " live and new ", according to one pupil. The researcher's experience was not unique.

" Students, who before I got the satellite working, would barely finish their assignments, now finish and do quality work so they can get the computer to study images " (Tindell, 1994). Another colleague shares her insight: " My students wouldn't take geography seriously until they started trying to find names for places on the images " (Stevenson , 1994). Obviously these techno-pioneers have also observed a difference in the attitude of their students and have equated that change to a fueled interest in subject matter and a deeper understanding of content.

Prior to initiating this study, the researcher was encouraged by using the weather satellite, telecommunications, and related technologies during the first twelve weeks of the school year. Afterwards, there was a seven month hiatus from teaching the meteorology unit but not the use of technology generally or the application of hands-on, cooperative learning. During that time satellite images continued to enter the classroom daily. Together with telecommunications the technology was expanded to include every area of earth science. Based upon these inital, positive experiences, this research study was conceived and administered. Early on, the researcher surmised that for student's " high tech " meant more than a novel break in a mundane routine. Instead, he saw it as an invaluable tool for making learning real and relevant.

If it's true that " Practice makes perfect ", then the traditional textbook-driven curriculum should be serving our students well. But not so, as signaled by plummeting objective test scores. One educator related the essence of the techno-dynamic: " The greatest benefit to the students, however, is that they do the thinking themselves rather than simply respond to question 7 on page 138 " (Walker , 1993 , p.190). Perhaps for many students their window to the " real world " has changed and is changing. To the researcher, properly infused technology is a window offering an exciting, panoramic view.

The development of higher-level thinking skills is as much a process of self-discovery as it is an exploration of the world. It is an activity that students need to own in order to put to practice. Through a techno-scientific approach, the cognitive stages involved in moving through Bloom's Taxonomy can be nurtured. A close examination of the Treatment Lesson Plans reveals that they predominately provide opportunities to demonstrate higher-level thinking skills (application, analysis, synthesis and evaluation). Yet, it is through a hands-on approach that creativity leads to understanding. Now the researcher acknowledges his two, principle support sources.

The Florida EXPLORES! (Floridians Exploring and Learning the Operations and Resources of Environmental Satellites) program was designed "to implement a systematic, state-wide weather satellite receiving program in Florida K - 12 schools to improve mathematics and science education" (Ruscher & Kloesel, 1993). The weather satellite used in the study was piloted in the classroom with the technical and content support of the Florida State Meteorology Department.

In addition, the Martin Marietta/UCF Academy was spearheaded "to improve mathematical and science excellence" (Hynes, 1993). Through the Martin Marietta/UCF connection, lessons providing practice and demonstration of higher-level thinking used in the study originated. The merger between these two schools of innovation greatly benefitted the research outcome.

Finally, added to the impetus of the aforementioned resources is

"BLUE-SKIES", an interractive internet program developed at the University of Michigan and released on Ground Hog Day, 1994. The "BLUE-SKIES" project is "a graphic interface allowing interactive access to weather and environmental images and animation" (Sampson, 1994). Developed by the University of Michigan, administration of the "BLUE SKIES" program required the skilled cooperation of the Martin Marietta/UCF Academy to provide the technical expertise and the Florida EXPLORES! / FSU Meteorology Department to offer training in curriculum formation.

Explanation of the background resources was included for two reasons: to credit those institutions which assisted the study and to provide recommendations for those individuals who seek their assistance in the future. The treatment conducted in this study is not readily available in most public schools. In fact, in the State of Florida, few schools operate weather satellites and fewer still have interactive internet access. Before the State Department of Education, government agencies, and local school districts spend enormous amounts of time and money seeking to seed these technologies in the classroom, the question - "How do we know that technology really makes a difference?" - honestly needs to be answered.
The researcher behind this study is totally convinced that it does.

Anyone having read this study must realize the importance of teacher training and the coordinated efforts of key resources. Only through cooperative networking can the gains made by the treatment group in this research be duplicated. Weather satellites in the classroom do improve student attitude toward science as they stimulate higher-level thinking skills. There is one proviso however. Techno-dynamics must be used to drive a curriculum based on positive change.

RECOMMENDATIONS

It is an educational given that more often than not, teacher attitude directly affect student desire. The cartoon character Aladdin, with his determination to rescue the Sultan's daughter is as important a role model to most children as was Churchill, with his " can do " attitude, to the British people during World War Two. The impact of teacher attitude toward infusing technology, was not measured in the research study. Nor was the support, both in teacher training and technology, of the two Florida University programs measured.

Weather satellites connects students to their world. They offer teachable moments to problem solving situations by requiring student practice and demonstration. The internet program "BLUE-SKIES" complemented the weather satellite program by providing resources that both explain and extend in an interactive setting. The research study focused on the effect of employing technology to teach the curriculum.

The researcher recommends that other instructors who are using weather satellites to teach meteorology perform similar studies. Since the use of interactive internet programs are soon to become a state wide reality, it would be exciting to investigate their effect on improving student attitude and higher-level understanding. Another beneficial and complimentary study would be to recruit teachers fortunate enough to receive the training and support of programs such as Martin Marietta / UCF Academy and FSU / Florida EXPLORES! in order to measure teacher attitude as related to student performance.

APPENDICES

APPENDIX A
Treatment Lesson Plan

Chapter 10 Treatment

Lesson Plans

Lesson 1

1) Use Birddog (satellite tracking program) to predict the satellit passes for the day.
2) Put geopolitical map on image.
3) Temperature calibration & display colorized image.
4) 3 D imaging.

Lesson 2

1) Use telecommunications (FIRN) to obtain the FSWN temperature and precipitation report.
2) Take temperature and precipitation readings at school.
3) USA Today Weather Page - isotherms, fronts, air masses.
4) Compare data.

Lesson 3

1) Build tornado in a bottle.
2) Make a weather cyclone.

Lesson 4

1) Use satellite program to use saved images of Hurricane Emily for tracking and intensity.
2) Plot hurricane path on chart.

Lesson 5

1) Use satellite program and saved images to show temperature and climate
changes in the visible part of the United States through the past school year.

Lesson 6

1) Use the Internet Program "BLUE_SKIES" to obtain interactive and graphic displays of violent storms.
2) Groups to prepare a group report with write up and visuals on violent storms to include:
   a) What they are.
   b) How they form.
   c) What keeps them going?
   d) What they do to the planet.
   e) How to predict if one is going to form.
   f) What to do if one comes.
   g) What they look like.

   The reports must include information from Blue Skies, the science text-book, the weather satellite and the cd-rom files in the media center.

Lesson 7

1) Use the Internet Program "BLUE_SKIES" to manipulate the interactive weather map to determine cold and warm fronts.
2) Play the 24 hour satellite quick time movie, watching fronts move across the United States.
3) Compare temperature, humidity and precipitation of 15 cities.
4) Use FIRN to compare Blue Skies readings with FSWN.
5) Use the weather satellite to compare temperature and fronts with "BLUE-SKIES" and FSWN.
6) Use FIRN to compare school readings with an elementary school in Holly Naverre County, Florida.
7) Use data from all sources to predict the weather (temperature and precipitation) in 15 cities for tomorrow.

Lesson 8

1) Check predictions and reflect on ways to improve them.
2) Repeat 7 and 8 for at least five days.

Lesson 9

1) Divide chapter into section for each group.
2) Groups present their sections of chapter to class.

Lesson 10

1) Administer Chapter 10 Test.
2) Administer attitude survey.

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