DOCUMENT RESUME

ED 383 445 PS 023 327

AUTHOR	Grangaard, Ellen Mannel
TITLE	Effects of Color and Light on Selected Elementary Students.
PUB DATE	May 93
NOTE	183p.; Ph.D. Dissertation, University of Nevada. For related document, see ED 382 381.
PUB TYPE	Dissertations/Theses - Doctoral Dissertations (041)
EDRS PRICE	MF01/PC08 Plus Postage.
DESCRIPTORS	*Classroom Environment; *Color; Elementary Education; *Elementary School Students; Environmental Influences; *Heart Rate; *Lighting; Student Adjustment; *Time on Task
IDENTIFIERS	Blood Pressure; Physiological Response

ABSTRACT

This study compared children's off-task behavior and physiological response in a normal elementary classroom setting with those in a prescribed classroom environment. In the prescribed environment, the colors of the classroom walls were changed from brown and off-white to blue, while Duro-test Vita-lite fluorescent tubes without diffusers replaced the standard cool-white fluorescent tubes with diffusers in the lighting fixtures. Eleven first-graders took part in the study, which measured their off-task behaviors, blood pressure, and pulse twice each day at the same time each day for 10-day periods in the original classroom environment, then in the prescribed environment, and back in the original environment. Results indicated that off-task behaviors, as recorded by three observers, dropped 24 percent after the change from the normal to the prescribed environment, and that systolic blood pressure readings dropped 9 percent after the change. Blood pressure readings demonstrated a gradual increase after the return to the normal environment. (Observer credentials, and blood pressure and pulse readings are appended. Contains 126 references.) (MDM)

EFFECTS OF COLOR AND LIGHT ON SELECTED ELEMENTARY STUDENTS

by

Ellen Mannel Grangaard

A dissertation submitted in partial fulfillment
of the requirements for the degree of

Doctor of Education

in

Educational Administration

Department of Educational Administration and Higher Education
University of Nevada, Las Vegas
May, 1993

ABSTRACT

EFFECTS OF COLOR AND LIGHT ON SELECTED ELEMENTARY STUDENTS

by

Ellen Grangaard

This research was a replication of original research conducted in 1981 by Dr. H. Wohlfarth at Elves' Memorial Child Development Centre in Edmonton, Ontario. The purpose of this study was to compare children's off-task behavior and physiological response in a normal elementary classroom setting with those in a prescribed classroom.

C.H.Decker, a public K-5 elementary school, was the research facility. The study population were five 6-year old boys and six 6-year old girls. The study took place during a seven week period in the fall of 1992.

Blood pressure and pulse readings were recorded twice a day, morning and afternoon at the same time each day in three environmental fields.

Phase I. Original classroom environment, ten days.

Phase II. Prescribed color and light environment, ten days.

Phase III. Return to original classroom environment, ten days.

Video tapes were filmed twice each day. During the first week of the study, video tapes were filmed and blood

pressure and pulse were taken, but not recorded, to acclimate the subjects to the test procedure.

Computer generated graphs utilizing three different types of lines through the coordinates differentiated the research phases for the Systolic blood pressure readings, since that has been ascertained to be the reading most responsive to environmental change. A nine percent decrease was recorded between the first phase mean and the second phase mean. Blood pressure readings demonstrated a gradual increase during Phase III.

Three observers counted off-task behaviors from recorded video tapes. Off-task behaviors decreased from a Mean of 66.5 during Phase I to a Mean of 50.8 during Phase II a 24% drop in the Mean readings of off-task behaviors.

Changes in Systolic blood pressure readings and off-task behavior recordings forge a strong argument for prescribed environments in the learning milieu.

CONTENTS

LIST OF TABLES

Table

ACKNOWLEDGEMENTS

Although many people are influential in the completion of this kind of endeavor, there are those that must be accorded special recognition. The Educational Administration and Higher Education Department at the University of Nevada-Las Vegas is made up of a group of professors uniquely endowed with a prodigious blend of acumen and empathy of which a great amount of both were needed to complete this work. The personal input of Dr. Hathaway, Dr. Wohlfarth and Frank and Rudolph Mahnke were invaluable in accumulating the information and formulating the insight to complete the research study. A grant from the Graduate Student Association helped defray the expense of the research. Research in lighting and the Duro-Test Vita-Lites were supplied by Duro-Test Corporation and their representative, Helga Love. The people who actually made the research happen by making the facility available were the Clark County School District, and Ron Fagan, C.H.Decker Elementary School's principal. Special acknowledgement must go to my husband, Chuck, who painted, changed lights and sent me to my computer.

CHAPTER I

INTRODUCTION

Winston Churchill said, "People build buildings, then buildings build people." (Van Horn 1980). The importance of the environment is often understated in the artificial milieus we call modern buildings. Man is, biologically, an animal. Inadequacies in the environment are not overtly recognized, even though they affect human performance. The artificial environment in which humans live and work must be controlled for biological efficiency.

The realization of the importance of the environment in human daily life has promulgated new fields of study: environmental mastery, environmental engineering, human engineering, environmental psychology, colorpsychodynamics, behavioral research, biopsychology. Neuropsychologists have undertaken in-depth studies of the interaction of humans with their environment.

Man is a sensory creature, reacting to the stimuli of his environment. Since the environment educates, it is necessary to evaluate and assess the educational environment and its stimuli. "Psychophysics involves attempts to measure the relationship between sensory experience and the physical stimulus energies arising from the environment." (Bennett 1978, 27).

Farmers and biologists experimented for years with many different kinds of environments to create better, larger, healthier plants and animals. They isolated the many interdependent variables within the environment, manipulated these variables to see which variations produced the best product and continued to expand their knowledge for a profit. The human learner is the product with the greatest profit potential, the product whose improvement most benefits mankind, yet it is the product whose environment has remained sterile, bereft of stimuli or bombarded by stimuli, in classrooms of industrial white with inadequate fluorescent lighting.

For maximum learning effectiveness there must be a symbiotic relationship between the learning environment, the learning program and the learner. Ross calls this relationship synomorphy as identified by the "similarity of structure or shape between the behavioral aspects of a school activity program and the physical aspects of the environment" (Ross 1982, 1).

"Color and light are major factors in man-made environments; their impact influences man's psychological reactions and physiological well-being. Research proves that light and color affect the human organism on both a visual and non-visual basis. It is no longer valid to assume that the significant role of light and color is to provide adequate illumination and a pleasant visual environment" (Mahnke 1987 p.X).

The role of the brain in human perception of color still requires much research. The magnitude of the problem the nervous system experiences in solving color assignment, the determination of the color of a particular object, is still unknown as is a complete understanding of the involvement of the cerebral cortex. Zeki accentuates this problem in stating that "to construct colors, the nervous system has to solve a problem exceeding in complexity anything predicted by classical color theory" (Zeki 1985 p.XII).

The physiological and the psychological effect of color on the human is of special importance to school administrators. Because there are many aspects of the child's well being over which the school has little control, it is imperative that any element of the learning milieu that can be improved must be improved.

Schools do not give enough consideration to color in the learning environment. "Many cases of nervousness, irritability, lack of interest, and behavioral problems can be attributed directly to incorrect environmental conditions involving poorly planned light and color. Studies have shown that a functionally and thoughtfully planned school interior facilitates learning new subject matter and improves scholastic performance" (Mahnke 1987, 82-83).

Felix Deutsch, as reported by Birren (1961) has done extensive research with light and color. He found that blood pressure and pulse rate can be controlled by placing people in specific environments. The problem this poses for the learning environment is that different people respond differently to a particular environment. But will students with similar problems respond similarly to a specific environment? Wohlfarth's research in Edmonton seems to corroborate this thesis in his findings of children with behavioral disorders (Wohlfarth 1981).

New fields of applied science were necessitated by the problems of glare and illumination which cause eye fatigue. This is a monumental problem now and in the future because of the countless people who spend many hours of every day at computer screens. Many industries and facilities' planners designate a reflection level for rooms in which people work. Paint manufacturers specify the reflection level of various colors in their color coding. Oftentimes, in direct conflict with color and light specifications, maintenance personnel use white or off-white in rooms in which people work at jobs with high vision use causing a negative production affect (Mahnke 1987).

Schools must consider color as a component of the workplace. In choosing colors for the learning environment, the only consideration must be what color will make the environment most productive.

Van Horn terms environmental psychology as a new technology (Van Horn 1980). Mahnke states that as humans are considering life in underground cities, their biological and psychological needs must be met (Mahnke 1987). Wohlfarth's Alberta Study revealed startling results which have led to even more sophisticated ongoing research in the area of environment (Wohlfarth 1981). The interaction of color and the "autonomic nervous system (which regulates the body's internal environment) and hormonal activity" (Mahnke 1987, 1) raises many unanswered questions for educators. Scientists and researchers are coming to the conclusion that manipulating man's environment leads to a greater realization of individual human potential.

Statement of the Problem

The purpose of this study was to compare children's behavior and physiological responses in a normal elementary classroom setting with those in a prescribed classroom setting replicating Wohlfarth's Elves' Memorial Study. The following questions served as a basis for the collection and analysis of data.

1. Do the environmental factors of color and light generate physiological changes in students in an elementary school setting?

2. Do the environmental factors of color and light generate behavioral changes in students in an elementary school setting?

Significance of the Study

Schools traditionally are simply places to house teachers and students, and places to store the accoutrements of the educational process. Called institutions, they, many times, exemplify the image of an institution in their lack of visual stimulation. Even though efforts to create a stimulating visual environment in the school are not acknowledged by children, researchers in visual stimuli have ascertained that children internalize these stimuli.

Experiments are being carried out in some school districts using types of lighting which have all the elements of sunlight, and are energy efficient. Research has been done on the effects of color in the classroom, but schools have a tendency, along with industry, to return to high utility white even though studies have shown a lack of efficacy in productivity attributed to its high level of reflectancy and its sterile nature (Mahnke 1987).

Much research has been conducted in the area of ecological milieu, "relationship of living organisms and the environment" (Taguiri 1968,21) within schools. Research shows that environment can improve achievement levels (Bowers 1987), increase production and accuracy (Bross & Jackson 1981), create more positive attitudes (Young 1982), and change behavior (Wohlfarth 1981). The major task of this study was to demonstrate the physiological effect of color and light in the educational environment.

Assumptions

1. It was assumed that color can induce changes in human behavior.
2. It was assumed that autonomic changes in the human caused by changes in color and light can be measured, other environmental factors remaining constant, heating and cooling maintained electronically.

Delimitations of the Study

This study was a replication of a study carried out by Dr. H. Wohlfarth, University of Edmonton, Alberta, in 1981 at Elves' Memorial Child Development Centre, an Edmonton private school for severely handicapped children.

Physiological changes and acting out behaviors in the educational setting were analyzed. In the course of the study, light and color was manipulated in one classroom. Specific acting out behaviors of this group of children were counted within the context of the manipulated environment. This study looked at one group of children within this environment and was not intended to indicate that humans of all ages and behavior patterns would react identically within the same environment.

Since the study was being carried out in a public scnool milieu, it was requisite that the research meet the parameters outlined within the Clark County Policy and Procedures Manual as disseminated by the Cooperative Research Committee of the Clark County School District.

The study was conducted in one classroom because the type of treatment did not necessitate a control group; the subjects within the changing environment became the control.

Conceptual Base for the Study

The analyses of the physiological and biological effects of color and light as portrayed in Frank and Rudolf Mahnke's Color and Light in Man-Made environments (1987) has pointed out the dangers that are inherent for humans as the 21st century creates a life-style committed more and more to living and working in artificial environments. As the human creature evolved over the centuries, the eye adapted to the fluctuations and intensity of sunlight and the colors of the earth. The biological human has had very little time to adapt to fluorescent lighting and industrial white. This is of particular importance for industry, hospitals and schools, environments in which the major part of human life is spent.

The Alberta school system studied the effects of light and color on student behavior for several years. Dr. Wohlfarth and Dr. Hathaway of the district's Facilities Planning Department are involved in on-going, in-depth research. In "The Effect of Colour Psychodynamic Environment on the Psychophysiological and Behavioral Reactions of Severely Handicapped Children. Effects of Colour/Light Changes on Severely Handicapped Children", Dr. Wohlfarth manipulated the environment while measuring physiological response and counting specific acting out behaviors. Blood pressure and pulse readings were taken three times a day. Specific acting out behaviors were counted for 15 minutes at the same time twice each day. The children were monitored in their regular educational environment for 10 days. Then the light and the color were changed to a prescribed environment for two weeks after which the original environment was reinstituted. The findings indicated a sharp drop in the systolic blood pressure of students in the color and light prescribed environment. Specific acting out behaviors decreased in the prescribed environment and continued to decrease during Phase III of the experiment, original environment, indicating a carryover.

Research Design

This study employed a quasi-experimental research design. It was a replication of a study done in Edmonton, Ontario, by Dr. Wohlfarth of the University of Ontario. The population included students from a selected elementary classroom. Manipulation of the classroom environment occurred in three phases during which time autonomic changes in the subjects were recorded for analysis. Video recordings were made daily at specified times. The films were used to make a frequency count of specific behaviors during each phase of the environmental manipulation. Descriptive procedures were used to analyze the data.

Through the use of a computer generated graph, recorded data of physiological changes for each phase of the study could be compared.

Definition of Terms

1. Color--a property of objects' surfaces; it is the sensation caused by certain qualities of light that the eye sees and the brain interprets. It is a form of energy which affects body function just as it influences mind and emotion (Mahnke 1987).
2. Light--objects have color from the kind of light they reflect and light has its color

from its disposition to produce color sensations. Color and light must be specified simultaneously. Lighting must be understood in order to know the effect of color (Hilbert 1987).

3. Environment--the ecological milieu is the relationship between living organisms and the space in which they live and grow (Taquiri 1968).

4. Reflectance--"the ability of a surface to reflect light of each given wavelength. It is the ratio of light incident on a surface to the light that the surface reflects." (Cytowic 1989 p. 291)

5. Hue--unsaturated primaries. There are six hues, even though there are thousands of colors; red, yellow and blue with the others being combinations of these. Hue is the attribute which allows colors to be classed as red, yellow, blue, green, orange, purple.

6. Saturation--as the colors vary from white.

7. Brightness--intensity.

8. Physiological--"process which can be observed to take place at some point along the visual pathway before it disappears into inaccessible regions of the brain" (Williamson 1983 p.327). Specific

physiological processes examined for this research were blood pressure and pulse rates.

10. Psychological--"a process that occurs too far along in the information processing system to be accessible to measurement with external probes" (Williamson 1983 p.327)

11. Value--By manipulating the value or chroma a single hue can comprise a range of over twenty colors. Value changes are derived by mixing the hue with black or white (Morriss & Dunlap 1987).

12. Color harmony--the joint effect of two or more colors.

13. Pulse--a wave which begins at your heart and travels through the arteries. Taking your pulse is counting the number of times the heart is beating against the blood circulating through the vessels. The strength of the pulse is an indication of the body's fitness (Morehouse 1975).

14. Behavior--(off task behavior) distractions from the lesson were counted as off-task behaviors. These included non-teacher centered; playing with pencils, pencil boxes; writing, coloring, during a listening based lesson; moving around the room; daydreaming.

15. Blood pressure--pressure exerted by blood against

the inner walls of the blood vessels. Systolic blood pressure is the process of pushing the blood out of the chambers; diastolic blood pressure is the pressure of the blood filling the chambers of the heart or blood vessels.

Organization of the Study.

1. Chapter 1 includes the introduction and background, the statement of the problem, the significance of the study, assumptions, the conceptual base, the research design, data tabulations, definition of terms and the organization of the study.
2. Chapter 2 contains a review of the literature as it pertains to the study of light and color in the human environment.
3. Chapter 3 includes (1) the research design, (2) recorded data, and (3) its analysis.
4. Chapter 4 presents a summary of the study, conclusions, recommendations and recommendations for further study.

CHAPTER II

REVIEW OF LITERATURE

Conceptual Base

The purpose of the study was to demonstrate the importance of color/light in the learning environment. The review of the literature concentrated on the importance of the visual environment, the role of perception in human behavior, the psychophysiological reaction to color/light and its influence on human engineering.

Ittelson, Proshansky, Rivlin, and Winkel (1974) in their study of environmental psychology, saw man as a biological creature in constant tension with his environment; shaping it, being shaped by it, and interacting within it. In order to reach a greater understanding of this process, they derived eight basic assumptions.

"The environment is experienced as a unitary field" (Ittelson et al. 1974 p.12). Biological species react to the environment in totality. The visual experience does not dictate that an entity isolate disparate elements of its milieu for conceptualization.

"The person has environmental properties as well as individual psychological ones" (Ittelson et al. 1974 p.12). The individual is a part of the environment and must see himself as being a part of it. When an entity views itself as being separate from its surroundings, it also becomes vulnerable, unprotected, and intimidated by the world in which it finds itself.

"There is no physical environment that is not embedded in and inextricably related to a social system" (Ittelson et al. 1974 p.13). The structure which develops within a social system and the way in which individuals and groups interact within that system is directly linked to the physical environment; a forest culture will develop differently from a desert culture.

"The degree of influence of the physical environment on behavior varies with the behavior in question" (Ittelson et al. 1974 p.13). The degree to which behaviors will be influenced by the environment is dependent upon the complexity of the behavior.

"The environment frequently operates below the level of awareness" (Ittelson et al. 1974 p.13). Our adaptive defenses begin working whenever there is a change in the environment. It is only when we notice a change that we are even cognizant of our environment because its effects are at the subconscious level.

"The 'observed' environment is not necessarily the 'real' environment" (Ittelson et al. 1974 p.13). Humans react to their perceptions; what is perceived is not always real. No two people react the same way to the same thing because they do not perceive the same thing. The total self, inclusive of its experiential base, is the perceiver and therefore is influenced by the totality of experiences.

"The environment is cognized as a set of mental images" (Ittelson et al. 1974 p.14). The environment as perceived by each individual becomes that person's cognitive map. No two cognitive maps will be identical. These mental images are interpreted according to individual social interactions, culture, and total life experiences.

"The environment has symbolic value" (Ittelson et al. 1974 p.14). The environment defines man's place within it. Its demands strengthen or destroy. The human species lives and thrives in almost every part of the earth regardless of its inhospitable characteristics. Humans develop a knowledge of environmental signals that dictate their actions.

Environmental psychologists were encouraged to promote training to make people more sensitive to their environment. Each environment embodies a specific set of behavioral characteristics. Often these characteristics have been investigated separately from the environment as not being caused by interaction with the environment. Scientists have been attempting to discover how man could live beneath the sea or out in space while completely ignoring the artificial environments in which humans are living out their daily lives. Behaviorists felt that social interaction dictated behavior, but as environmental concerns were pushed forward into public scrutiny during the 1960's and 70's it became more apparent that humans were not living and working in environments designed for that purpose (Holahan 1978).

All sensory organs are involved at all times in interpreting the varying and complex messages received via the surrounding milieu; however, vision has been determined to be the dominant sense.

"Vision apparently is dominant over the other sensory modalities in humans. If humans perceive one piece of information visually and another piece of information through another sensory modality, and if the pieces are conflicting, it is the visual information that will be responded to" (Bennett, 1978, p.47).

As vision is the dominant sense, so then color becomes important as a secondary property of objects, important in defining the space in which humans exist. Researchers continue to attempt to decipher the role of the human brain in its relationship to color perception. The eye receives only the illumination reflected from the surface. The conditions under which seeing takes place are constantly changing. Color and shape perception, which occurs in the brain, not in the eye, are inextricably linked. "It is not easy to understand that the color is in our mind, not an intransmutable property of the object" (Cytowic 1989 p.292). As the photoreceptors constantly record change, the eyes are in constant motion. Color as well as boundary changes are registered in the retina.

Color vision is three dimensional. The perceptual variables that aid in defining the environment are size, shape, texture, and color. Adding color to this dimensionality is actually the addition of three spatial dimensions. Black and white equals two dimensions; the addition of color is equal to five dimensions. Color is perceptually defined by the human animal as a redundant cue along with shape to identify visual objects. This color dimensionality comes from the presence of cone receptors in the retina, which have three different sensitivity functions (Ware 1988).

Color, as the third dimension, has always been important in the environment. In nature, color is used as a protective device in camouflaging animals and plants from their predators. Man's sensitivity to color allowed him to distinguish his enemies from their surroundings and made him the supreme predator. Plants use color as a protective device to aid in propagation, with seed bearing fruit retaining the color of the foliage. When the seeds become ripe, the changing color of the fruit makes it easily distinguishable to species which will eat the fruit and disperse the seeds.

In the technological sphere, color added the third dimension in medical technology, in advertising, in data collection of all kinds. It is used "as a tool in exploratory data analysis" (Ware 1988 p.128).

Understanding of the involvement of the cerebral cortex as well as the way in which the autonomic nervous system experiences color denotation is not well understood. The task the nervous system undertakes in unraveling color assignment is still a puzzle (Zeki 1985).

The autonomic nervous system is a part of the peripheral nervous system. Many times it is referred to as the automatic nervous system which, even though it is a misnomer, may be an accurate descriptive phrase because of the system's ability to take action without conscious help. Many Eastern cultures have studied the autonomic nervous system in such great depth that they have learned to control it.

The autonomic nervous system consists of both sensory and motor nerves. An increase in blood pressure and pulse occurs through the "sympathetic division;" a decrease is caused by the "parasympathetic division" (Teyler 1984, p.44). They are sometimes referred to as the brake and the accelerator of the nervous system.

Neuropsychologists attempt to understand how the message stimulus from the environment is changed into feelings and thoughts. G. Moruzzi and H.W. Magoun as reported by Mahnke (1987) have attempted to explain this phenomenon. All stimulation through the central nervous system affects the ascending reticular activation system which becomes a clearinghouse for all the various stimuli that are present in the environment. Little stimuli can cause a condition of sensory deprivation, or at the other extreme, great amounts of stimuli can cause an overload of stimulation.

Discovered during the 1940's, the reticular formation is a part of the brain stem. Its discovery fomented many new theories concerning brain function. It is a collection of neurons found in the core of the brain stem which projects into the cortex from the spinal cord. It is the alarm system of the organism, alerting it to specific elements of the environment.

"Each sensory area of the neocortex receives projections primarily from a single sensory organ. That is, the visual-receiving area, in the occipital lobe, processes sensations received by the retina. . . .Within each sensory-receiving area, the sense-organ projections form a map of the sensory organ on the neocortical surface, called a receptortopic mapping" (Teyler 1984 p.61). The area of the body mapped is proportional to the sensitivity of the body part. Through this map, the responders within our nervous system determine the individual picture of the environment. Our reality, our picture of who we are and what we can do, is controlled by the picture our nervous system paints of the world. Misinformation processed by the central nervous system and processed through the brain creates a distorted picture (Teyler 1984).

Although color vision is not well understood, it has been ascertained that it is an extremely complex process. Light passes through the pupil. The amount of light is controlled by the iris which is a part of the muscle of the eye. Within the retina, receptor cells and neurons convert the light impulses to the brain. One hundred twenty million receptor cells called rods carry the brightness message. Six million cones carry the message of color and detailed vision. At the back of the eye in the region of the fovea only cones are located.

Helmholtz theory of color vision as reported by Mahnke (1987) stated that one type of cone is sensitive to red, one to blue, one to green and some types are sensitive to combinations of the three. The three sensors contain peak sensitivities in differing positions within the spectrum, but each responds over a broad range on either side of the peak much as the value range within a color chart. Scientific research using the Macaque Monkey and the Horseshoe Crab shows the complexity of the procedure during which much of the processing is done within the retina itself. The method the neurons use in interpreting stimuli is much like the encoding of colors through the television. As objects change when viewed through glass, they also change when passing through the visual receptor system. This change is determined by the molecules, their arrangement and the size of the particles (Williamson 1983).

The Retinex Theory of color vision, as hypothesized by Thomas Young in 1802, stated that there were three kinds of receptors, and that each possessed a specific spectral sensitivity. Color vision requires that these receptors work together to produce an image. Light does not make the colors but contains information which the nervous system utilizes in making color. A combination of the retina and the cortex, with each forming its own picture of the world, compares these separate images while forming a biologically independent image. The rods within the eye cannot determine color, only brightness. Energy equals illumination times reflectance, but the quality of lightness as perceived at three different wave lengths is the source of color perception. Color does not "reach" the eye, the eye produces color, a part of which occurs in the retina and a part in the cortex (Land 1989 p.298).

One of the most wonderful, natural phenomena known to man is a rainbow. It is that of which myths and legends are derived and unbelievable as it may seem, an illusion created within the eye. It truly is as illusive as the pot of gold at its end (Brousek 1984). It is a creation of the retina that can only occur when drops of rain in the atmosphere are at the correct angle to disperse light rays toward the observer. Even though all colors are reflected by each drop, the observer will see only one color at a time from each drop. Brighter, more vivid colors, are produced by larger drops (Varley 1980).

Sir Isaac Newton, reproduced a similar phenomenon in his color studies. While investigating something totally different, he inadvertently discovered his theories of color and their arrangement within the physical universe, whether in an oilslick or in a rainbow. This arrangement of colors, found in infinitude in nature, is the spectrum.

In attempting to analyze color with the use of the theories of Locke, Galileo, and Boyle, Newton offered the most detailed description of the nature of color. By passing sunlight through a prism onto a surface, the rays of light are bent or refracted, each at a different angle, with red having the greatest refractibility and blue the least (Varley 1984).

Although Newton is not credited with the wave-length theory of color, many aspects of this theory are revealed in his writings as he described the color of an object varying with changing illumination. This phenomenon is solely dependent on the amount of the reflectance of the object. "Objects have their color from the kind of light they reflect and light has its color from its disposition to produce color sensation" (Hilbert 1987 p.6). Newton's theories opened the door for all the color and light research to the present time.

Most studies which have concerned the effect of color on living things have been wave-length studies. The area of the spectrum which is visible to the human eye is minute compared to the entire range of electromagnetic energy.

<u>Infrared</u>

760

<u>Red</u>

<u>Orange</u>

600

<u>Yellow</u>

<u>Green</u>

500

<u>Blue</u>

<u>Violet</u>

380

<u>Ultraviolet</u>

The electromagnetic spectrum includes white light, ultraviolet, infrared, radio waves, x-rays and other radiations given off by the sun and other stars, many of which do not penetrate the earth's atmosphere (Varley 1984).

The range visible to the human eye is from 380 nanometers to 760 nanometers, with the eye being most sensitive to yellow-green midway through the visible spectrum (550 nanometers) (Teyler 1984).

"The human eye is an exquisite, complex sphere, actually a miniature brain in itself" (Teyler 1984 p.68).

A transducer changes one form of energy into another. Visual transducers present within the eye (rods and cones) are the receptors which change light energy into neural energy. The rods transfer only dark and light sensations. The three types of cones, blue, red, and green, transmit color through photochemicals which have the ability to change their molecular structure with light exposure. The three cone receptors, each being sensitive to specific wave-lengths of light, work together to produce color vision. The absence of any one of the cones results in a type of color blindness. "The visual cortex is so organized-apparently from birth-that it can respond to rather complex visual stimuli without having any prior experience with these stimuli" (Teyler 1984 p.89).

Despite the complexity of our visual system it "is inadequate to adequately describe physical components of light." We see our sun as yellow, but it is actually green, red and yellow, part of which is removed in artificial light. "Vision cannot perceive colors of light" (Williamson 1983 p.13).

It has been recognized that those colors which have the longest wave-length (reds) have the most arousing effect. As the wave-length shortens so does the arousing effect of the color with red at one end of the spectrum and blue at the other. New research has indicated that the arousing effect does not have permanency. The greater use of color to affect behavior lies in the use of variety, the lack of or the overuse.

Use of one color in the extreme from any part of the spectrum will become monotonous. The important consideration in the use of color lies in achieving coherence. Monotony or overstimulation alike create behavioral changes. Overstimulation can lead to a change in the rate of breathing, higher pulse rate and blood pressure; muscle tension will be increased. A lack of concentration, restlessness, irritation can all be caused by overstimulation (Mahnke 1987).

"In response to environment, people expect all of their senses to be moderately stimulated at all times. This is what happens in nature, and it relates not only to color and changing degrees of brightness, but to variations in temperature and sound. The unnatural condition is one that is static, boring, tedious and unchanging. Variety is indeed the spice-and much needed substance of life." (Birren 1961, p.167).

Unity and complexity are the opposite ends of the pole for the person who would use color to influence. Too much of one creates a dull, boring environment; too much of the other leads to confused visual stimuli and over-response.

The degree to which a person experiences excitement has been defined as introversion or extroversion. For many years it was thought that the introvert needed more arousing colors in order to bring him out and the extrovert needed less arousing colors to calm him down. However, the introvert has the more easily aroused nervous system and therefore needs the more calming colors of the short wavelength to help him feel more comfortable and able to deal with things. The extrovert needs the more arousing colors because stimulation is his comfort zone, less arousing surroundings cause him to lose interest and cause a stimulus craving. This has ramifications for the learning environment because young children are more extroverted, thus crave stimulation, becoming less extroverted as they become older. The environment should change with the age of the student (Mahnke 1987).

Studies of hyper-active children indicate the need for a different kind of environment. This may be extremely important in the treatment of children with attention deficit disorders or children who are "drug babies." "....hyperactive children derive greater gains than normal children from situationally manipulated stimulants" (Zentall 1986 p.164).

Research has proven "that color affects cortical activation, functions of the autonomic nervous system (which regulate the body's internal environment) and hormonal activity, and that color arouses definite emotional and aesthetic associations." Our response to color is physiological (Mahnke 1987 p.X).

Felix Deutsch as reported in Birren (1961) conducted extensive research with light and color use with patients. He continuously monitored patients' pulse and blood pressure rates. He writes, "Every action of light has in its influence physical as well as psychic components." In his use of color and light while controlling other variables, "Changes in pulse frequency and rhythm as well as fluctuations in blood pressure are objective expressions of the psychically influencing factors which have taken place." He found that blood pressure could be controlled as well as pulse rate by placing people in specific environments. The problem this poses for the learning environment is that different people respond differently to a particular environment (Birren 1961, p.144, 145). Wohlfarth's research in Edmonton seems to corroborate this thesis in his findings of children with behavioral disorders in an educational environment (Wohlfarth 1981).

"Life is a condition alternating between excitation, destruction, and unbalance and reorganization, equilibrium and rest. In the course of life, colors play their role. Each color has a special importance and all colors help quarantee normal life. It is probably not a false statement if we say that a specific color stimulation is accompanied by a specific response pattern of the entire organism." (Birren 1961 p.144,145)....Some colors tend to stimulate, some soothe and relax, and others create fatigue, depression and irritation. For any given color there is an association that goes with it in the subconscious mind....color may cause emotional reactions and create feelings of coolness, warmth, size, dimension, weight and distance" (Day 1980).

The basic meanings of color are temporized by cultural ramifications. When presented with yellow squares, Japanese, American, and Canadians associated the color with feelings of happiness. This is in sharp contrast to the cultural connotations of yellow as the color of the face of the avenger of wrongdoers (Young 1982).

"One can depict the spectrum thus:

R > O > Y > G < B < I < V "

(Van Horn 1980 p.696).

<u>Red</u>

The color Buddha wore in meditation seldom is used in its purest form because of its aggressive, advancing characteristics. Mentally it is associated with blood. Red, most often is used in its variations. Its hue effect is considered to be exciting, stimulating; its emotional effect, positive-passionate, active, warm: negative-aggressive, intense. The character of red is its dominance over all other colors because red objects always seem closer than all others (Mahnke 1987).

Red is the beginning of the color spectrum having the longest wave-length. It is the stimulator of physical energy, the initiator, the pioneer. Red will lead as others follow, self-assertion, movement, activity (Don 1977).

Red radiation has great power of penetration and probably affects the blood. "Red light has been found to affecc the activation of sex hormones and on weight gains and growth in animal experiments. Experiments with red light in combatting inflammation are inconclusive at this time (Birren 1961 p.128). Babbitt found a relationship between red rays in paralysis and other chronic conditions. Red has been found to stimulate plant growth.

Psychologically red appears to upset the equilibrium of the body of the human. It will raise blood pressure and pulse rates for a period of time. Increasing the excitement level and restlessness, it becomes a stimulus. Time is overestimated and weight increases. It is used in psychotherapy to reduce depression and to raise moods. "It helps to distract attention from within and to direct it outward" (Birren 1961 p.258).

"Red means love. It means courage and passion....a fiery temper. Red is extremes of despair and elation" (Wilson & Bek 1979 p.23).

"Red, the dynamo....the first to appear after distinctions between light and dark....the hottest and nearest in wavelength to infrared which actually produces the sensation of heat. It is the fastest moving colour in terms of catching the eye, and has the greatest emotional impact. Red sits at the top of the rainbow" (Varley 1980, p. 186).

Orange

Orange is a secondary color creating a balance between the physical red and the intellectual yellow. It stimulates the nerves and creates coping energy (Don 1977).

The second longest in wave length, orange is still a color of high energy but moderating from the red "it is less primitive" (Birren 1961, p.12).

The hue effect of orange is exciting, stimulating, cheering. Mental associations that characterize orange are positive jovial, energetic. The color of the extrovert. "It has virtually no negative cultural or emotional associations" (Mahnke 1987 p.12).

"Orange the understudy star.....orange is an earth colour....Psychologically, it is linked to comfort and security (Varley 1980 p.194).

Yellow

Buddha's hair was the color yellow designating it as the color of the mind. In yoga, the yellow person is an intellectual, delving into the pursuits of the mind. Yellow, being the color of the sun, is stimulating (Wilson & Bek 1979). Yellow allows man to think rather than to depend upon instinct to survive. It allows for the awakening of mental capacity. Yellow affects the nervous system in a way that allows relaxation for the resolution of problems. It enables repulsion of negative feelings. Yellow is a creative color which will help the daydreamer capture those illusions which strengthen coping skills for real life situations (Don 1977). It radiates warmth, cheerfulness, and inspiration (Mahnke 1987).

"Yellow is the central principle of nerve stimulus as well as the exciting principle of the brain which is the foundation head of the nerves." Used in medical practice in the middle ages, it was believed to help the human system generally (Birren 1961, p.57).

"Yellow, tidings of joy....bond between two phenomena ....life-giving sun above, and gold, the measure of earthly wealth....symbol of enlightenment....represents the intellectual." (Varley, 1980 p.200) Yellow, however, is generally not preferred for use in decorating because it is hard on the complexion. At its fullest saturation, yellow is the brightest in color; whereas, all other colors become darker as they become more saturated. It is within the area of the spectrum most sensitive to the eye, so it is used heavily in advertising (Varley 1980).

Green

"Psychologically, green represents a withdrawal from stimulus. Since the lens of the eye focuses green light exactly on the retina, it is also the most restful color to the eye" (Mahnke 1987 p.12).

Green epitomizes the color of nature, man's natural environment; therefore, it is the balancing color of the spectrum, midway between red and violet. It creates a sense of self between the material and the spiritual being. Harmony, peace, serenity describe environments created by green. It borrows from the happiness of yellow on one side of the spectrum and from blue's tranquillity in the shorter wave length. Spring and the renewal of life and hope are frequently symbolized by green. Green is the color of order, organization, completion, system, achievement and a firm foundation (security). On the negative side, green can also mean that because purpose is the ultimate, nothing must stand in the way. In this manner, it is the color of envy, jealousy and cruelty (Don 1977).

In yoga, green is considered the color of the heart center, the color of procreation, reaffirming the idea from ancient times of the new earth, hope, and rebirth (Wilson & Bek 1931).

In the latter part of the 19th century, Hessey's work as reported by Birren (1961) indicated that green light lowered the blood pressure. "It affects the nervous system and is a sedative and hypnotic. It is useful in cases of nervous irritability, exhaustion, neuralgia, headaches, anxieties, neurotic fears, and shell shock" (Birren 1961, p.60). In other medical experiments green has been found to be neutral.

"Green for life and love....a most ambivalent hue." It is thought of as being the color of life, rebirth, vegetation on one hand, yet it is the color of mold and decay, poison, envy and jealousy. "In daylight, when the majority of colour receptor cells in the eye are working together, they are most sensitive to yellowish green light." (Varley 1980 p. 206). It is associated with stability and security, love, infinity (Varley 1980).

Blue

"In all aspects, blue is the antithesis of red. In its appearance, blue is transparent and wet; red is opaque and dry. Psychologically, the cool and relaxing nature of blue is in direct opposition to the warmth and excitement of red. While red seems vulgar at times, blue exhibits a noble character. In its action upon the human organism, blue will decrease blood pressure and pulse rate while red will have the opposite effect (followed by a reversal in both cases after a period of time)" (Mahnke 1987, p.13).

Blue, the color of the sky, bringing contemplation, meditation, is not so much physical as it is spiritual. Descriptors for the feelings created by blue are comforting, pacification, but with the stimulating effect of the red, enlightenment, quietude, tranquillity, stability, dependability, creating a mood for a search for truth, introspection, faith, calm. Because it creates a sense of security, it can stimulate inspiration (Don 1977).

The practice of yoga denotes blue as the color of aloofness creating the spiritual over the temporal. A sense of apartness, observation rather than participation, blue is a sea of serenity in an ocean of disorganization (Wilson & Bek 1979).

Blue has been used in the past to treat inflammatory diseases and nervous conditions such as sciatica, hemorrhage of the lungs, nervous irritability. Hessey contended that blue contracted the arteries and raised the blood pressure. Blue was prescribed because of its bacterial properties for headaches and insomnia. "Blue light produces a direct action through the eye and the nervous system" (Birren 1961, p.109).

"The infinity of blue....it flatters nearly everyone,...peacemaker....salubrious. the blue sky is a cure for the blues. Blue blood, bluestocking, true blue, blue gown, blue movies, blue ribbon, blue chip, different connotations of blue are drawn from the lightness or darkness (value) of the blue" (Varley 1980).

<u>Indigo</u>

"Attuned to the reality of living,....related to the artistic and the idealistic, indigo seeks to give the feeling of beauty. Associated with family and personal relationships it is a comforting color. It creates a sense of fulfillment" Don 1977 p.79).

In yoga, indigo denotes the intuitive abilities of man; therefore, it is the color of healing because of its ethereal quality (Wilson & Bek 1979).

Violet

"Purple is a blend of red and blue, the two colors that are physically and psychologically most opposed. In its various tone, purple may evoke delicacy and richness or appear unsettling and degenerate. Violet is a lighter shade of purple and a pure spectral hue. Purple is a mixed color. The two encompass vast differentiations of hue" (Mahnke 1987, p.13).

Violet goes one step beyond the spiritual, searching beyond reality within enchantment. It is the color of royalty and of evil. It, like its close neighbors in Newton's color spectrum blue and indigo, is relaxing for frayed nerves (Don 1977).

"Violet....means a sense of art and beauty" (Wilson & Bek 1979 p.44).

"Deep, deep violet", red and blue, which compose violet are opposites, psychologically and physiologically. They can portray a heavenly color or a hellish color. Violet is a spectral hue, purple is a mixed hue. Born to the purple, not just the color of power, but the color of corrupt power, purple is the color of deep feeling, self-esteem, not to be thought of as a shrinking violet (Varley 1980).

Gray

Gray is perceived when the same amounts of all wavelengths are absorbed. Gray is the color of industry, man-made environments, mechanical. It is also the color of wisdom and intelligence as evidenced through the term gray matter or respect for the gray head. When something is not clear, it lies within the gray area (Varley 1980).

The color gray has been used in combination with many colors in the environment as a decorative trend which is not rooted in any kind of color research and actually goes against the logic of color research (Mahnke 1987).

White

White is the color of reflectance; when maximum wave-lengths of light are reflected back to the eye, white is perceived. There is no true white; however, a small percentage of wave-lengths are absorbed even with white. White is illusory, there are many different whites even though they can only be distinguished when placed in close conjunction. White magic, white lies, truce, surrender, inhumanity, anti-septic all are white connotations (Varley 1980).

White must go and off white must follow. Many times termed industrial white because of easy match and easy fix up, many institutions use white because it appears to be cost effective. Considering the research concerning the color white on the human nervous system, white can be considered extremely expensive. As early as 1947, Louis

Cheskin wrote: "White walls....are an optical strain and a psychological hazard" (Mahnke 1987, p.23).

A West German study on white walls in the work place resulted in findings that termed this environment as being neutral, sterile, empty, without vitality. Psychologically, white has nothing to offer. In color preference tests, it comes out at the bottom of the list. Many decorators use white because they claim it is effective in placing bright colors within a plan, but they fail to recognize that much physiological adaptation is required within this kind of environment which causes eye strain and fatigue. In schools, hospitals, places of work, depending on the purpose of the environment, to stimulate, to enervate, to produce, or to convalesce, white has no therapeutic or any kind of value. Because a basic need of the environment is sensory variety-a relief from monotony which induces tension, anxiety, fear-white must not be used. White has a high reflectance which also makes it a bad choice for walls. If designers are adhering to recommended light levels it would be unusual for them to choose white because of its high reflectance level (Mahnke 1987).

Researchers are constantly attempting to measure color in its relationship to human reaction. It is not enough to say short wave length colors are calming, long wave length colors are arousing. Definitive tests are being developed, but the realm of color grows increasingly more complex each year as colors are created through new processes. Even though the basic spectral colors remain the same, mixing them in ever greater color varieties creates a more complex problem for the researcher attempting to measure the reaction of the human psyche to color in the environment.

Review of Related Literature

In attempting to understand the impact of color and light on the human within his environment, researchers continuously search out better ways to isolate the interdependent variables influencing human behavior. Color, an integral part of the human milieu, aids memory in creating the environmental map with which biological creatures ascertain location within the milieu. Because the influence of color on light and light on color are conjoined, they are often examined as a single entity within the complete environment.

The Journal of Art Therapy has published many studies relating to the color/light phenomenon. Dr. Bernard Levy used a standardized test called the Profile of Mood States or POMS to test subjects involved in two studies designed to define mood states when exposed to different hues. Using three colors, he first determined that on this test there was no difference between men and women in their reaction to the three tints; bright intense yellow; a light, pastel blue-violet and a vivid yet dark, cool green with a blue cast.

Since men and women were compatible on the first test, the whole group was exposed to three more tints; a vivid scarlet-vermillion; a light blue-green, and a dull, dark mustard yellow. Since the <u>POMS</u> was designed for psychiatric treatment, it only measures negative effects. Its primary purpose was to measure freedom from psychological stress or the presence of psychological stress.

Subjects were placed in a well lit environment where they were first given one of the three colors, asked to stare at it intently, then record their responses as to the feelings engendered by the color. They were asked to work quickly and to record their first response. The two other colors were presented in the same way.

The study attempted to ascertain whether the subjects responded differently as individuals to different colors and whether as a group they responded similarly to the same color.

Findings indicated that color elicits strong emotion with no change occurring by varying the order of the presentation of colors. Since each of the three colors was preferred by a third of the group, there is a predictability that color preference has little or no effect on reaction to color. But like much of the color research, this study points out that there are still more questions to be asked than have been answered (Levy 1984).

Mood has also been studied in children to discern the effects of color. A study conducted by Hamid and Newport (1989) over a period of twenty weeks reported that colors not only affect mood but physical strength. The subjects, six preschool children, were tested for manual dexterity, sorting, and physical strength as measured by pounds with an Ergometer, within different colored rooms: gray, pink, blue. The tests within the different rooms were arranged so that the children were first tested in a gray room, then a pink room, gray room, blue room, gray room, pink room, (a,b,a,c,a,b) (Hamid and Newport 1989).

The results of grip strength as tested in pounds with the Ergometer produced an increase in the pink room over the original test in the gray. The second gray room produced a decrease over the pink room. There was a more rapid decrease in the blue room. The third gray room yielded a slight increase in grip strength. The final pink room engendered a marked increase.

While in the differing environments, the children completed pictures using poster paints and newsprint to measure the effect of environment on creativity. These were randomly assigned to four judges who were asked to rate them according to mood. It was expected that the mood scores by the judges on the seventy-two paintings would fall quite evenly across the positive-negative scale, but the positive paintings were more likely to have been completed in the pink rooms than in either the gray or the blue rooms, ($p < .001$) with the blue room yielding more negative ratings (Hamid and Newport 1989).

The best efforts of teachers in all fields are utilized to fend off that chronic student complaint, boredom. Although there are abundant indicators, actual proof that the environment can be one of the prime precipitators of this syndrome in the classroom or the boardroom is negligible. One hundred forty undergraduates, seventy male and seventy female, took part in a study to determine the color which would allow them to successfully complete a repetitive task designed to be lacking in stimulation.

The subjects were tested individually with instruments designed to assess arousal, dominance, pleasant, unpleasant and comfort. The tests were administered before entering the room, after entering the colored research area, and after completing the boredom induction task.

The colored research area consisted of carrels painted two meters high with different pigments; light blue, blue, pink, red, orange, white, brown, green, yellow, gray. While within the carrels participants listened to an audio tape which asked them to record specific word changes.

No differences were noted between subjects when tested prior to entering the test area. Exposure to the colors resulted in yellow being considered the most pleasant, orange the most arousing on one measure with yellow most arousing on all instruments. However, the researchers felt no conclusions could be reached from this study because it appeared the color affect was of short duration and that the participants responded subjectively. A larger colored field of vision was recommended in future studies as well as variations in hue and saturation levels (Greene 1983).

Saturation, the least considered and most difficult to measure color characteristic, may play a larger role in influencing human behavior than any specific hue. Seventy-eight students participated in a study designed to evaluate techniques used in determining the effect of the hue, saturation and chroma of twenty-four colors making up a color circle. The color chips were in the shape of a circle, a triangle, or a square. According to a schedule designed to eliminate shape and background perceptions the subjects judged each color according to its own characteristics as being pleasant or unpleasant.

A positive relationship was found between pleasantness and saturation. Researchers may have been mistakenly adjudging red and blue as being colors of preference because they are naturally the most saturated. The dichotomy between hue and saturation further points out the need for varying these disparate elements of color for a more effective environment (Smets 1982).

The link between color and emotional state continues to bring emphasis to the utilization of preferred colors in order to create a more comfortable and efficient environment. Hue, chroma, and saturation are manipulated to discern their most productive variations. One hundred seventy 8th to 10th grade students took part in a study designed to determine if extraverts prefer long wave length color and introverts prefer short wave length colors.

Two cards were painted with a commercial paint, one red, one blue. Classroom illumination was unchanged. Colors were shown to participants at the same time with the students responding with a short answer of "I prefer the color blue," or "I prefer the color red."

Zuckerman's Sensation Seeking Scale, Form IV (1979) was used to determine whether students were high or low stimulation seekers.

Scores indicated that high stimulus seeking people prefer red; low stimulus seeking people prefer blue. Corroborating research by Dr. H. Wohlfarth in Edmonton, Alberta, specified yellow as being the color of preference with black being least preferred. Because of the ability of color to arouse and stimulate, greater emphasis should be put on its use in creating motivating classroom interiors (Nelson 1984).

Cockerill and Mill (1983) conducted a study to ascertain the effects of color on accuracy in performing motor tasks. A Grooved-Pegboard Test was used to study changes in the ability to accomplish specific tasks while wearing goggles which were fitted with different colored lenses. Sixty boys and sixty girls between the ages of six to eleven years were the subjects.

The children were asked to perform a pegboard test with the use of their preferred hands. The pegboard was painted a matte white. The children were fitted with goggles which had four different colored lenses; blue, green, yellow and red. A clear transparent goggle was used as a control. Each child performed the test three times using the least preferred, most preferred and control goggles.

In all cases, the children performed the task more effectively, in a shorter time and with fewer errors, while using the goggle of their preferred color. The researchers felt that predominant evidence indicated that children work more effectively when operating within environments which are more pleasing to them. "Research tends to support the view that colour has a crucial role to play in the general cognitive and motor development of children" (Cockerill and Miller 1983).

Consciously and subconsciously the classroom imparts a variety of messages with color and texture being prominent characteristics of importance to children. Because a definitive relationship seems to exist across children's environmental preferences, home and school, Cohen and

Trostle (1990) designed research to ascertain how children "selectively discriminate among school-related environmental setting characteristics." The subjects were 78 kindergarten and first grade children, 32 boys and 46 girls.

Through the use of a guided story walk, separate characteristics within the environment were presented to the children in contexts easily comprehended by them. The children participated in the task in a manner which was interpreted as extremely motivated. Although a naturalistic milieu was contrived, each element was presented individually which would not be reasonable in the real environment.

The individual characteristics of indoor and outdoor environments were presented and compared to determine the children's preferences for size, shape, color, texture, complexity, and lighting. Cards which pictorially featured the characteristics in three different degrees (ex. size; small, medium, large) were presented to the children who chose one. Following an explanation in which the tester told the children that they would be taking a guided tour around a pretend school, the tester presented the pictures in two 10-ten minute sessions over a three day period.

In both the indoor and outdoor environments the girls preferred more dramatic hues and greater complexity than boys. The boys were able to reconstruct the main elements of the environment more effectively than the girls and appeared to be more observant of the milieu macroscopically. The girls attended more to details within the environment defining it microscopically. The differences between boys and girls in the selection of spatial arrangements appeared to be the result of a socialization process which encourages expanding of the milieus for boys and restricting it for girls.

Of the six elements of the environment studied, correlations for color and light were statistically significant. Color along with shape, complexity, texture, size were all determined to be statistically significant for older children. Color preferences remained stable across settings for both boys and girls.

The authors contend that the capacity to discriminate among various environmental settings is highly developed by the time children start school. Color stands out as being an element of the environment that is important regardless of the sex or the age of the child. Shape and lighting were also adjudged to be of great importance. This research demonstrates the necessity of recognizing the importance of a child's sense relationship with the environment in establishing his place within the world of which he needs to see himself a part. A recognition of the differing ways in which boys and girls see their places within the educational setting may enhance learning (Cohen and Trostle 1990).

Controversy was created over the findings that color affects muscle strength. Some researchers have validated measurements verifying that viewing blue panels increases strength and viewing pink panels decreases strength. Others have taken exception to these findings (Hathaway 1988).

The literature has many contradicting citations about the effects of color on strength. Through the pituitary gland, colors affect the endocrine system. Tests using mice exposed to pink light revealed enlarged pituitary glands. Ott (1979) as reported by Smith, Bell, and Fusco (1986) ascertained that pink and orange decreased muscle strength. Green et al. (1979) as reported by Smith, Bell, and Fusco (1986) reported that blue increased muscle strength with pink and red causing a decrease. This has also been reported by other researchers.

Smith, Bell and Fusco (1986) used a hand dynometer to measure muscle strength while subjects, 30 men and 29 women, were exposed to painted (pink, orange, blue, light blue, yellow, brown, red, green) panels. The Russel and Pratt (1980) questionnaire was administered after each color trial. Subjects were asked to gaze at the colored panel for 60 seconds after which they completed the questionnaire. A new panel was installed and immediately upon completion of the questionnaire the subjects stared at the new panel. Subjects were programmed with a statement informing them of a pink-weaken statement or a pink-strengthen statement before beginning their trials. They were also advised that the programming statement was supported by research.

Men viewing under the pink-strengthen instructions did show greater grip strength than under pink-weaken. The blue panel also showed men having greater grip strength under the pink-strengthen instructions, but not as great as while viewing the pink panel. Women showed greater grip strength under the pink-weaken instructions for all colors with the greatest grip strength while gazing at the pink panel and the least for the brown and green panels.

On the affective scales, blue was considered the most relaxing, pleasant color; red was the most exciting (Smith, Bell and Fusco 1986).

O'Connell, Harper, and McAndrew (1985) collaborated in a study to determine if sex associations may have been a determinant in grip strength being stronger when subjects were exposed to a blue panel than when exposed to a pink panel. They tested 40 male college students with colors determined to be lacking in sex associations, green and red.

Each subject was exposed to a brightly colored wall for 60 seconds with grip strength being measured with a hand dynometer at the end of this period. After a brief resting period the subject repeated the task before the second brightly colored wall. One half of the subjects were exposed to the wall in reverse order. Twenty-six subjects had higher grip strength when exposed to the red wall; fourteen had higher responses for the green wall.

Numerous studies were conducted to test children's catching ability with balls of various colors. Many factors contributing to children's developmental skills can be hypothesized from this kind of study. In one study of motor tasks, the effects of ball color on the catching ability of children were tested. The subjects were 90 children between the ages of six and ten years old. The study describes environmental conditions as well as the preferred ball color and ball color effects.

The research design included two separate experiments in which the children attempted sets of catches with different sized balls at different heights. Because of the different heights of the children, a human thrower was trained in tossing under handed in a manner that required the children to make the catch according to specification. Little relationship was found between preferred ball color and catching scores. The mean catching scores with the blue ball which had the highest contrast between ball color and background were significantly greater than scores for the yellow ball which had the lowest ball color environment contrast ratio. This occurred only during the distance catching experiment. The red ball also scored higher than the yellow ball.

This study found no significant relationship between preferred or nonpreferred colored balls in a catching task. Further study is indicated, however, in the relationship between color and performance (Belka 1985).

The Edmonton, Ontario School District conducted a study of handicapped children in which environmental interventions were designed to alter behavior. The subjects studied had gained a reputation for being extremely hard to handle with multiple behavior problems. The children were video-taped at the same time morning and afternoon. Specific instances of behavior were counted in categories. Blood pressure and pulse were recorded three times a day at the same time. Each phase of the study lasted for 10 days: Phase I environment, phase II environment, then return to Phase I environment. All persons that were in the environment were test subjects, teachers as well as students.

"Phase I-<u>baseline conditions March 17-27 (10 school days)</u>

-cool white fluorescent lighting, diffuser panels.

-bright orange carpet over 4/5 of floor.

-rust brown tile on 1/5 of floor.

-one long wall solid orange vinyl.

-other walls off white, painted.

-dark trim around doors and windows.

-bright yellow storage cupboards.

-bright yellow shelving.

-bright yellow bulletin board.

-chairs neutral grey.

-tables, one blue, 2 peach.

-1 orange screen.

Phase II-<u>colorpsychodynamically prescribed environment April 6-24 (13 school days</u>)

-full spectrum fluorescent lighting-diffuser panels removed.

-light warm grey carpeting 4/5 of floor.

-rust brown tile 1/5 floor.

-white walls painted a light warm blue.

-window and door frames painted medium tone royal blue.

-shelving, bulletin boards, storage cupboards painted medium tone royal blue.

-furnishings remained the same.

-orange screen was removed.

Phase III <u>April 27-May 15 (15 school days)</u>

-room returned to original Phase I baseline conditions" (Wohlfarth 1981, p.6).

The results of the study showed that aggression, self abuse and nonattentive behavior dropped markedly from Phase I to Phase II, although destruction remained the same. In Phase III, aggressions begin to reappear, although destruction, self abuse and non-attentive behaviors continue to decrease suggesting a lasting effect of the Phase II environment. The physiological results of the study showed that blood pressure and pulse rose during the day in Phase I whereas in Phase II blood pressure and pulse were lower at the outset and remained constant throughout the day indicating that blood pressure is responsive to environmental impact and will go up in stressfully, colored environments but remain constant in prescribed environments (Wohlfarth 1981).

In a study of differences in stimulation between hyperactive and nonhyperactive children, the relationship between color stimulation and instrumental response was scrutinized. Activity is a regulator of incoming stimulation, therefore Zentall (1988) theorized that different color stimulators would affect hyperactive and nonhyperactive children differently. The purpose of the study was to see if the effects of the stimulators when presented at different times during the tasks affected the task outcomes. The two tasks presented were a continuous performance task and a complex learning task. Hyperactive and normal children performed similarly at the beginning of continuous performance tasks, but hyperactive children were unable to sustain performance.

When the hyperactive children were given additional color stimulation early and late in the sustained performance tasks, they performed similarly to normal children. When additional color stimulation was added to later trials of complex learning tasks, the hyperactive children became less active and were better able to work on the task.

Hyperactive children may need to have special accommodation within the educational milieu to allow for performance at the same level as normal children. An absence of sufficient stimulation lowers their ability to accomplish tasks at their optimum level of ability (Zentall, 1988).

Special attention has also been paid to the kinds of lighting used in classrooms to provide sufficient amounts of stimulation. When the fluorescent lights in a special education classroom were replaced by incandescent lamps, hyperactive behavior decreased by thirty-two percent (Painter 1976).

A classroom in Santa Cruz, New Mexico, was lit by the same lights used in schools across the country, cool-white fluorescent. Although fluorescent lights have been coming under the close scrutiny of environmental researchers, (Ott, Wohlfarth, Hathaway) research at this time is inconclusive.

In the Santa Cruz study, an observer sat quietly at the back of the classroom for one week counting incidents of hyperactive behavior, the definition of which had been agreed upon beforehand. A total of 297 incidents were counted. At the end of the week, the florescent lights were turned off and incandescent lamps were installed. The students had one week to become acclimated to the new lamps. The next week behaviors were again counted. Hyperactive incidents dropped to 201 during this period of time.

Since this experiment in Santa Cruz took place, a new four classroom facility for aphasic and language-disabled children has been built. A dual track lighting system has been installed in order to carry out more comprehensive studies of classroom lighting (Painter 1976).

A further study of full spectrum lighting versus standard cool white fluorescent carried out in Sarasota, Florida, confirms the data in the Painter (1976) study. Two classrooms were utilized as control classrooms while the other two classrooms were retrofitted with Vita-Lite fluorescent bulbs. Open diffusers were installed in all the classrooms to replace the closed diffusers. Unknown to the teachers and students, time lapse cameras were placed in each room to record behavior at specific intervals. Each student hyperactive behavior was timed with a stop watch to calculate a percentage, total time/hyperactive time. Age differences, sex differences, and academic achievement were also studied as a part of the research.

Hyperactive behavior was reduced dramatically in the classrooms containing the full spectrum lighting. Significant differences were also noted in academic achievement, but these differences could not be attributed to the lighting alone. Extremely poor instruction was being conducted in one classroom versus outstanding instruction in the other. However, there appeared to be no correlation between the paucity of hyperactive behavior and academic achievement (Mayron, Ott, Nations, and Mayron 1974).

Bross and Jackson (1981) did a study entitled "Effects of Room Color on Mirror-Tracing By Junior High School Girls." Sixty girls in the seventh, eighth and ninth grades were given the Room Color Preference Questionnaire. A criterion score was achieved by having all subjects practice the task in a neutrally colored room. There was no difference in initial ability as determined by an analysis of variance using criterion scores.

Three trials were administered in each of three differently colored rooms. Order effect was determined to be nonsignificant through the use of t-tests for errors and time.

The hypothesis that muscle tension is less in rooms with "liked" colors was supported by the fact that girls in all three grades made fewer errors in the rooms with preferred colors. Muscle tension seemed to be greater in rooms of nonpreferred colors as demonstrated by the fact that speeds were greater in those rooms (Bross & Jackson 1981).

In order to support their philosophy that "students are affected positively or adversely due to visual, acoustical and thermal characteristics purposely or inadvertently built into the classroom environment" Bowers and Burkett (1987) carried out a year long study in two schools ir Tennessee. The basic premise of the study was that "student learning would be directly related to the physical environment of the respective facilities" (Bowers & Burkett 1987, p.3).

Principals and teachers were assumed to be equal because of Tennessee certification laws. Students were given an achievement test at the beginning of the year to match them for ability levels. Similar socio-economic levels were assumed. The two campuses were housed in totally dissimilar physical plants. One school was the newest school in the district, the other the oldest.

Hypotheses were tested through the use of ANOVA, Chi-Square, and t-tests. ANOVA was used to analyze attendance and achievement, Chi-Square for health and discipline, t-tests were computed to determine differences in attendance.

Significantly higher scores in reading, language, arithmetic, and listening were attained by students, fewer discipline problems were recorded, students had fewer health problems, and higher rates of attendance were registered in the newer environment than in the old (Bowers & Burkett 1987).

Sinofsky and Knirk (1981) stress the importance of environmental psychology to the repertoire of the educational administrator because of the human interaction with color at different age and grade levels; its effect on time sense, IQ levels, on closure, knowledge levels and perception.

Research in the industrial sphere has shown that color can increase production, improve morale, and decrease absenteeism. This research has been ignored within the educational community. Color prescriptions should be used in schools to promote positve feelings and reduce absenteeism. Window walls should be painted a lighter color, walls opposite windows should be darker to reflect the sun's rays. Educators should follow the lead that industry has provided (Papadatos 1973).

In doing research on noise levels, cool colors in libraries have contributed to findings of significantly quieter libraries (Sydoriak 1987).

"Buildings send messages; they are never neutral" (Hathaway 1988, p.29). In Light, Color & Air Quality: Important Elements of the Learning Environment, Hathaway writes that color is reported to affect "mood and emotional state, psychomotor performance, muscular activity, rate of breathing, pulse rate and blood pressure." Studies have been conducted which attest to a perception of temperature increases in red rooms and decreases in rooms decorated in blues and greens. In a study where a bank office painted a salmon-grey was thought to be too warm, the problem was solved by changing the color scheme to a blue green. "It is reported that Knute Rockne had his team's locker room painted high energy red and the locker rooms of the visiting team painted a restful blue" (Hathaway 1987, p.40).

Dutczak (1985) carried out a 2 year case control study, the subjects of which were severely, physically and mentally handicapped students, aged 3 through 21. Environmental color and full-spectrum lighting were utilized to observe their effects on this population. Orange produced a decrease in muscle strength in a cerebral palsied subject, and it was hypothesized that it may help alleviate the excessive muscle tone in patients with this or other muscle related diseases.

While prone under green lights, subjects engaged in developmental movements. Blue lights and darkness helped to relax students, while red was used to stimulate.

Full spectrum lighting appeared to have reduced the number of seizures in one student by 72% at a time when seizures in other environments were increasing (Dutczak 1985).

As a followup study to the Elves' Memorial study, which this research will replicate, H. Wohlfarth did an in-depth study during the fall through spring academic period in four schools in Wetaskiwin, Alberta. Approximately 560 elementary school children were subjects in the study. One elementary school was the control, a second school, the architectural twin to the control, had a color and light psychodynamically designed interior, the third school had only the lights changed and the fourth had only its color changed.

Blood pressure and pulse readings were recorded twice daily for the students. Students in all four schools came to school with nearly identical blood pressure and pulse; however, the color and light psychodynamically prescribed school had significantly different afternoon pulse and blood pressure readings at the .05 level. It recorded the lowest levels while the control school recorded the highest.

The following achievement measures were used to pre-test the children during the year prior to the color and light research study: Metropolitan Readiness Tests, Otis-Lennon Mental Ability Test, Canadian Tests of Basic Skills, Kindergarten A.G.S. First Grade Screening Tests, Metropolitan Achievement Test, Otis-Lennon Elementary I, Canadian Lorge-Thorndike Intelligence Tests. At the conclusion of the study, the tests were again administered as part of the post-test design. The nine academic tests in grades two through six showed the greatest improvement in the light only school, but the greatest improvement in the IQ tests was in the school with the prescribed color and light.

The control school showed the least improvement with the color and light school showing the greatest overall improvement.

"Percentages of increase on academic tests

control	color and light	light	color
+8.55	+12.56	+16.84	+9.91

Percentage increase of performance on I.Q. tests.

-1.29	+ 8.98	+ 2.07	-1.84

Percentage of improvement of performance in academic and IQ"

control	color and light	light	color
+3.63	+10.77	+ 9.45	+4.03

(Wohlfarth 1983).

In studying the effects of color and light within the four schools, it was found that the greatest decrease in aggression, destructiveness, and habitual disciplinary problems was found in the color only school. The combination of full spectrum lighting and psychodynamic color did not make as great a difference in student behavior as did the color by itself.

The effects of noise levels were checked in the libraries of the two architecturally twin schools. The psychodynamically color/light school experienced significantly lower noise levels in the library (Wohlfarth 1986).

This research was one of the most comprehensive studies carried out within the public school milieu. The fact that it took place over several months, included over five hundred subjects in four schools, one of which was a control, and utilized several valid and reliable tests to determine results, added valuable credibility to the argument that school environment needs to be considered as an important element in improving our schools.

Despite the lack of extensive research within the educational environment, it is the learning environment within which humans spend a large part of their lives, the most important part. The research cited exemplify the effect that color/light have on the biological organism. Even though categorical statements concerning the cause and effect relationship between the human and his environment cannot be validated at this time, the existence of a relationship has been recognized and puzzled over by the greatest minds of many centuries from Aristotle to Sir Isaac Newton to scientists in the twentieth century working with sophisticated instruments and computers (Varley 1980).

The enhancement of human performance requires the optimum environment. Educators must recognize the fact that surroundings are never neutral. Just as the teacher and the materiel set the stage for learning, the milieu becomes a part of the tableau which creates a user-friendly school (Hathaway 1988).

CHAPTER III

RESEARCH DESIGN

This study was a replication of a study conducted by Dr. H. Wohlfarth of the University of Ontario as reported in "The Effect of Colour Psychodynamic Environment on the Psychophysiological and Behavioral Reactions of Severely Handicapped Children. Effects of Colour/Light Changes on Severely Handicapped Children". In 1981, Professor Wohlfarth conducted what he termed a "quick study" of severely handicapped children at Elves' Memorial Child Development Centre. The study proceeded through three phases during which blood pressure and pulse were recorded and a frequency count was made of specific acting out behaviors.

Phase I. Regular classroom environment.

Walls, orange vinyl and white paint.

Dark trim around doors and windows.

Yellow shelving, one blue table, two peach tables.

One orange screen.

Cool white fluorescent lights, diffusers in place.

Four-fifths of floor bright orange carpet.

One-fifth of floor brown tile.

Phase II. Prescribed environment.

Full spectrum lighting, diffuser panels removed.

Neutral grey carpeting on four-fifths of floor.

Rust brown tile on one-fifth of floor.

Medium tone royal blue, one wall.

Light warm blue, on other walls.

Trim, royal blue.

Shelving, bulletin boards, storage cupboards, royal blue.

Orange screen removed.

Furnishings, the same.

Through the use of color and light research, this design scheme was determined to have maximum effect in decreasing "autonomic and behavioral response" (Wohlfarth 1981 p.8).

Phase III. Return to Phase I environment.

The population in Dr. Wohlfarth's Elves' Memorial Study consisted of seven handicapped children, one boy and six girls, two of whom were blind and two staff members. Once these children arrived at school, they and the staff members who worked with them, stayed in the study environment for the entire school day. It was necessary to contain their entire schedule of activities because of the severity of their handicaps.

The children in the study had severe behavior problems. "Unprovoked aggression, tantrums, various manifestations of short attention span, and self abuse are typical examples of problem behavior" (Wohlfarth 1981, p.1).

The study reported in this paper took place during the fall of 1992 at C.H. Decker Elementary School, a non-specialized public elementary school. Because of restrictions on population selection, the research design for this study was quasi-experimental. Permission was obtained for the use of 18 subjects in the study which was the total population of this classroom. However, just prior to, and during the first week of the study, classroom readjustment took place in the Clark County School District. One teacher was surplussed because of too few students in some classrooms. This necessitated the realignment of all classrooms. Some students were reassigned which caused the population of the research classroom to increase to 31. It was at this time necessary to obtain new permission slips. In the final analysis of data, 11 students were determined to have a full complement of scores with few or no absences, five 6-year old boys and six 6-year old girls.

The color/light environment in this classroom was modelled after Dr. Wohlfarth's classroom with adjustments having been made according to the specifications of the Clark County School District Environmental Protection Office and the approval of the Clark County School District Rehab Office.

Phase I. Standard classroom environment-orange, red, and yellow paper covering the brown wallboard. Front and back walls were an off-white semi-gloss standard paint color in the Clark County Schools. (See appendix for paint specifications)

Round woodtone tables.

Doors and trim were woodtone or brown.

Carpet was a brown variegated with gold and beige.

Standard cool-white fluorescent lights with diffusers in place.

Visual noise (alphabet, number line, posters, charts, mobiles) was distributed throughout the room as is considered standard classroom practice.

Phase II. Front and back walls were painted blue with the front wall, a darker shade for emphasis, using Glidden 2000 Clean Air Paint as recommended by the Clark County School District Environmental Office. Side walls of brown wallboard were covered with blue fabric which was color matched to the front and back walls.

Round woodtone tables.

Doors and trim, wood stain or brown.

Carpet-variegated brown with gold and beige.

Duro-test Vita-lite fluorescent tubes with diffusers removed.

Visual noise was returned to the walls as recommended in Dr. Wohlfarth's research.

Phase III. Return to Phase I environment.

A naturalistic contrived situation observation was derived. The observers were a first grade classroom teacher, an elementary school counsellor and a first grade classroom teacher with special early childhood training. All of the three observers have Master's Degrees in their specialties and more than ten years experience in the educational milieu. The observers provided the researcher with a short summary of their educational and experiential backgrounds. (appendix)

The classroom behaviors in Dr. Wohlfarth's study were separated into agressive behaviors and non-attentive behaviors. Behaviors in this study were labelled off-task behaviors as determined through dialogue with the Cooperative Research Committee of the Clark County School District.

The criteria for counting the specific behaviors were arrived at through consensus in a training session involving the three observers and the researcher in which a video tape filmed prior to the study was viewed and behaviors were analyzed.

The video tapes used for the actual tabulation were filmed during the day at specified times for 15 minutes in the morning and 15 minutes in the afternoon for the duration of the study. The subjects were filmed during a phonics lesson in the morning and a writing lesson in the afternoon.

Because this study took place in a public elementary classroom, there was a conscious effort to follow the daily routine. If it was necessary for the children to leave the room for another activity at the time the filming was scheduled, the filming did not take place that day.

The three judges viewed the tapes individually in a random order. Although the environment was easily visible in the tapes so that Phase II was distinguishable from Phase I and Phase III, there was no discernible difference between Phase I and Phase III on the random order tapes.

Off-Task Behavior Criteria

1. The child is not visually following the lesson being presented.
2. The child appears to be attending, but is playing with objects.
3. The child is moving the chair or his body in a way which precludes his being able to concentrate on the lesson.
4. The child appears to be daydreaming, is not involved in the lesson.
5. The child is covertly bothering the children around him while appearing to be involved in the lesson.
6. The child is overtly acting out-not attending to the lesson.

There were a total of 1110 off-task behaviors counted during the seven weeks of the study. Three hundred ninety-nine off-task behaviors were counted during Phase I of the study. Ninety-eight or 25% were counted by Judge A, early childhood specialist, 190 or 48% were counted by Judge B, counsellor, and 111 or 28% were counted by Judge C, first grade classroom teacher.

Table 1

Phase I Off-Task Behaviors Recorded By Three Observers

Day	1	2	3	4	5	6	Totals	
Judge A	10	13	15	15	23	22	98	25%
Judge B	40	38	43	22	19	28	190	48%
Judge C	23	26	17	17	12	16	111	28%
Totals	73	77	75	54	54	66	399	
Daily Mean	24.3	25.7	25	18	18	22		
Phase I Mean	66.5				Standard Deviation 7.33			

Seventy-three off-task behaviors were counted the first day of the study, the second day showed an increase of 5% or 77 off-task behaviors. Day 3 off-task behaviors (75) decreased by two and continued their decrease with days three and four demonstrating a substantial difference (54) 28%. On Day 6, off-task behaviors again increased from 54 to 66 (18%). During all three phases there was a decrease in off-task behaviors on Day 5 of the recordings.

A total of 310 off-task behaviors were counted during the first six days of Phase II with a total of 356 for the seven days of Phase II. Judge A accounted for 25% or 86 of them, Judge B, 50% or 200, with 70 or 20% having been counted by Judge C. Table 2

Table 2

Phase II Off-Task Behaviors Recorded By Three Observers

Days	1	2	3	4	5	6	7	Total	
Judge A	12	14	8	16	11	13	12	86	25%
Judge B	29	34	30	23	25	30	29	200	56%
Judge C	12	16	11	12	8	6	5	70	20%
Total	53	64	49	51	44	49	46	356	
Daily Mean	17.7	21.3	16.3	17	14.6	16.3	15.3		
Phase II Mean	50.8				Standard Deviation 5.05				

Off-task behaviors on the first day of the second phase were less than one standard deviation above the mean (53). Day 2 exhibited an increase of 11 (17%) more than Day 1, 53 to 64. Off-task behaviors decreased on Day 3 from 64 to 49 (23%), but increased by two on Day 4 and then made a sharp increase on Day 6 (11). The last day of Phase II showed off-task behaviors at 46, 4.8 below the Phase II mean and 28%

below the second day of Phase II which had the highest number of recorded off-task behaviors for this phase, but 20 off-task behaviors below the last day of Phase I (30%).

Judge A recorded the same percentage of the total off-task behaviors during Phase I and Phase II demonstrating a greater consistency in counting procedures. The school counsellor accounted for a higher percentage of the total, from 48% to 56% during the second phase while Judge C had a lower percentage of the total, decreasing from 28% to 20%.

Total off-task behaviors decreased by 89 or 22% from 399 during the first phase (original environment) of the study to 310 during the first six days of the second phase (prescribed environment). The decrease was recorded between Phase I and Phase II when the only change in the classroom was in the color and light. The standard classroom off-white and standard fluorescent cool-white tubes were changed to the blue environment with the full-spectrum Vita-Lites. With other factors remaining constant within the classroom, there is substantial reason to believe that the change in the classroom color and light contributed to an important decrease in off-task behaviors.

During Phase III, Judge A accounted for 4% more of the off-task behaviors than during Phase I and II while Judge B the school counsellor had a smaller percent of the total at 49%, but still counted more than twice as many off-task behaviors as Judge C (21%) the first grade classroom teacher.

The recorded off-task behaviors during Phase III differed from Phase II by one off-task behavior, decreasing from 356 to 355. Even though the environment had been returned to its original colors and lighting, off-task behaviors remained constant with a standard deviation of 5.05 during Phase II and a standard deviation of 5.17 during Phase III. Table 3

Table 3

Phase III Off-Task Behaviors Recorded By Three Observers

Day	1	2	3	4	5	6	7	Total	
Judge A	17	16	13	15	14	16	14	105	29%
Judge B	24	30	19	23	26	34	18	174	49%
Judge C	12	12	13	13	4	10	12	76	21%
Total	53	58	45	51	44	60	44	355	
Daily Mean	17.7	19.3	15	17	14.7	20	14.7		
Phase III Mean	50.7				Standard Deviation 5.17				

Phase III off-task behaviors demonstrated a persistent pattern from day to day. The first day total was the same as the first day total in Phase II (53). An increase of 11 was counted on the second day (18%) with a 22% decrease accounted for on the third day. The fourth day showed a further increase of 12% from 45 to 51. Another decrease occurred on the fifth day (14%) with a corresponding increase on Day 6 from 44 to 60 (26%) and a decrease from 60 back to 44 on the last day of Phase III. This continued a yo-yo effect which began on the first day of Phase II and occurred regularly through the end of Phase III.

No record was kept of school activities for which the children might have had to leave the room or which may have affected their behavior. No record was kept of other changes in the environment which may have affected the results on particular days of the study.

The discrepancy rate between judges was extremely high exceeding 58% on some days. In evaluating the films, it was found that the classroom teachers considered an off-task behavior of lengthy duration to be one off-task behavior, while the counsellor considered the same behavior several times if the child did not return to task within a given time frame. The classroom teachers also felt that even though children were not in eye contact with the presenter, they were not necessarily off-task. Some children are on-task despite the fact that their bodies are not quiet and they do not appear to be listening. Though this was discussed during the orientation, the classroom teachers felt that experience had given them expertise in determining different learning modes or the body language of small children indicating on-task behavior, though a more inexperienced observer may consider them as being off-task.

Judge B, the school counsellor, recorded 48% of the off-task behaviors during Phase I in comparison to 25% recorded by Judge A, early childhood specialist and 28% by Judge C, the first grade classroom teacher.

The mean score of off-task behaviors recorded during Phase II (50.8), prescribed environment, was 15.7 points below the mean recorded during Phase I (66.5), original environment, indicating that all other factors remaining constant, the test environment appeared to affect off-task behaviors. Recorded means for Phase II (50.8) and Phase III (50.7) demonstrated a .1 decrease in off-task behaviors.

Total off-task behaviors ranged between 77 and 54 during Phase I with a mean of 66.5 and a difference of 30% between high and low recordings. During Phase II with a mean of 50.8, the high and low scores were 64 and 44 respectively with a difference of 31%. Both Phase I and Phase II demonstrated scores within the same range, but Phase II scores were more than ten points lower. Phase III high and low totals 60 and 44 with a 24 point disparity demonstrated a difference of 40%.

Table 4

Off-Task Behaviors As Recorded by Three Observers

Phase I

Day	1	2	3	4	5	6	Totals	
Judge A	10	13	15	15	23	22	98	25%
Judge B	40	38	43	22	19	28	190	48%
Judge C	23	26	17	17	12	16	111	28%
Totals	73	77	75	54	54	66	399	
Daily Mean	24.3	25.7	25	18	18	22		

Phase I Mean 66.5 Standard Deviation 7.33

Phase II

Day	1	2	3	4	5	6	7	Totals	
Judge A	12	14	8	16	11	13	12	86	25%
Judge B	29	34	30	23	25	30	29	200	56%
Judge C	12	16	11	12	8	6	5	70	20%
Totals	53	64	49	51	44	49	46	356	
Daily Mean	17.7	21.3	16.3	17	14.6	16.3	15.3		

Phase II-Mean 50.8 Standard Deviation 5.05

Phase III

Day	1	2	3	4	5	6	7	Totals	
Judge A	17	16	13	15	14	16	14	105	29%
Judge B	24	30	19	23	26	34	18	174	49%
Judge C	12	12	13	13	4	10	12	76	21%
Totals	53	58	45	51	44	60	44	355	
Daily Mean	17.7	19.3	15	17	14.7	20	14.7		

Phase III-Mean 50.7 Standard Deviation 5.17

Even though a training session was held prior to the actual counting of off-task behaviors, a wide range of differences is demonstrated in the counts of the three observers with the school counsellor (Judge B) judging many more off-task behaviors in some films than either of the classroom teachers (Judges A and C). Judge A recorded 26% of the total off-task behaviors, Judge B, 51% and Judge C, 23%. Table 5

Table 5

Off-Task Behaviors Recorded During Three Phases

Stage	I	II	III	Totals	Percent
Judge A	98	86	105	289	26
Judge B	190	200	174	564	51
Judge C	111	70	76	257	23
Totals	399	356	355	1110	

The off-task behavior differential between Judge B and Judge A was 49%, between Judge B and Judge C, 54%, and between Judge A and Judge C is 12%.

An Automatic Oscillometric Digital Blood Pressure/Pulse Monitor with a tape print-out was utilized. The blood pressure monitor was calibrated at the time of purchase and was also compared to hand taken readings by the school nurse. Practice in filming and taking the blood pressure started a week early to acclimate the children to the procedure and to attempt to minimize the research effect.

Physiological tests (blood pressure and pulse) were recorded twice each day at the same time for the duration of the study. This was done within the regular context of the school day. Because it was important to continue school practices, assemblies, fire drills, schedule changes, there were days when the physiological tests could not be completed. Extra days were included in the testing time to accommodate this problem.

Systolic blood pressure readings were computed for the tables and the graphic representation because the systolic blood pressure is most responsive to changes in the environment according to Dr. Joe Kaufman, Cardiologist, Cardiovascular Center of Nevada. (statement included in appendix) In analyzing the data collected from Dr. Wohlfarth's Elves' Memorial Study, computer generated graphs were utilized for individual students. Individual student graphs from the C.H. Decker study are included in the appendix.

Phase I blood pressure mean scores (98.3) were 8.1 points higher than Phase II mean scores (90.2) showing an 8% drop in the mean blood pressure scores at the beginning of Phase II when the test environment was instituted, with mean blood pressure readings continuing to drop at the beginning of Stage III, two points below Phase II and 16 points below

Phase I. Mean scores increased (1%) from a mean of 90.2 during Phase II to a mean of 91.3 during Phase III. Table 6

Table 6

Group Daily Mean Systolic Blood Pressure Readings

Day	1	2	3	4	5	6	7	8	9	10	M
I	106	100.5	97.5	95	99	89	96.5	98.5	101	100	98.3
II	92	98.5	83	97	87.5	94.5	91.5	81.5	89.5	87	90.2
III	90	91	91	92	94.5	90.5	90	91.5	0	0	91.3

Day 2 mean scores showed a 2 point difference between Phase I (100.5) and Phase II (98.5) continuing to decrease, but Phase III (original environment) blood pressure scores (91) are 7.5 points lower than Phase II and 9.5 points below Phase I which utilized the same environment.

Mean scores of the blood pressure readings in the Phase II, prescribed environment, dropped dramatically on Day 3 (83) compared to Phase I (97.5) and Phase III (91).

Day 4 was one of two instances in which Phase II blood pressure readings exceeded Phase I readings, 97 and 95 respectively; Phase III recorded the lowest mean score for this day.

Phase II recorded the lowest mean blood pressure reading (87.5) on Day 5 with Phase I (99) 11.5 points higher and Phase III (94.5) 7 points higher.

The second day on which Phase II (94.5) mean blood pressure reading exceeded both Phase I (89) and Phase III (90.5) was Day 6. It exceeded the Phase I reading by 5.5 points and the Phase III reading by 4.5 points. Day 6 was the only day on which the Phase III reading was higher than the Phase I reading, 90.5 and 89 respectively.

Day 7 demonstrated a substantially lower blood pressure reading during Phase II (91.5), 5 points lower than the comparable day in Phase I (96.5). Phase III readings on Day 7 (90) were lower than either the Phase I reading, 6.5 points and the Phase II reading, 1.5 points.

The Phase II mean blood pressure reading (81.5) was demonstrably lower than either the Phase I reading (98.5) and the Phase III reading (91.5). The difference between the Phase I and II readings was 17 points, a decrease of 17%; the difference between the Phase II and Phase III readings was 10 points. The lowest blood pressure readings were recorded (mean 81.5) during Phase II of the study when the prescribed color/light environment was present in the test field indicating its affect on the systolic blood pressure readings.

The ninth day of blood pressure readings continued to show a substantial difference between the Phase I and Phase II readings with the Phase II reading (89.5) 12.5 points below the Phase I reading (101). Due to a conflict between data collecting and school scheduling the last two days of Phase III could not be included in the analysis.

The Day 10 difference was comparable to Day 9 in that the difference between Phase I (100) and Phase II (87) exceeded 12 points. Day 10 of the Phase II prescribed environment and Phase I, regular school environment, demonstrated the greatest difference between group blood pressure means with the prescribed environment showing a 13 point lower score than the regular environment.

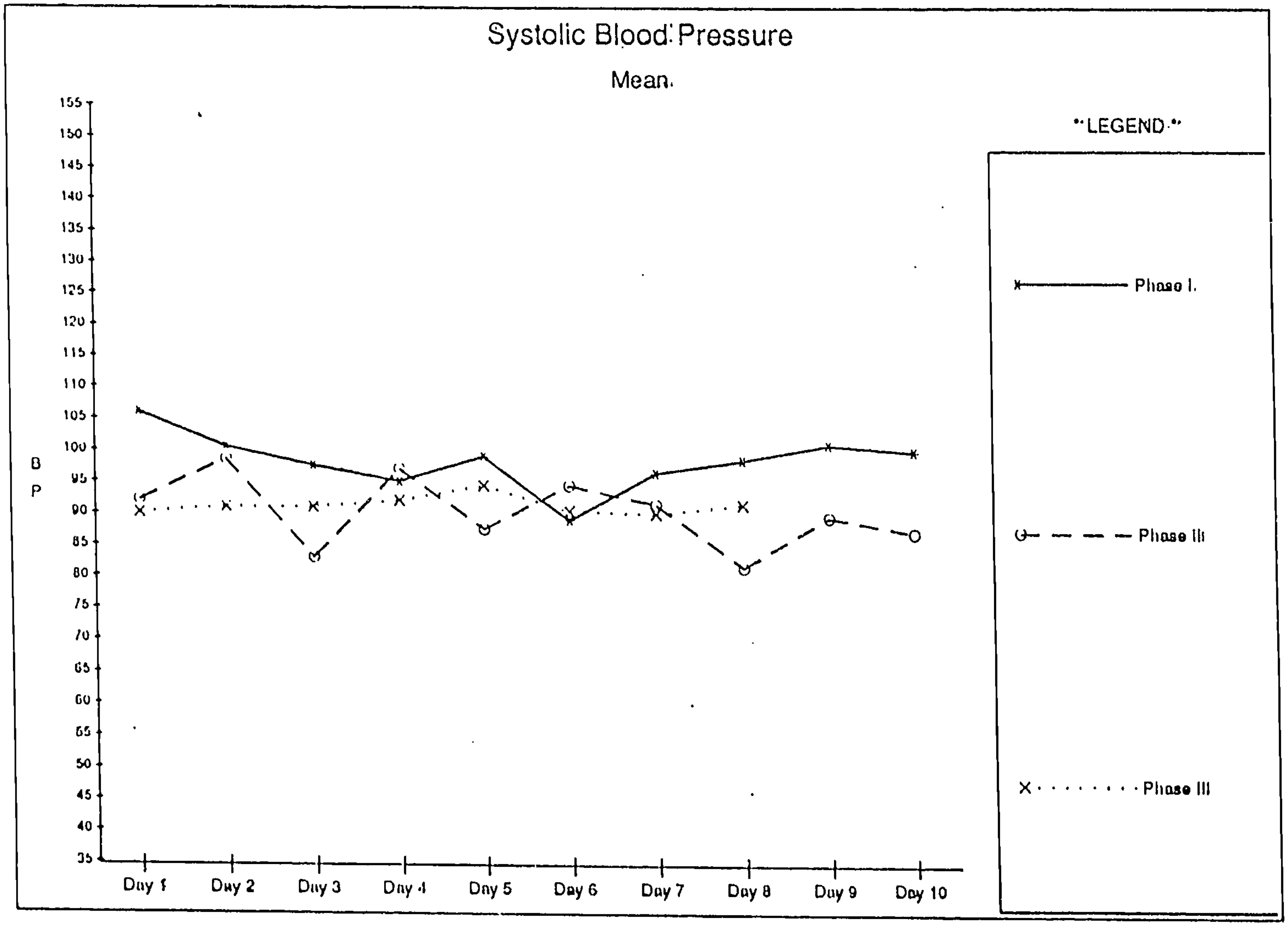
A daily mean of the pulse rates and the blood pressures of individual students as well as the group were used to derive computer generated graphs to pictorially compare results. The original pulse rate and blood pressure readings as copied from the Oscillometric Digital Monitor tapes, computed means and a complete sets of the graphs are included in the appendix.

Table 7 is a computer generated graph of the group mean systolic blood pressure readings computed daily during each phase of the study. The daily group blood pressure mean scores used in generating the graph are contained in Table 6. The same graph was used to depict the individual student scores and the group mean scores for both the systolic blood pressure and the pulse rates. Increments of five were chosen for measurement of the blood pressure on the y axis because of the disparate scores of individual students and the desire to allow the reader to compare individual student and group scores. The x axis delineates the days of each phase of the study. Each phase is represented by a different type of line with the coordinates marked by distinguishing symbols.

The coordinates for Phase I demonstrate a degree of consistency with only one dramatic dip on Day 6 when the mean blood pressure readings for that day were lower than either Phase II or Phase III. Phase II showed extensive fluctuation, but every coordinate with the exception of Day 4 and Day 6 was below Phase I appearing to demonstrate a difference due to the prescribed environment, other factors remaining constant.

The coordinates delineating Phase III were the most consistent, only ranging as high as Phase I on Day 6, but lower than Phase II on Days 3, 5, and 8.

Graphed scores in Phase I ranged from a high of 106 on Day 1 to a low of 89 on Day 6, a variation from 7.7 to 2.2 respectively with a standard deviation of 3.82. The standard deviation for Phase II was 5.51 with scores fluctuating around the mean (90.2) from a low of 81.5 to a high of 98.5. During Phase III (91.3), the mean blood pressure scores produced a flattened curve with one score deviating 3.2 from the mean score and a standard deviation of 3.87.


Systolic Blood Pressure
Mean.
B
P
155
150
145
140
135
130
125
120
115
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
Day 1
Day 2
Day 3
Day 4
Day 5
Day 6
Day 7
Day 8
Day 9
Day 10
"LEGEND"
Phase I.
Phase II
Phase III

Discussion

This study was planned and implemented to utilize the methods and procedures of Dr. Wohlfarth's Elves' Memorial Study to determine if similar results could be obtained.

Two of the most important aspects of the study were the differences in the study facilities and in the study populations. The ramifications of the effects of the relationship between the environment and public school children in an open setting from that of severely handicapped children in a closed setting are far more extensive. School Districts which have conducted this kind of research have been so challenged by preliminary results that they have continued with and broadened their research (Sydoriak 1984 and Painter 1977).

Whereas the subjects in Dr. Wohlfarth's study remained in the test environment for the whole school day, the subjects in this study were in the test environment for a fraction of the school day. The number of excursions from the room were not counted and the exact minutes in the test environment were not measured. Recess, noon lunch, special classes, breaks, assemblies, library were just a few of the regularly scheduled excursions. Because it was important to carry out the filming and blood pressure readings at specific times, there were many days when the schedule was interrupted due to public school activities. In discussions with the Clark County School District Cooperative Research Committee, special emphasis was put on the research study not impacting other activities of the class. Because the test environment was not a facsimile, but the real thing, careful scrutiny of the concurrent findings of substantial differences between the first and second phase of the study is even more imperative. The study was scheduled for a period of time in the school year when all phases of the study could be completed with no prolonged breaks for holidays or vacations. C.H.Decker Elementary is a year-round school, therefore the study was planned for a seven week period in the fall when there were two 3-day week ends, three weeks apart to allow for the painting of the classroom to have a minimal effect.

The study classroom was a team teaching classroom, in which two teachers and a double complement of first graders learned together in a team environment. One teacher had over 20 years teaching experience; the other teacher was a third year teacher. In observing the preliminary tapes, it was noted by the observers that there were far less off-task behaviors when the experienced teacher was presenting; therefore, the teaching schedule was planned so that the same teacher was presenting at scheduled filming times.

The population were all six year olds with one more girl than there were boys. During the course of the study, the school nurse came in at regular intervals to calibrate the blood pressure monitor. The blood pressures of six year olds are usually only taken when they are sick, so the very erratic fluctuations in the children's blood pressure readings were of some concern. (See appendix) The school nurse presented the two classroom teachers with information on Childhood Hypertension. In studying the daily blood pressure readings, it became possible to make predictions concerning the blood pressure readings of children who had difficulty with self-control.

Dr. Wohlfarth's computer generated graphs demonstrated coordinates which fluctuated from morning to afternoon, but decreased gradually, mean reading (120), throughout the first phase of the study, the original environment. The second phase coordinates showed no fluctuations, but a flat line, mean reading 104, with a slight imcrease in the mean reading during Phase III, 105 and the coordinates beginning to ascend.

The graphed line in the C.H. Decker Study was similar in that it decreased with fluctuations from a high of 106 to a final reading of 100 during Phase I even though prior training in the research methods had been utilized. The greatest difference and the greatest similarity is in the results obtained during the prescribed environment. In both studies, the lowest blood pressure readings, 13% drop in the Elves' Memorial study, 9% drop in the C.H.Decker study were taken during Phase II, the test field. Even though the student populations, the scheduled activities, and the amount of student time spent in the test field were dissimilar, the research results from both studies are similar, seeming to indicate the extensive effect of color/light on modifying physiological and behavioral reactions. Dr. Wohlfarth's data recorded a constant blood pressure, whereas the C.H.Decker study recorded fluctuating readings continuing to decrease. These differences can be accounted for by the differing amounts of time within the test milieu and the activity levels of the differing populations.

The Phase III readings in both studies remained close to the Phase II readings with the coordinates assuming an upward movement during Phase III at the conclusion of both studies.

Off-task behaviors decreased by 30% from a high of 399 during Phase I, the original environment, to 310 during Phase II, the prescribed environment. This reaffirms the findings of Dr. Wohlfarth's study in which behavior appears to be modified during the prescribed environment. Behaviors remained stable during Phase III in both studies with an increase demonstrated at the conclusion of the study.

Teacher's subjective reactions to the prescribed environment cannot be discounted. The teachers felt the room to be brighter as well as larger during the Phase II test environment. During the Phase II, blue environment, one of the teachers felt cold constantly which necessitated wearing a sweater or jacket while in the room. The teachers felt less agitation in the room, felt themselves to be more in control, and sensed a decreased noise level. The third year teacher had not taught in this room before the 1992-1993 school year. At the beginning of the year she felt the room, which was standard classroom Phase I environment, was beautiful. After having been in the Phase II test environment, and then returning to the Phase I environment, she was so dissatisfied with the classroom that she would check to see how many days were left in the research. She wanted the Phase II, test environment, to be reimplemented in the room. The children seemed noisier and more hyper-active, the room felt more crowded and the teachers felt less in control in the Phase I-Phase III environment.

Because of interest expressed by the C.H.Decker School Community a further study utilizing similar methods and procedures is in the planning stages for the 1993-1994 school year. At the present time the research environment is being reimplemented into the classroom because the occupants <u>feel</u> better in that environment.

CHAPTER IV

SUMMARY, CONCLUSIONS, RECOMMENDATIONS, IMPLICATIONS

"Today I will go through all your flock. Take out of it every black animal among the sheep, and every speckled or spotted one among the goats. Such shall be my wages, and my honesty will answer for me later: when you come to check my wages, every goat I have that is not speckled or spotted, and every sheep that is not black shall rank as stolen property in my possession. Laban replied, Good! Let it be as you say. That same day he took out the striped and speckled he-goats and all the spotted and speckled she-goats, every one that had white on it, and all the black sheep. He handed them over to his sons, and put three days' journey between himself and Jacob. Jacob took care of the rest of Laban's flock.

Jacob gathered branches in sap, from poplar, almond and plane trees, and peeled them in white strips, laying bare the white on the branches. He put the branches he had peeled in front of the animals, in the troughs in the channels where the animals came to drink; and the animals mated when they came to drink. They mated therefore in front of the branches and so produced striped, spotted, and speckled young. As for the sheep, Jacob put them apart, and he turned the animals towards whatever was striped or black in Laban's flock. Thus he built up droves of his own which he did not put with Laban's flock" Genesis 30: 32-41 (Metzger & Murphy 1989).

This biblical story dates from the second millenium before Christ. At that time, it was widely believed that something magical happened at the time of conception that caused visual impressions to become imprinted upon the offspring of animal and human mothers. This is an example of the large array of cultural beliefs concerning color that have been passed down to us through generations of acculturation. From the Hindu Upanishads, the De Coloribus of Aristole, through Leonardo da Vinci's A Treatise on Painting, a continuing dialogue concerning the mysteries and vagaries of the spectrum has haunted poets, philosophers and scientists. These beliefs of countless generations are a part of our collective subconscious which arouses our senses to interaction with our environment.

Purpose of the Study

The purpose of this study was to compare children's behavior and physiological response in a normal elementary classroom setting with those in a prescribed classroom setting replicating Dr. H. Wohlfarth's Elves' Memorial study.

These questions served as a basis for collecting and analyzing data.

1. Do the environmental factors of color and light generate physiological changes in students in an elementary classroom?

2. Do the environmental factors of color and light generate behavioral changes in students in an elementary classroom?

Research Design

This study, identified as the C.H.Decker Study, took place at a public elementary school, C.H.Decker Elementary School, located in Las Vegas, Nevada, during the fall of 1992. It was a replication of a study conducted by Dr. H. Wohlfarth in 1981 at Elves' Memorial Child Development Centre, Edmonton, Alberta.

The population of the replicated study were nine severely handicapped elementary students. The C.H.Decker Study took place in a regular school environment, in which there were 31 children present in the environment due to class adjustment, eleven of whom were included in the final analysis.

Manipulation of the classroom environment occurred in three phases: Phase I environment, original environment; Phase II environment, prescribed color/light environment; Phase III, original environment. Blood pressure and pulse readings were recorded twice each day, at the same time in the morning and in the afternoon. Computer generated graphs were derived from the group daily mean and from the daily mean of each student.

The subjects were video-taped for 15 minutes in the morning and 15 minutes in the afternoon at the same time each day as classroom schedules permitted. In prior agreement with the Clark County School District, it was necessary to emphasize the fact that the regular student schedule be protected from interruption. Three observers utilized the video-tapes to count and record off-task behaviors.

Summary of Data

Physiological changes were measured by recording each subject's blood pressure twice a day at the same time in the Phase I, original environment, Phase II, prescribed environment, Phase III, original environment. A daily mean was computed for each student and for the group. The group and individual means of the systolic blood pressure readings were depicted as coordinates on a computer generated graph with each phase represented by a differentiating line on the graph. The systolic blood pressure readings formed the basis for the graph because systolic blood pressure has been ascertained to be more responsive to environmental changes. (appendix)

Computer generated graphs demonstrated Phase II coordinates as being lower each day of the study with the exception of two days. Readings during Phase I ranged from a high of 106 to a low of 89; Phase II readings reached a high of 98.5 from a low of 81.5 with Phase III remaining low, 90 to 94.5.

There was an 8.1 point drop in mean blood pressure readings from Phase I (98.3) to Phase II (90.2). The difference on the final day of Phase I exceeded Phase II by more than ten points.

The video tapes were utilized by three qualified observers (appendix) to count off-task behaviors. The observers included two first grade teachers and a school counsellor. The school counsellor, Judge B, counted almost twice as many off-task behaviors (51%) as Judges A and C, 26% and 23%, respectively, but all three judges were consistent throughout the three phases of the study. Differences between the Phase I and Phase II mean scores were 24%, with Phase III beginning to increase at the end of the study. The mean score, however, was equivalent to Phase II.

Dr. Wohlfarth's Elves' Memorial Study, the replicated study, and the C.H.Decker Study, as reported, exhibited decreased blood pressure readings and decreased off-task behaviors during Phase II, with the C.H.Decker Study demonstrating an 8.24% drop in the mean blood pressure readings and a 22% drop in the count of off-task behaviors.

The only change in the environment was the color of the paint and a non-reflective full-spectrum lighting system. There was strong evidence that a prescribed environment facilitated a change in children's behavior and enhanced opportunities for the maintainance of a more positive learning mode in the classroom.

Conclusions

The results of this study demonstrat the importance of greater emphasis being put on prescribed learning environments for elementary school children. Industrial white, off-white and white must not be considered as satisfactory.

In both the Elves' Memorial Study and the C.H.Decker Study white or off-white, termed industrial white in the literature, Semi-Gloss was the basic color of the first phase environments. The same accompanying colors, bright primaries, orange, red, yellow were also present in the two environments.

"The lessons learned from color perception may have significance for studying other cognitive domains. So far as we know only small fractions of the neurons in the visual system respond in a way that corresponds to our perceptual report of color. The locations in the brain where links between physiological states and perceptual states can be found vary from the retina to deep in the visual system for different aspects of color perception"
(Churchland 1988, p.173).

The C.H.Decker Study and the Elves' Memorial Study indicate that something happened when the environment in the educational field was manipulated. A decrease in systolic blood pressure readings as well as a reduction in off-task behaviors occurred in both of these studies, even though the Elves' Memorial Study was a closed environment in which the children remained within the test field for the entire school day and the C.H.Decker was an open public school. This may, however, explain more dramatic differences in the day to day blood pressure readings.

Eminent value was inherent in the fact that the C.H.Decker Study took place in an open school environment where many disruptions had to be accommodated in order to carry out the study without interfering with traditional school activities.

Recommendations

Although it was important that a study of this type be undertaken in a regular school setting, it would have been efficacious to have kept a journal of each days proceedings as well as notes on each student involved in the study and to have correlated these with the systolic blood pressure readings and the off-task behavior counts. This may have helped to account for some of the dramatic fluctuations in individual readings as well as in the group mean. In similar environmental research recorded in the literature, researchers kept records of time in minutes and hours spent in specific environments (Mayron, Ott, Nations, and Mayron 1974).

It was also noted in the course of taking blood pressure readings that there seemed to be a correlation between children who spend a great deal of time off-task and their blood pressure readings. Teachers need to be more aware of childhood hypertension, its indicators, and its implications.

Because the C.H.Decker Study was implemented in an open environment where many scheduled and unscheduled interruptions took place, a greater number of days for all three phases would have facilitated the research. This would have enabled the researcher to have tested only on days when similar activities were occurring. Arrangements to keep the children in the test environment throughout the day, between blood pressure readings and filming sessions could be implemented in subsequent tests, however it must be recognized that that does not constitute a typical schoolday for most children.

The Elves' Memorial Study utilized the observations of one observer; three observers counted off-task behaviors in the C.H.Decker Study. A problem encountered in the latter study seemed to be the dissimilarity of the observer's counts. Even though there was consistency between the three phases, the school counsellor counted many more off-task behaviors. The observers should have more similar responsibilities in their occupational interactions with children which may preclude dissimilarities in perception.

Several of the studies reviewed in the literature utilized observers in the classroom. An observer present in the classroom would have a clearer picture of events as they are occurring, however, a video tape can afford the observer an opportunity to double-check the findings.

In the C.H.Decker Study the visual noise; posters, wall decorations, charts, alphabet, number lines, were returned to the walls during Phase II as recommended by Dr. Wohlfarth. This may have caused a smaller percentage of decrease than the Elves' Memorial Study demonstrated.

Some school districts control for materials that can be used in classroom decoration. In many classrooms, teachers spend a lot of money to make a classroom stimulating for their students. The result is wall decoration of bright, disharmonious, primary colors. These are often laminated with materials that cause a glare which precludes clear perception of the information on charts or posters. Distractions are constantly within student's visual space. The only elements which should be within children's visual space are the materials upon which they are working. Children need to be stimulated by the learning material; stimulation from the environment is more likely to cause acting out behaviors.

"Too many colors in one setting are disconcerting, whether they are on a color preference sheet, in a room, or in a dress. Too many colors evoke incorrect responses to test questions, a higher than normal number of errors in arithmetic problems, and a general diffusiveness" (Sharpe 1974 p.138).

Future Implications

Manipulation of the environment needs to be conducted at all age levels within the educational field and within the work milieu to ascertain which setting is the most healthy and productive for the human. As technology forces more and more people indoors into artificial surroundings in front of Visual Display Terminals, in small office cubicles, and as the public and legislative bodies call for greater productivity from educators, the places where humans live, work and learn must be attuned to every advantage.

John Flynn in writing for the National Academy of Sciences (1973) posed the question "Can light, color, and pattern make an identifiable contribution in this regard by adding meaning to our experiences in some man-made space?" The problem the symposium was debating concerned the quality of life. Designers are beginning to study the effects of design on human behavior and motivation in order to knowledgeably define the need for clients spending their money on spatial effects in order to make work areas better. The following specific questions were considered by the symposium:

* "How does the occupant visually define his environment, and how does spatial design relate to this?

* How are focal centers created? What spatial influences (light, color, and pattern) affect the occupant's center of visual interest?

* When are focal centers meaningful, and what is the influence of 'visual clutter' in the environment?

*What factors contribute to a 'sensory overload' condition; what conditions produce 'sensory deprivation'?

*Beyond simple orientation and identification of relevant information, what spatial influences affect social interaction in the space?" (Flynn 1973 p.110).

More and more consideration has been given to the biological organisms which live and work in the environments of the technological age. It was necessary to fill the huge gap between research and implementation. Unaware of the long run cost benefits of prescribed environments, designers and architects were unable to recommend prescribed design elements to clients who were determined to adhere to budgeted economies. "There is good argument that a new paradigm integrating research and design is required to deal with the phenomena of change in the relationships of people, organizations, and their buildings." (Kernohan 1987 p.322)

Interaction with the environment produces the picture of human reality. It paints the picture from which humans draw their concept of who they are and what they can do

(Teyler 1984). "....the function of seeing is not limited to the visual system." (Cytowic 1989 p.286).

The quantifiable asset of any company or any educational system is its people. It is easy to overlook methods through which production can be increased by simply dealing with the psychodynamic interaction of people and environment. People are placed in small cubicles with fluorescent lights, bereft of the elements of biological need, yet they are expected to produce. Breathing diseases run rampant, stress and anxiety cause high rates of work loss, heart disease is on the rise. The efficacy of returning to environments more empathetic with our caveman subconscious; sunlight; clean, fresh air; the colors of the earth and sky, have proven to boost productivity in the private sector wherever it has been emphasized. There is no place that needs a low cost, high productivity boost like the place where we educate children. Industry hires color consultants to determine what color cars, home appliances, thermos bottles, coolers, and carpets the public will buy. Progressive industries hire color consultants to paint the insides of factories and offices because they know that they will be able to increase output. When Igloo Coolers wanted to increase sales, they hired a colorist who changed their cooler colors from standard red and blue to purple, tangerine and lime green. Sales increased by 15%. Weinerschnitzel added a touch of orange to the magenta and red color scheme in a prototype store and sales increased 7% (Lane 1992).

Color is so important that each year 1200 color gurus assemble and determine what the colors of the year will be in everything from cars to carpets. "Man responds to form with his intellect and to color with his emotions; he can be said to survive by form and to live by color" (Sharpe 1974 p 123).

Change is being touted from boardrooms to classrooms. Sacrifice, make do, do more with less. Educators have had plenty of practice in doing just that. Change in the form of new environments in newer schools is relatively inexpensive; apply a new coat of paint, create aesthetic arrangements utilizing principles of variety and unity with visual aids, and switch to energy efficient full spectrum lights. Research has indicated that with these relatively inexpensive changes, educators can reduce illness caused absenteeism, increase achievement and IQ scores, improve on-task behaviors.

According to the National Association of School Administrators report "Schoolhouse in the Red" (1992), one in eight schools has been adjudged to be physically inadequate for the job of educating. Not only is the visual environment lacking in sensory stimulation, but these facilities are overcrowded, structurally unsafe, and operate faulty mechanical systems contributing to health problems which in turn decrease learning. These older schools will cost many millions of dollars to remediate, but even they, at little cost, can create aesthetically pleasing interiors which will facilitate learning.

Elementary classrooms have become places to display innumerable, "cute" decorations because we believe this is what will make children comfortable and stimulated. Secondary schools and universities create a milieu in which there is little stimulation. Why then does the human reflective thinker imagine himself beside a murmuring brook in a primeval forest or lying on his back, watching the clouds move across a blue sky feeling that by his becoming more "sensitive to natural harmonies" he will be able to clear his mind for new thoughts and creative ideas? (Ferguson 1987 p.191).

Elementary classrooms must <u>not</u> be places where students are bombarded with color and objects that are distractions to reflective thinking. As a super-energetic beginning teacher, I thought if children were just sitting quietly and not involved in some project they were not busy. I would remind them to get busy, get busy. One day a first grader looked up at me and very seriously asked, "Aren't we allowed to think in here?" By creating psychodynamically prescribed learning spaces, we can create places for thinking, places for coherent thought which can precede and produce action.

BIBLIOGRAPHY

Bechtel, Robert B., Marans, Robert W., & Michelson, William. (1987). Methods in Environmental and Behavioral Research. New York: Van Nostrand Reinhold.

Belka, David E. (1985). Effects of Ball Color and Preferred Ball Color on Catching by Elementary School Children. Perceptual and Motor Skills. 61 1011-1018.

Bennett, Thomas L. (1978). The Sensory World. An Introduction to Sensation and Perception. California: Brooks/Cole Publishing Company.

Birney, Robert & Teevan, Richard. (1961) Color Vision. New York: D.Van Nostrand Company.

Birren, Faber. (1961). Color Psychology and Color Therapy. A Factual Study of the Influence of Color on Human Life. New Jersey: The Citadel Press.

Birren, Faber. (1979). Color in Your World. London: Collier MacMil] ın Publishers.

Blades, Mark. (1989). Children's Ability to Learn About the Environment from Direct Experience and from Spatial Representations. Children's Environments Quarterly. 6 4-12.

Boles, Harold W. (1965). Step By Step to Better School Facilities. New York: Holt, Rinehart & Winston.

Bowers, J. Bowers, & Burkett, Charles W. (1987). Relationship of Student Achievement and Characteristics in Two Selected School Facility Environmental Settings. A paper presented at the 64th Council of Educational Facility Planners, International Conference in Edmonton, Alberta, Canada.

Bray, Normal W., Justice, Elaine M., & Zahm, David N. (1983 August) Two Developmental Transitions in Selective Remembering Strategies. Journal of Experimental Child Psychology 36 43-55.

Brousek, Jan. (1984) The Rainbow As a Visual Illusion. Psychologia-a-Patopsychologia-Diettata. 19 259-265 abs.

Bross, Cindy & Jackson, Karen. (1981). Effects of Room Color on Mirror-tracing by Junior High School Girls. Perceptual and Motor Skills. 52 767-770

Brozek, Josef., Kuthan, Vilem., & Arens, Katherine. (1991) Contributions to the History of Psychology: LXXXIII. J.E.Purkinje and Mathias Klotz: Who First Described The Phenomenon? Perceptual and Motor Skills. 73 511-514.

Cantor, Joan H., Spiker, Charles C. (1982 December) The Effect of the Temporal Locus of the Introtact Probe on the Hypothesis-testing Strategies of Kindergarten Children. Journal of Experimental Child Psychology 34 510-525.

Caltagirone, Carlo & Gainotti, Guido. (Eds.), (1989). Emotions and the Dual Brain. New York: Springer-Verlag.

Churchland, Patricia S. & Sejnowski, Terrence J. (1988 November) Perspectives on Cognitive Neuroscience. Science. 22 741-745.

Cockerill, Ian M.,& Miller, Brian P. (1983). Children's Colour Preferences and Motor Skill Performance with Variation in Environmental Colour. Perceptual and Motor Skills. 56 845-846.

Committee on Vision, Division of Behavioral Sciences, National Research Council. Hurvich, Leo., Paulson, Helen, Judd, Deane., Anson, Abraham., Flynn, John., & Faulkner, Waldron. (1973) Color Vision. Symposium/ National Academy of Sciences. Washington, D.C.

Cohen, Stewart & Trostle, Susan L. (1990 November) Young children's Preferences for School-Related Physical-Environmental Setting Characteristics. Environment and Behavior 22 6 753-766.

Cytowic, Richard E. (1989) Synesthesia: A Union of the Senses. New York: Springer-Verlag, 1989.

Czekely, George. (1980). Interior Design for Elementary School Children. School Arts 79 6 52-53.

Davis, Goode P., Park, Edwards. & the Editors of U.S.News Books. (1971) The Heart: The Living Pump. Washington, D.C.: U.S.News Books.

Day C. William. (1980). The Physical Environment-Revisited. CEFP Journal. 18 2 4-6.

Don, Frank. (1977) Color Your World. New York: Harper & Row.

Duplessis, Yvonne. (1985). Dermo-Optical Sensitivity and Perception: Its Influence on Human Behavior. The International Journal for Biosocial Research. 7 76-93.

Dutczak, Sally E. (1985). The Effects of Cool-White, Full Spectrum Fluorescent and Color Adusted Diffused Lights on Severely Physically and Mentally Handicapped Children: A Preliminary Study. The International Journal for Biosocial Research. 7 17-20.

Durrett, John & Trezona, Judi. (1982 Fall). How to Use Color Displays Effectively. Pipeline. 7 13-16.

Eastman, A.A. (1968). Color Contrast versus Luminescence Contrast. Illuminating Engineers. 63 613-620.

Eisenstein, Naomi. (1985 Winter). Effects of Contractual, Endogenous, or Unexpected Rewards on High and Low Interest Preschoolers. The Psychological Record 35 29-39.

Evans, Ralph M. (1974). The Perception of Color. A Wiley-Interscience Publication. New York: John Wiley & Sons.

Faulkner, Waldron. (1973). Color in Architecture. Color Vision. Washington, D.C.: National Academy of Sciences.

Feher, Elsa and Rice, Karen. (1988). Shadows and Anti-Images: Children's Conceptions of Light and Vision II. Science Education. 72 637-649.

Ferguson, Marilyn. (1980). The Aquarian Conspiracy: Personal and Social Transformation in Our Time. New York: St. Martin's Press.

Fischman, Joshua. (1986 April). A Memory of a Different Color. Psychology Today 20 6.

Fisher, Jeffrey D., Bell, Paul A., & Baum, Andrew. (1984). Environmental Psyshology. 2nd Edition. New York: Holt, Rinehart and Winston.

Flock, Howard., & Nunsiwitz, Steven. (1987 November). Specularity, brightness, Achromatic Color-and Orthogonality. Perception and Psychophysics. 42 439-456.

Flynn, John. (1973). Color, Pattern, and Related Visual Influences in Architecture. Color Vision. Washington, D.C.: National Academy of Sciences. 1973.

Foote, Kenneth E. (1983). Color in Public Spaces. University ofChicago Deparment of Geography Research Paper No. 205.

Gifford, Robert. (1980 September). Environmental Dispositions and the Evaluation of Architectural Interiors. Journal of Research in Personality. 14 386-399.

Goetz, Jill. (1987 July). Extra! Extra! Red All About It! Psychology Today. 21 24.

Graves, Ben E. (1985 March). Shedding Light on Learning. American School and University. 57 88-90.

Greene, Thomas C., Bell, Paul A., & Boyer, William N. (1983) Coloring the Environment: Hue, Arousal, and Boredom. Bulletin of the Psychonomic Society. 21 4 253-254.

Greenman, Jim. (1987). Thinking About the Aesthetics of Children's Environments. Caring Spaces, Learning Places: Children's Environments That Work. Exchange Press, Inc. 58 9-12.

Halford, Graeme S., & Kelly, Mavis E. (1984 August) On the Basis of Early Transitivity Judgments. Journal of Experimental Child Psychology 38 42-63.

Hamid, Nicholas P. (1992). Colour of Reading Material and Performance Decrement. Perceptual and Motor Skills 74 689-690.

Hamid, Nicholas P. & Newport, Adrienne G. (1989). Effect of Colour on Physical Strength and Mood in Children. Perceptual and Motor Skills. 69 179-185.

Hanlon, Heather. (1979). A Learning Working Environment. Educational Horizons. 58 88-90.

Hanson, Gayle. (1992 February 3). Prognosis: Trends Are Us. Insight on the News. 12-13, 36-38.

Hargreaves, J.A. & Thompson, G.W. (1989). Ultraviolet Light and Dental Caries in Children. Caries Research 23 389-392.

Hathaway, Warren. (1982 September) Lights, Windows, Color: Elements of the School Environment. CEFP 59th Annual Conference. Columbus, Ohio.

Hathaway, Warren. (1987 Fall). Light, Colour & Air Quality: Important Elements of the Learning Environment? Education Canada.

Hathaway, Warren. (1988 Winter). Designing to Enhance Learning and Human Performance. Education Canada.

Hathaway, Warren. (1988 July) Educational Facilities: Neutral With Respect to Learning and Human Performance? CEFP Journal.

Heubach, Janet G. (1985 March). Effects of School Settings, Visual Space, and Behavior on Evaluations of Appropriateness. Paper presented at the Annual Meeting of the American Educational Research Association. Chicago, IL.

Hilbert, David R. (1987). Color and Color Perception. A Study in Anthropocentric Realism. Center for the Study of Language and Information.

Humanski, Richard & Shevell, Steven. (1985). Color Perception with Binocularly Fused Adapting Fields of Different Wavelengths. Vision Research. 25 1223-1235.

Holahan, Charles J. (1978). Environment and Behavior. New York: Plenum Press.

Inel, John P.J. (1990). Biopsychology. London: Allyn and Bacon.

Ittelson, William H., Proshansky, Harold M., Rivlin, Leanne G., & Winkel, Gary H. (1974). An Introduction to Environmental Psychology. New York: Holt, Rinehart and Winston, Inc.

Izawa, Chizuko., & Silver, N. Clayton. (1988 May). Response Variations to Stroop Color-Word Stimuli. Genetic, Social, and General Psychology Monographs. 114 211-255.

Jokl, M.V. & Faculty of Engineering, Technical University of Prague, Czecholslovakia. (1982 December). The Effect of the Environment on Human Performance. Applied Ergonomics. 13 269-280.

Kahneman, Daniel., & Chajczyk, Diane. (1983 August). Tests of the Automaticity of Reading: Dilution of Stroop Effects by Color-irrelevant Stimuli. Journal of Experimental Psychology 9 497-509.

Karp, Eric M., & Karp, H.B. Color Associations of Male and Female Fourth-Grade School Children. The Journal of Psychology 122 (4) 383-388.

Katz, Arnold M. (1977). Physiology of the Heart. New York: Raven Press.

Kernohan, David & Environmental Design Research Association. (1987) 'Einstein's Theory' of Environment-Behavior Research. Advances in Environment, Behavior, and Design. New York: Plenum Press.

Keller, Mary Ann. (1986 January-February). Interior Design's Role in Educational Specifications. CEFP Journal.

Kovach, Joseph K. (1983 March). Constitutional Biases in Early Perceptual Learning. Journal of Comparative Psychology 97 226-248.

Lampi, Eino. Finnish Ergophthalmological Society. (1984). The Sources of Light and Lighting at Work. American Information Center for Color and Environment. San Diego, CA.

Land, E.H. (1989). The Retinex Theory of Color Vision. Scientific American. 237 108-128.

Lane, Randall. (1991 December 3). Does Orange Mean Cheap? Forbes. 144-146.

Tevy, Bernard I. (1984 January). Research into the Psychological Meaning of Color. American Journal of Art Therapy. 23 58-62.

Mahnke, Frank H. & Mahnke, Rudolf H. (1987). Color and Light in Man-made Environments. New York: Van Nostrand Reinhold Co.

Mayron, Lewis W., Ott, John., Nations, Rick., & Mayron, Ellen. (Fall 1974) Light, Radiation, and Academic Behavior. Academic Therapy 10 1

Miller, Mark J. (1981 December). The Cosmetic Effect: The Impact of Office Environment on the Client. Journal of Employment Counselling. 18 4 161-167.

Mollon, J.D. & Estevez O. (1988) Tyndall's Paradox of Hue Discrimination. Optical Society of America. 5 151-159.

Maloney, Laurence T. & Wandell Brian A. (1986) Color Constancy: A Method for Recovering Surface Spectral Reflectance. Optical Society of America.3 (1) 29-32.

Montag, Ethan D. & Boynton, Robert M. (1987). Rod Influence in Dichromatic Surface Color Perception. Vision Research. 27 2153-2162.

Morehouse, Laurence E. (1975). Total Fitness in 30 Minutes a Week. New York: Simon and Schuster.

Morriss, Robert & Dunlap, William. (1987 October). Influence of Value on Spatial Balance of Color Pairs. Journal of General Psychology. 114 353-361.

Nathans, Jeremy., Thomas, Darcy., & Hogness, David. (1986 April). Molecular Genetics of Human Color Vision: the Genes Encoding Blue, Green, and Red Pigments. Science. 232 193-202.

Nelson, Gordon J., Pelech, Marc T., & Foster, Stephen F. (1984 December). Color Preference and Stimulation Seeking. Perceptual and Motor Skills. 59 913-914.

Olds, A.R. (1979). Designing Developmentally Optimal Classrooms for Children with Special Needs. Special Education and Development: Perspectives on Young Children with Special Needs. Baltimore: University Park Press.

Ott, John. (1987) Color and Light: Their Effects on Plants, Animals and People, Part 3. International Journal of Biosocial Research. 9

Ott, John N. (1990). Light, Radiation, & You. Greenwich, CN: Devin-Adair, Greenwich, Connecticut.

Painter, Marilyn. (1976-1977). Fluorescent Lights and Hyperactivity in Children: An Experiment. Academic Therapy. 12 2.

Park, Denise Cortis, & James, Charles Q. (1983 February). Effect of Encoding Instructions on Children's Spatial and Color Memory: Is There Evidence for Automaticity? Child Development 54 61-68.

Poysner, Larry R. (1985 May). An Examination of the Classroom Physical Environment. Journal of Research In Education RIE.

Prinzmetal, William., Hoffman, Hunter., & Vest, Kimberly. (1991 November). Automatic Processes in Word Perception: An Analysis from Illusory Conjunctions. Journal of Experimental Psychology. 17 902-923.

Profusek, Pamela J. & Rainey David W. (1987) Effects of Baker-Miller Pink and Red on State Anxiety, Grip Strength, and Motor Precision. Perceptual and Motor Skills 65 941-942.

Rankin, John C. (1982 September). Lighting for Our Schools. Paper presented at the Annual Meeting of the Council of Educational Facility Planners. Columbus, OH

Restak, Richard. (1991). The Brain Has a Mind of Its Own. New York: Harmony Books, a division of Crown Publishers, Inc.

Roessing, Linda J. (1984 October). Adapting the Environment for the Visually Impaired Student: Practical Methods and Materials to Enhance the Use of Low Vision. Conference paper: Proceedings of the Conference on the Visually Impaired Child. Vancouver, British Columbia.

Ross, Rhonda P. (1982 March) The Design of Educational Environments: An Expression of Individual Differences or Evidence of the Press Toward Synomorphy? Conference paper. American Educational Research Association. New York.

Rothwell, Susan E. & Campbell, Fergus W. (1987). The Physiological Basis for the Sensation of Gloom: Quantitative and Qualitative Aspects. Ophthalmics and Physiological Optics: The Journal of the British College of Ophthalmic Opticians. 7 161-163.

Ryan, William P. (1974 Fall). Workshops About the Physical Structure of the Classroom: An Intersting Way to Work With Teachers." Journal of School Psychology. 12 242-246

Rosenstein, L.D. (1985 April). Effect of Color of the Environment on Task Performance and Mood of Males and Females with High or Low Scores on the Scholastic Aptitude Test. Perceptual and Motor Skills 60 550

Sharpe, Deborah T. (1974). The Psychology of Color and Design. Chicago: Nelson-Hall.

Sinofsky, Esther R. & Knirk, Frederick G. (1981 March). Choose the Right Color For Your Learning Style. Instructional Innovator 26 17-19.

Smets, Gerda. (1982). A Tool for Measuring Relative Effects of Hue, Brightness and Saturation on Color Pleasantness. Perceptual and Motor Skills. 55 1159-1164.

Smith, Jeffrey M., Bell, Paul A., & Fusco, Marc E. (1986). The Influence of Color and Demand Characteristics on Muscle Strength and Affective Ratings of the Environment. The Journal of General Psychology. 113. (3) 289-297.

Smith, Linda B. (1984 April). Young Children's Understanding of Attributes and Dimensions: A Comparison of Conceptual and Linguistic Measures. Child Development 55 363-380.

Smith, Nancy R. (1980 March-April). Color Selection-A Key Element in Learning. CEFP Journal. 18 6-7.

Schnapf, J.L., Kraft, T.W. & Baylor, D.A. (1987 January). Spectral Sensitivity of human Cone Photoreceptors. Nature. 325 439-441.

Sullivan, Janet. (1981 March). Nine Design Factors for Better Learning. Instructional Innovator. 26 14-16.

Sydoriak, Diane. (1984). Light and Color Research Continues in Arkansas. CEFP Journal 22 16.

Tavel, Morton E. (1967). Clinical Phonocardiography and External Pulse Recording. Chicago: Year Book Medical Publishers.

Teyler, Timothy J. (1984). A Primer of Psychobiology: Brain and Behavior. Second Edition. New York: W.H. Freeman and Company.

Van Horn, Royal W. (1980 June). Environmental Psychology: Hints of a New Technology? Phi Delta Kappan. 61 10 696-97.

Wardle, Francis. (1989 June). Ideas for Infant and Toddler Environments. Research in Education.

Ware, Colin. (1988). Using Color Dimensions to Display Data Dimensions. Human Factors. 30 127-142.

Weller, Leonard. (1988 October). Effect of Color of Questionnaire on Emotional Responses. The Journal of General Psychology. 115 (4) 433-440.

Whitfield, Allan. (1984 August) Individual Differences in Evaluation of Architectural Colour: Categorization Effects. Perceptual and Motor Skills 59 183-186.

Wiegersma, Sjoerd & Van Der Else, Gerard. (1988). Blue Phenomenon: Spontaneity or Preference? Perceptual and Motor Skills. 66 308-310.

Day, William, C. (1980 Mar-Apr). The Physical Environment-Revisited. CEFP Journal. 18 4-6.

Williamson, Samuel & Cummins, Herman. (1983). Light and Color: In Nature and Art. New York: John Wiley & Sons, Inc.

Wohlfarth, K. & Sam, C. (1981). The Effects of Color/Light Changes on Severely Handicapped Children. Planning and Research Branch, Alberta Education.

Wohlfarth, H. (1985). The Effects of Color-Psychodynamic Environmental Color and Lighting Modification of Elementary Schools on Blood Pressure and Mood: A Controlled Study. International Journal of Biosocial Research. 7 9-16.

Wohlfarth, H. (1986). Color and Light Effects on Student's Achievement, Behavior and Physiology. Edmonton, Alberta; Planning Services Branch, Alberta Education.

Wohlfarth, H. & Hargreaves, J.A. (1990). The Effect of Middle and Long Wave Ultraviolet Radiation from Full Spectrum Lighting on the Incidence of Absences Due to Illness in School-Aged Children. International Journal of Biosocial and Medical Research. 12 119-132

Varley, Helen (Ed) (1990). Color. Marshall Editions Limited. Los Angeles: The Knapp Press. New York: The Viking Press.

Young, David E. (1982 Fall). Aesthetic Response as Coping Behavior: An Anthropological Perspective. Studies in Art Education. 24 5-15.

Zeki, Semir and Ottoman, David. (1985). Central and Peripheral Mechanisms of Colour Vision. Proceedings of an International Symposium held at the Wenner-Gren Center, Stockholm, June 14-15 1984. Great Britain: The MacMillan Press.

Zentall, Sydney. (1986). Effects of Color Stimulation on Performance and Activity of Hyperactive and Nonhyperactive Children. Journal of Educational Psychology. 78 159-165.

Zube, Ervin H. & Moore, Gary T. (1990) Advances in Environment, Behavior, and Design. 3 New York: Plenum Press.

Zold, Balint.,Toth, Tibor., & Tolna, Judit. (1986). Colour Preference: A New Approach. Perceptual and Motor Skills 62 739-752.

APPENDIX

OBSERVER CREDENTIALS

Judge A B.A University of Missouri
Elementary Education/ Special Education
M.S. Elementary Education/Curriculum & Instruction/Reading
Experience includes 4 years teaching at the kindergarten level, 10 years teaching at the first grade level.

Judge B B.S. Elementary Education/Special Education
Indiana University
M.S. Counselling
Experience includes 7 years teaching special education inclusive of mentally challenged, learning disabled, emotionally handicapped.

Judge C A.A. Northeastern Junior College/Arts and Sciences
B.A. University of Northern Colorado/Arts and Sciences/Elementary Education/Psychology.
M.S. University of Nevada-Las Vegas/Elementary Education.
Experience includes 22 years teaching first grade
Two years teaching second grade.

CARDIOVASCULAR CENTER
of
SOUTHERN NEVADA

Joseph A. Kaufman M.D., F.A.C.C.
Paul V. Heeren M.D., F.A.C.C.
Syam S. Munthia M.D.
Richard R. Shehane M.D., F.A.C.C.
Donald J. McSweyn M.D.
Cres P. Miranda, Jr. M.D.

March 29, 1993

Dear Ellen,

I will try to answer your question regarding the effect of environment on systolic blood pressure in a way that will present you with some scientific basis for the observations made, but I will also try to present it in a way that is reasonably easy to understand. Some of the basic principles do involve physics to some degree and that has never been my strong point, but I will try to simplify it.

Basically, Resistance (R) is expressed as the ratio of pressure gradient (P) to the flow rate (F) by the equation R = P/F.

The Resistance (R) in any tube involves the radius of the tube (r), the length of the tube (l), the viscosity of the liquid in the tube (v), and a constant derived from calculus integration.

These fundamental hydrodynamic principles can be translated into clinical terms by the equation: MAP = CO x TPR where CO (cardiac output) = F in our original equation, MAP (mean arterial pressure) = P in our original equation, and TPR (total peripheral resistance) = R in our original equation.

Without getting into a lot of sophisticated mathematics, suffice it to say that in our original equations, the radius (r) is raised to the fourth power in the calculations. What this means is that small changes in the diameter of a tube can have profound effect on flow. This concept is central to the understanding of high blood pressure.

Within the usual physiologic limits, blood viscocity does not change and vascular length in an individual person does not change abruptly. Therefore, variations in resistance reflect functional or structural changes in vessel diameter, and because of the mathematics involved, small changes in the diameter can have significant effects on blood flow.

Now, to put this in some perspective as it relates to your observations. There are both direct and indirect determinants of arterial pressure in any individual. One of the most important indirect determinants is the activity of the autonomic nervous system.

Westside: 2625 S. Rainbow Blvd., Suite A-100, Las Vegas, NV 89102 • Telephone (702) 364-0505
Eastside: 3930 S Eastern, Las Vegas, NV 89119 • Telephone (702) 892-0052

CARDIOVASCULAR CENTER of SOUTHERN NEVADA

Joseph A. Kaufman M.D., F.A.C.C.
Paul V. Heeren M.D., F.A.C.C.
Syam S. Munthia M.D.
Richard R. Shehane M.D., F.A.C.C.
Donald J. McSweyn M.D.
Ches P. Miranda, Jr. M.D.

March 29, 1993

Dear Ellen,

I will try to answer your question regarding the effect of environment on systolic blood pressure in a way that will present you with some scientific basis for the observations made, but I will also try to present it in a way that is reasonably easy to understand. Some of the basic principles do involve physics to some degree and that has never been my strong point, but I will try to simplify it.

Basically, Resistance (R) is expressed as the ratio of pressure gradient (P) to the flow rate (F) by the equation R = P/F.

The Resistance (R) in any tube involves the radius of the tube (r), the length of the tube (l), the viscosity of the liquid in the tube (v), and a constant derived from calculus integration.

These fundamental hydrodynamic principles can be translated into clinical terms by the equation: MAP = CO x TPR where CO (cardiac output) = F in our original equation, MAP (mean arterial pressure) = P in our original equation, and TPR (total peripheral resistance) = R in our original equation.

Without getting into a lot of sophisticated mathematics, suffice it to say that in our original equations, the radius (r) is raised to the fourth power in the calculations. What this means is that small changes in the diameter of a tube can have profound effect on flow. This concept is central to the understanding of high blood pressure.

Within the usual physiologic limits, blood viscocity does not change and vascular length in an individual person does not change abruptly. Therefore, variations in resistance reflect functional or structural changes in vessel diameter, and because of the mathematics involved, small changes in the diameter can have significant effects on blood flow.

Now, to put this in some perspective as it relates to your observations. There are both direct and indirect determinants of arterial pressure in any individual. One of the most important indirect determinants is the activity of the autonomic nervous system.

Westside: 2625 S. Rainbow Blvd. Suite A-100, Las Vegas, NV 89102 • Telephone (702) 364-0505
Eastside: 3930 S. Eastern, Las Vegas, NV 89119 • Telephone (702) 892-0052

DIASTOLIC BLOOD PRESSURE READINGS

Diastolic Blood Pressure-Stage I

	28	29	30	1	2	5	6	7	8	9
(1)	115 96	118 48	59 52	52 44	60 62	103 58	52 92	59 97	115 60	62 84
(2)	56 66	28 53	43 56	78 106	54 52	57 45	78 54	50 44	46 93	63 86
(3)	49 40	52 35	86 38	50 43	30 62	39 42	78 48	41 101	44 33	47 47
(4)	53 49	----- 48	85 46	53 56	45 41	51 41	44 32	84 78	91 76	61 21
(5)	40 123	144 -----	38 51	80 49	40 38	89 68	71 71	-- 70	94 40	54 122
(6)	50 62	28 44	46 53	46 52	61 67	61 64	94 38	30 49	66 49	-- --
(7)	52 41	55 46	91 43	45 86	44 72	36 34	30 46	50 41	44 72	44 52
(8)	41 ---	57 47	75 46	42 35	61 43	54 48	45 34	41 52	42 32	63 63
(9)	136 42	95 50	43 38	42 114	49 49	50 56	44 39	52 38	97 67	107 95
(10)	108 ---	120 48	52 69	41 46	104 117	43 113	76 54	-- 114	56 50	40 52
(11)	44 67	--- ---	37 ---	53 44	40 31	53 63	112 129	87 66	50 --	111 48
(12)	93 48	--- ---	67 ---	--- ---	--- ---	-- --	-- --	40 48	74 --	42 51
(13)	59 37	--- ---	58 ---	--- ---	--- ---	-- --	-- --	42 49	39 37	48 42
(14)	03 41	--- ---	111 ---	--- ---	--- ---	-- --	-- --	92 --	48 44	34 45
(15)	67 60	--- ---	40 ---	--- ---	--- ---	-- --	-- --	53 --	56 59	65 --
(16)	56 47	--- ---	44 ---	--- ---	--- ---	-- --	-- --	47 --	28 --	36 --
(17)	58 43	--- ---	49 ---	--- ---	--- ---	-- --	-- --	101 101	46 52	47 117
(18)	--- ---	--- ---	74 ---	55 72	77 81	-- 82	-- --	70 69	69 --	77 --
(19)	55 ---	--- ---	57 ---	60 91	75 65	-- --	-- --	65 --	-- --	74 --
(M) (M)	74 73	77 60	60 49	53 61	54 58	66 57	66 58	68 68	68 57	64 67

Diastolic Blood Pressure-Stage II

	13	14	15	16	19	20	21	22	23	27	28
(1)	82	55	54	60	91	56	59	59	59	64	62
	92	154	--	71	53	61	72	64	59	55	55
(2)	47	54	96	40	137	48	67	74	41	78	63
	57	104	--	34	55	45	59	67	57	59	63
(3)	73	34	48	46	32	49	45	41	42	61	85
	48	27	--	67	67	36	48	47	44	77	47
(4)	43	47	45	47	44	35	48	48	42	49	47
	50	34	--	50	46	61	50	52	55	48	46
(5)	43	116	70	57	61	92	50	61	47	33	73
	31	92	--	45	93	32	60	75	42	65	42
(6)	--	94	77	48	46	47	60	107	48	101	33
	--	55	--	39	45	44	43	113	48	56	49
(7)	43	79	46	42	113	107	52	48	43	31	47
	49	40	--	50	48	40	47	45	42	45	49
(8)	35	63	58	53	56	47	59	49	34	47	46
	32	55	--	47	50	57	58	57	45	49	48
(9)	48	55	53	40	60	49	100	35	56	39	57
	56	73	--	51	49	54	71	55	49	42	57
(10)	85	50	--	58	48	49	48	--	46	46	52
	--	49	--	48	60	49	72	--	44	51	52
(11)	60	61	43	46	52	52	44	44	45	56	53
	56	49	--	--	--	54	57	57	53	55	53
(12)	72	42	42	42	44	48	44	40	52	49	48
	--	42	--	55	--	56	44	49	56	55	53
(13)	---	46	52	40	71	35	41	55	48	56	46
	--	43	--	42	67	41	46	44	40	30	48
(14)	45	53	33	41	38	39	43	--	--	--	--
	--	41	--	50	50	53	35	--	--	--	--
(15)	60	55	62	70	72	65	61	49	52	59	59
	--	58	--	60	58	60	59	41	56	68	55
(16)	90	41	--	41	80	31	81	49	82	42	48
	--	--	--	46	48	47	75	44	106	34	48
(17)	--	39	52	43	50	97	108	51	51	53	68
	--	52	--	50	48	53	55	51	54	51	47
(18)	70	72	--	110	--	62	63	77	74	71	62
	69	73	71	74	--	76	70	76	73	70	69
(19)	--	73	67	59	--	63	63	64	68	78	68
	--	60	--	71	--	79	61	64	70	68	69
(M)	56	64		49	67	57	57	57	46	55	57
(M)	52	67		50	57	48	58	63	49	55	51

Diastolic Blood Pressure-Stage III

	3	4	5	6	9	10	11	13	16
(1)	63 58	76 --	65 67	44 70	72 24	65 65	102 112	56 65	87 58
(2)	44 55	35 --	46 55	45 59	35 41	60 51	48 50	47 57	54 69
(3)	28 44	-- --	74 46	50 47	49 52	49 46	41 42	47 71	43 47
(4)	48 45	52 --	52 49	41 58	53 55	54 47	34 47	44 87	28 56
(5)	95 90	75 --	64 74	83 76	79 44	82 73	82 40	56 66	67 59
(6)	45 47	78 --	40 54	49 49	54 55	77 52	-- --	46 80	56 52
(7)	45 53	45 --	45 44	-- --	53 47	49 50	40 34	62 49	42 57
(8)	40 74	62 --	64 84	52 49	60 42	70 47	48 39	-- --	44 53
(9)	45 46	52 --	50 51	41 41	60 49	64 54	71 56	52 47	41 51
(10)	50 50	47 --	48 50	51 56	49 59	52 46	55 55	50 50	53 77
(11)	-- --	46 --	46 55	47 83	44 51	55 104	59 65	50 50	77 49
(12)	45 48	48 --	46 55	54 46	57 42	44 39	46 37	42 94	39 74
(13)	46 45	44 --	47 40	45 65	50 51	37 48	26 52	-- --	44 42
(14)	75 46	40 --	38 54	-- --	44 41	-- --	39 38	-- --	46 37
(15)	-- --	52 --	49 97	64 59	49 62	56 45	59 72	55 79	58 68
(16)	49 49	53 --	52 47	48 --	47 52	52 --	62 54	44 47	-- --
(17)	44 53	68 --	54 86	53 44	60 50	-- 45	82 54	46 49	54 45
(18)	-- --	73 --	72 71	76 69	70 69	70 70	68 66	67 69	73 78
(19)	-- --	-- --	73 65	72 --	69 --	73 65	75 80	68 73	-- --
(M) (M)	50 56	56	59 62	55 65	61 52	55 64	64 60	57 69	59 63

SYSTOLIC BLOOD PRESSURE READINGS

Systolic Blood Pressure-Stage I

	28	29	30	1	2	5	6	7	8	9
(1)	140 151	150 93	95 105	105 64	113 117	142 127	93 137	102 130	136 122	101 106
(2)	149 104	93 91	100 129	100 149	93 99	89 86	102 100	96 82	90 115	106 108
(3)	80 89	76 77	113 85	90 83	90 99	69 86	102 93	54 124	80 71	77 76
(4)	83 78	--- 77	119 91	88 93	103 74	76 67	61 76	115 114	135 116	98 107
(5)	77 78	166 77	77 91	110 93	90 74	118 67	105 76	--- 114	113 116	86 107
(6)	123 117	42 92	97 81	65 87	100 105	101 81	150 82	54 104	94 70	--- ---
(7)	99 79	120 81	133 110	81 109	68 128	76 76	45 91	86 109	77 113	81 91
(8)	81 ---	91 88	110 79	93 77	114 68	83 85	112 67	76 86	81 73	94 90
(9)	169 75	124 110	87 68	89 144	92 107	100 82	64 100	92 94	157 98	123 126
(10)	140 ---	158 90	86 106	81 83	126 167	82 144	115 94	--- 144	99 85	81 113
(11)	93 126	--- ---	81 ---	94 107	69 81	96 88	140 172	107 106	84 ---	141 84
(12)	128 85	--- ---	139 ---	--- ---	--- ---	--- ---	--- ---	75 81	110 ---	89 86
(13)	91 85	--- ---	102 ---	--- ---	--- ---	--- ---	--- ---	--- 78	70 81	74 74
(14)	141 88	--- ---	134 ---	--- ---	--- ---	--- ---	--- ---	115 ---	85 81	68 83
(15)	105 89	--- ---	100 ---	--- ---	--- ---	--- ---	--- ---	79 ---	83 108	101 ---
(16)	94 84	--- ---	88 ---	--- ---	--- ---	--- ---	--- ---	81 ---	50 ---	62 ---
(17)	97 107	--- ---	99 ---	--- ---	--- ---	--- ---	--- ---	136 127	84 89	92 153
(18)	--- ---	--- ---	102 ---	104 122	112 122	105 ---	--- ---	107 111	99 ---	111 ---
(19)	105 ---	--- ---	105 ---	106 121	134 96	--- ---	--- ---	111 ---	--- ---	113 ---
(M)	112 100	113 88	100 95	91 99	96 102	94 84	94 99	87 110	104 98	99 101

Stage II Systolic Blood Pressure

	13	14	15	16	19	20	21	22	23	27	28
(1)	122 147	97 183	125 ---	99 101	126 89	97 94	108 110	104 101	94 94	109 100	104 88
(2)	84 92	88 128	117 ---	58 59	160 97	75 87	113 96	96 94	62 90	104 93	94 98
(3)	120 81	65 77	73 ---	84 91	76 91	79 73	79 79	54 86	69 68	86 101	107 75
(4)	86 84	81 68	75 ---	84 81	94 77	77 91	90 97	81 89	76 84	77 77	82 75
(5)	73 52	150 118	100 ---	86 91	86 117	115 58	76 98	90 106	73 69	80 94	100 74
(6)	--- ---	111 91	118 ---	83 75	80 81	80 90	94 77	138 132	95 75	126 118	72 70
(7)	82 96	109 68	90 ---	67 70	140 71	130 60	82 94	78 77	81 81	73 78	84 87
(8)	51 87	97 87	96 ---	88 98	90 92	93 93	91 101	76 86	78 73	86 85	74 88
(9)	77 108	81 104	78 ---	96 90	104 85	85 70	126 104	59 90	91 79	82 71	99 99
(10)	112 ---	94 84	--- ---	84 77	109 93	91 88	85 109	--- ---	82 104	74 88	85 88
(11)	90 101	106 85	67 ---	87 ---	88 ---	99 98	74 94	107 91	77 98	78 85	85 83
(12)	108 ---	82 75	76 ---	88 90	88 ---	85 87	82 83	85 83	94 92	82 88	91 84
(13)	--- ---	79 70	80 ---	75 64	89 93	69 63	87 66	107 71	88 64	96 78	71 72
(14)	68 ---	87 71	67 ---	85 83	73 78	69 87	74 71	--- ---	--- --	--- ---	--- ---
(15)	106 ---	97 96	100 ---	104 110	112 100	92 94	101 108	98 106	93 96	196 101	94 104
(16)	125 ---	83 ---	--- ---	85 78	109 97	85 75	108 116	98 86	114 131	72 73	89 75
(17)	--- ---	82 88	85 ---	87 73	101 91	123 105	142 93	77 96	99 93	83 85	90 80
(18)	97 102	106 113	--- 106	131 106	--- ---	98 112	108 113	105 109	110 107	105 110	95 99
(19)	--- ---	122 112	116 ---	109 112	--- ---	104 122	102 124	105 112	108 109	110 116	107 99
(M) (M)	90 94	98 99		83 83	105 89	93 82	93 96	88 95	80 83	89 90	90 84

Systolic Blood Pressure-Stage III

	3	4	5	6	9	10	11	13	16
(1)	104 105	95 ---	104 115	106 108	96 116	100 116	127 120	84 101	115 105
(2)	92 86	72 ---	100 91	83 91	77 96	90 80	90 90	91 90	88 114
(3)	70 83	--- ---	99 84	88 84	90 85	77 84	70 77	74 103	75 81
(4)	82 83	81 ---	76 84	88 84	107 85	67 84	88 77	77 103	83 81
(5)	126 109	99 ---	91 125	118 92	110 78	106 96	113 85	86 87	97 104
(6)	78 87	116 ---	89 102	80 85	100 85	101 77	--- ---	87 106	74 87
(7)	73 96	100 ---	77 75	--- ---	74 78	83 81	66 69	89 80	70 91
(8)	83 100	88 ---	86 99	85 89	92 81	97 92	84 93	--- ---	83 84
(9)	77 85	85 ---	88 70	75 85	92 90	97 129	104 84	90 98	74 89
(10)	92 90	83 ---	80 86	85 99	92 104	102 89	94 94	84 92	108 108
(11)	--- ---	83 ---	90 93	[illegible] 112	92 99	102 130	94 92	84 91	108 91
(12)	84 87	102 ---	83 82	77 82	87 88	88 65	87 83	90 113	91 131
(13)	79 71	76 ---	70 87	67 94	77 99	65 83	64 89	--- ---	75 79
(14)	--- ---	96 ---	102 121	101 106	80 76	--- ---	73 77	--- ---	79 72
(15)	111 85	70 ---	68 88	--- ---	83 100	105 95	99 100	99 118	105 109
(16)	85 77	95 ---	88 87	83 ---	85 77	86 ---	91 83	81 83	80 ---
(17)	89 86	86 ---	96 118	81 86	84 79	--- 94	95 83	81 86	89 85
(18)	--- ---	105 ---	112 106	121 110	105 108	117 104	105 105	105 101	105 118
(19)	--- ---	--- ---	108 117	109 ---	97 ---	104 106	109 124	107 108	--- ---
(M) (M)	88 92		89 93	89 93	93 91	93 96	93 88	85 95	89 94

PULSE READINGS

Pulse-Stage I

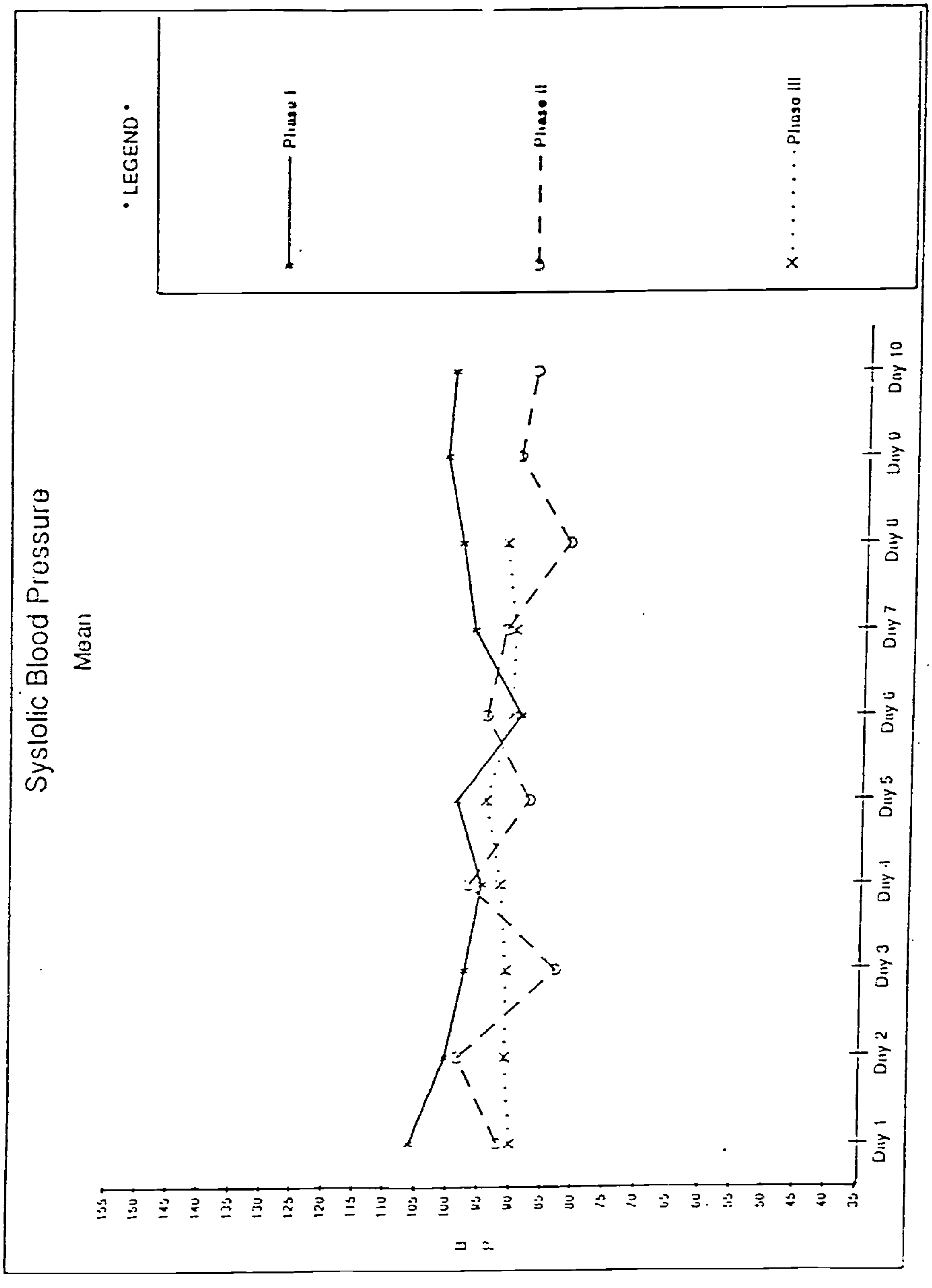
	28	29	30	1	2	5	6	7	8	9
(1)	52 94	66 93	91 110	108 44	77 83	69 112	95 45	81 95	41 119	115 76
(2)	43 78	86 59	71 81	55 44	76 59	65 58	79 105	93 86	75 34	94 76
(3)	91 71	55 69	46 80	76 81	53 59	82 52	79 78	57 42	79 76	92 103
(4)	94 49	--- 102	57 100	97 47	57 82	59 73	63 86	80 59	95 45	109 65
(5)	82 39	65 ---	80 78	92 81	44 106	49 36	90 54	--- 90	64 54	61 44
(6)	75 59	68 71	84 89	97 83	79 89	82 83	92 91	91 101	79 86	--- 78
(7)	73 101	69 102	68 59	131 59	91 79	83 83	91 93	101 103	86 64	78 100
(8)	103	86 33	80 81	59 46	46 76	65 70	84 66	89 78	81 34	90 76
(9)	36 43	40 48	58 100	71 56	30 101	90 61	84 72	98 61	107 115	32 32
(10)	69 ---	38 86	55 92	93 79	41 57	90 67	86 94	--- 54	95 107	57 95
(11)	82 84	--- ---	88 ---	99 88	65 81	79 66	33 48	60 35	86 ---	59 90
(12)	71 98	--- ---	70 ---	--- ---	--- ---	--- ---	--- ---	87 89	100 ---	101 71
(13)	57 56	--- ---	42 ---	--- ---	--- ---	--- ---	--- ---	51 72	76 59	78 64
(14)	42 41	--- ---	35 ---	--- ---	--- ---	--- ---	--- ---	32 ---	81 64	61 69
(15)	68 77	--- ---	54 ---	--- ---	--- ---	--- ---	--- ---	46 ---	78 106	98 ---
(16)	67 83	--- ---	76 ---	--- ---	--- ---	--- ---	--- ---	82 ---	61 ---	88 ---
(17)	69 81	--- ---	87 ---	--- ---	--- ---	--- ---	--- ---	90 68	69 64	100 42
(18)	--- ---	--- ---	86 ---	97 88	80 93	--- 100	--- ---	73 76	80 ---	79 ---
(19)	97 ---	--- ---	89 ---	89 98	94 99	--- ---	--- ---	83 ---	--- ---	100 ---
(M) (M)	73 69	64 77	71 74	89 87	60 64	74 80	80 69	83 76	80 73	79 76

Pulse-Stage II

	13	14	15	16	19	20	21	22	21	27	28	29
(1)	43 100	106 63	98 --	97 60	36 100	97 105	101 81	106 116	82 --	103 105	117 105	88 --
(2)	93 83	106 86	41 --	64 43	93 67	67 76	45 53	45 78	82 78	58 56	55 78	90 --
(3)	89 46	95 80	70 --	76 85	77 45	88 68	91 81	76 88	87 82	77 40	53 66	86 --
(4)	57 82	93 55	43 --	56 56	77 93	79 80	92 102	65 46	93 107	94 99	100 91	62 --
(5)	69 44	53 51	34 --	40 54	35 56	36 88	47 35	83 54	80 80	76 65	53 99	43 --
(6)	81 92	44 90	34 --	89 98	89 84	89 83	45 82	35 53	92 83	56 59	92 59	84 --
(7)	55 99	76 99	92 --	94 83	43 95	48 81	82 116	88 87	93 107	33 87	95 101	63 --
(8)	79 66	84 75	64 --	68 75	79 63	93 91	89 68	82 85	84 93	92 86	84 91	70 --
(9)	36 --	94 45	40 --	74 107	32 67	74 78	58 46	137 98	103 96	74 98	83 101	83 --
(10)	69 66	88 86	42 --	75 92	68 95	85 93	88 81	-- --	93 101	70 101	94 97	84 --
(11)	97 --	69 56	69 --	92 --	92 --	87 68	79 108	104 65	84 59	89 83	92 88	89 --
(12)	56 90	93 77	85 --	96 94	81 --	100 93	107 106	110 98	104 94	92 98	104 91	-- --
(13)	81 56	75 73	-- --	90 90	55 55	73 43	89 75	68 91	73 78	57 77	59 59	85 --
(14)	45 --	50 69	76 --	54 75	63 65	74 61	71 76	-- --	-- --	95 62	57 --	40 --
(15)	66 --	71 77	88 --	70 89	69 73	71 72	64 79	77 55	67 70	83 84	67 80	70 --
(16)	45 --	75 --	-- --	54 90	42 91	68 87	68 69	92 88	41 80	83 85	92 101	84 --
(17)	82 --	63 66	90 --	75 97	97 84	64 103	56 101	97 106	99 110	88 97	93 112	94 --
(18)	83 --	87 77	-- 71	77 78	88 88	82 81	88 85	92 80	77 84	71 71	68 84	73 --
(19)	--	88 94	95 --	93 94	-- --	93 93	77 87	95 90	84 98	84 98	97 84	-- --
(M) (M)	70 86	83 71		75 75	66 77	77 83	74 78	82 77	88 80	75 80	83 89	

Pulse-Stage III

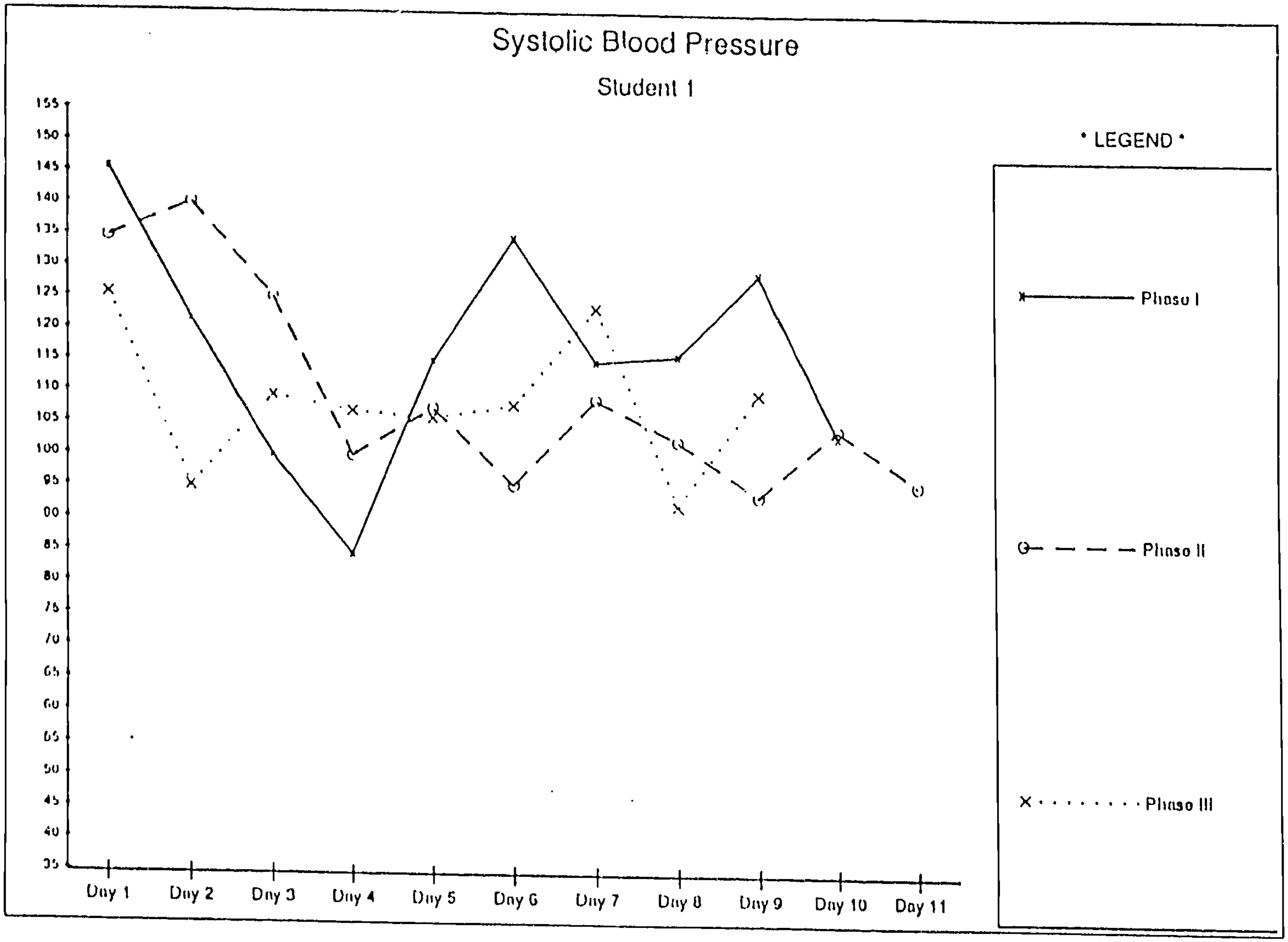
	3	4	5	6	9	10	12	13	16
(1)	92	76	99	77	107	90	40	56	83
	115	---	118	78	120	123	33	88	107
(2)	71	110	76	78	76	60	72	81	82
	35	---	83	86	56	77	87	104	75
(3)	71	---	69	103	107	91	77	113	104
	86	---	89	97	90	109	91	79	106
(4)	101	68	98	98	101	59	97	104	67
	76	---	101	97	110	109	97	42	101
(5)	32	30	48	77	46	53	40	81	48
	35	---	60	53	95	58	81	72	106
(6)	76	91	88	95	91	107	---	90	71
	87	---	107	95	47	94	---	100	84
(7)	104	77	107	---	99	98	114	81	92
	111	---	103	---	112	111	83	113	65
(8)	86	76	80	99	83	100	87	---	106
	84	---	45	102	79	77	84	---	78
(9)	70	86	112	95	83	92	72	70	102
	92	---	113	80	110	119	58	111	67
(10)	68	81	86	78	79	84	98	83	83
	98	---	110	105	99	98	108	101	41
(11)	---	86	94	101	81	97	107	59	105
	---	---	101	42	70	37	103	83	106
(12)	93	78	103	88	104	82	58	95	81
	90	---	101	100	88	60	95	45	79
(13)	77	87	89	70	87	83	52	---	79
	46	---	88	93	90	88	67	---	79
(14)	30	76	72	---	71	---	63	---	66
	50	---	83	---	67	---	64	---	74
(15)	---	72	74	74	63	78	82	63	83
	---	---	64	84	76	83	82	94	103
(16)	78	85	86	88	88	98	87	80	64
	88	---	90	---	97	---	92	85	---
(17)	87	103	77.	79	81	---	81	91	89
	95	---	103	110	65	111	92	99	77
(18)	---	74	82	106	76	78	72	74	90
	---	---	84	71	84	72	82	81	98
(19)	---	---	93	94	111	94	90	103	---
	---	---	106	---	---	95	100	90	---
(M)	77		87	87	85	85	80	82	86
(M)	81		94	84	90	92	83	89	85



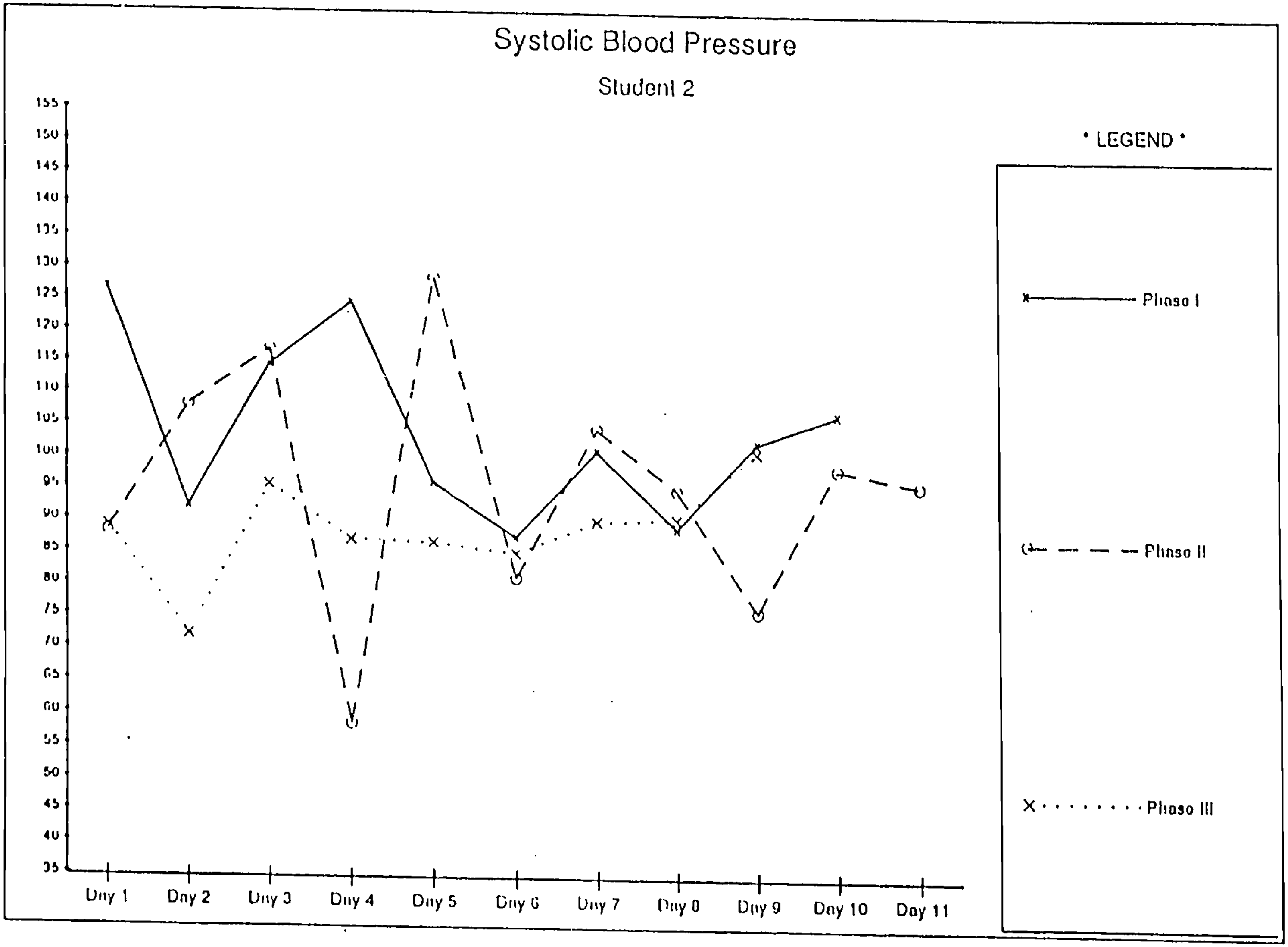
BEST AVAILABLE

136

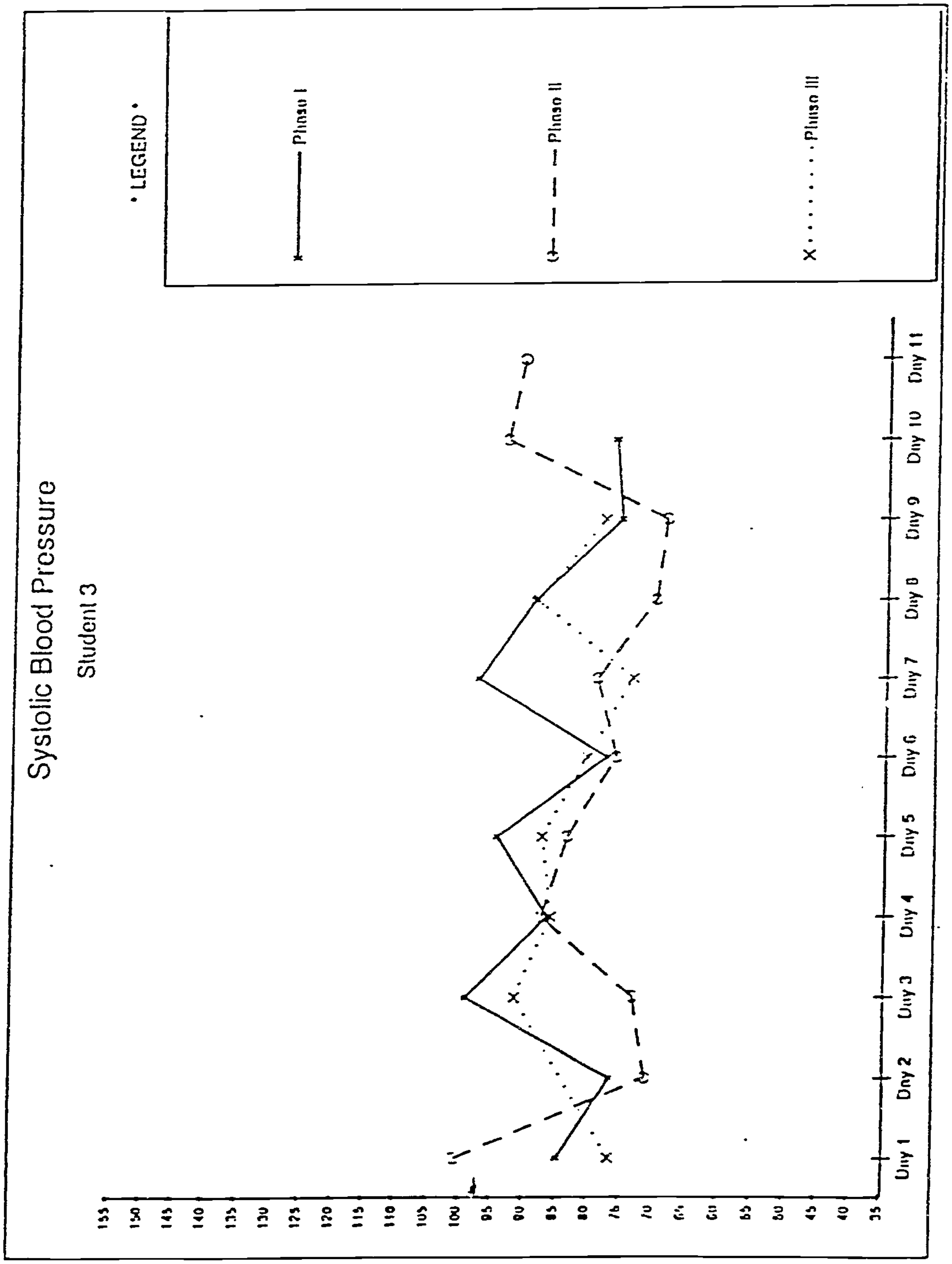
137



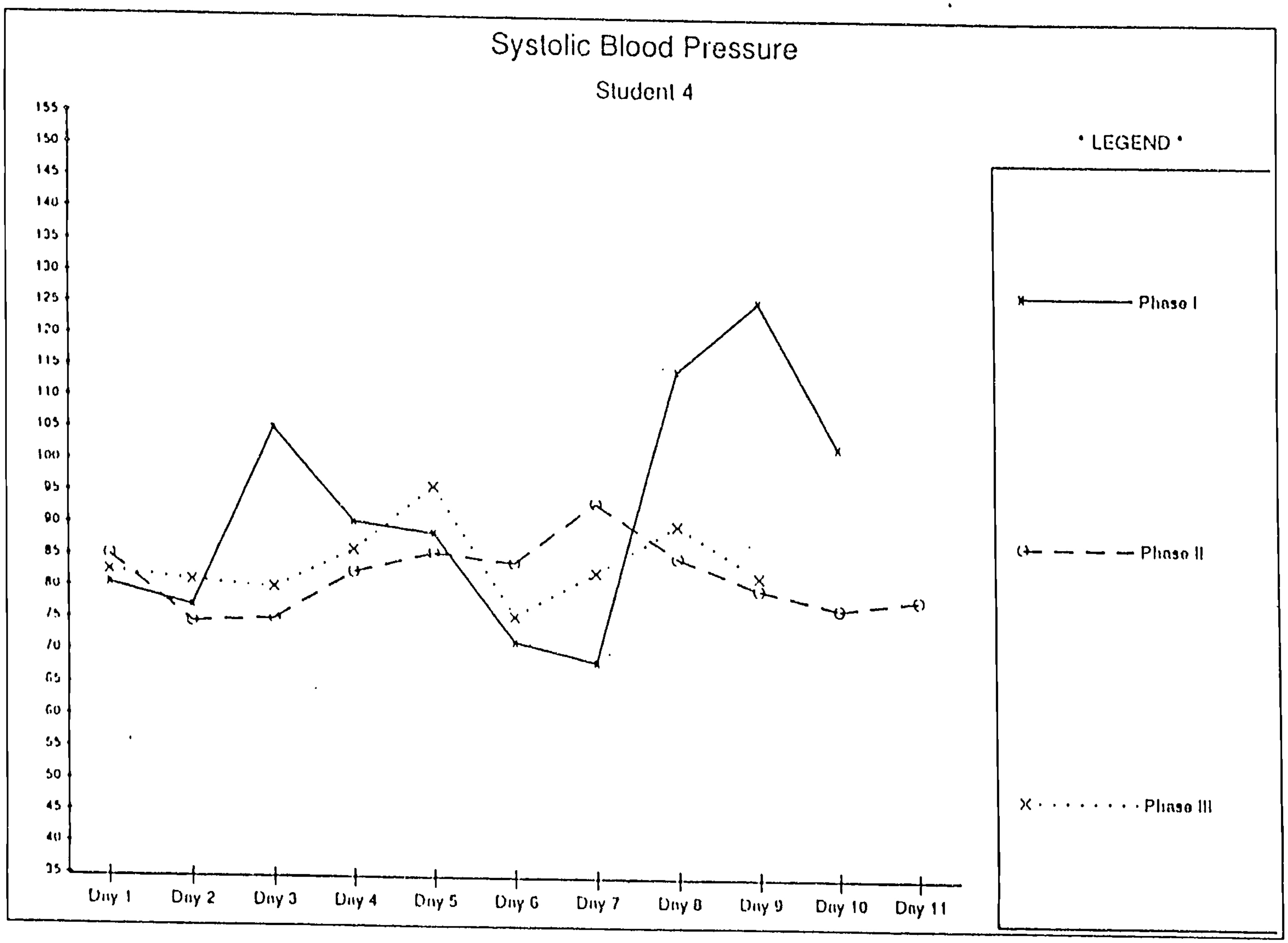
Systolic Blood Pressure
Student 1
155
150
145
140
135
130
125
120
115
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
Day 1
Day 2
Day 3
Day 4
Day 5
Day 6
Day 7
Day 8
Day 9
Day 10
Day 11
• LEGEND •
Phase I
Phase II
Phase III

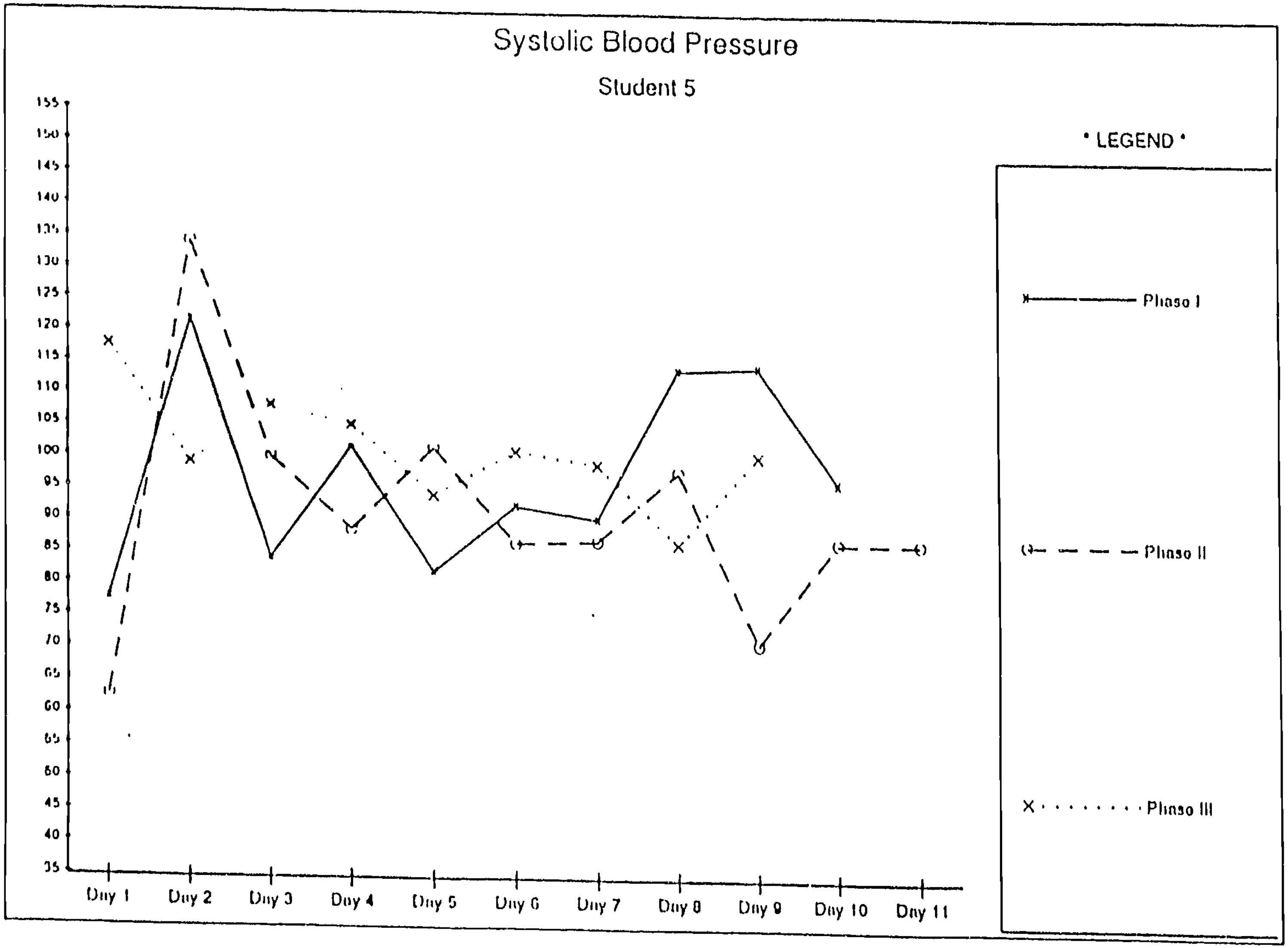

Systolic Blood Pressure
Student 2
155
150
145
140
135
130
125
120
115
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
Day 1
Day 2
Day 3
Day 4
Day 5
Day 6
Day 7
Day 8
Day 9
Day 10
Day 11
• LEGEND •
Phase I
Phase II
Phase III

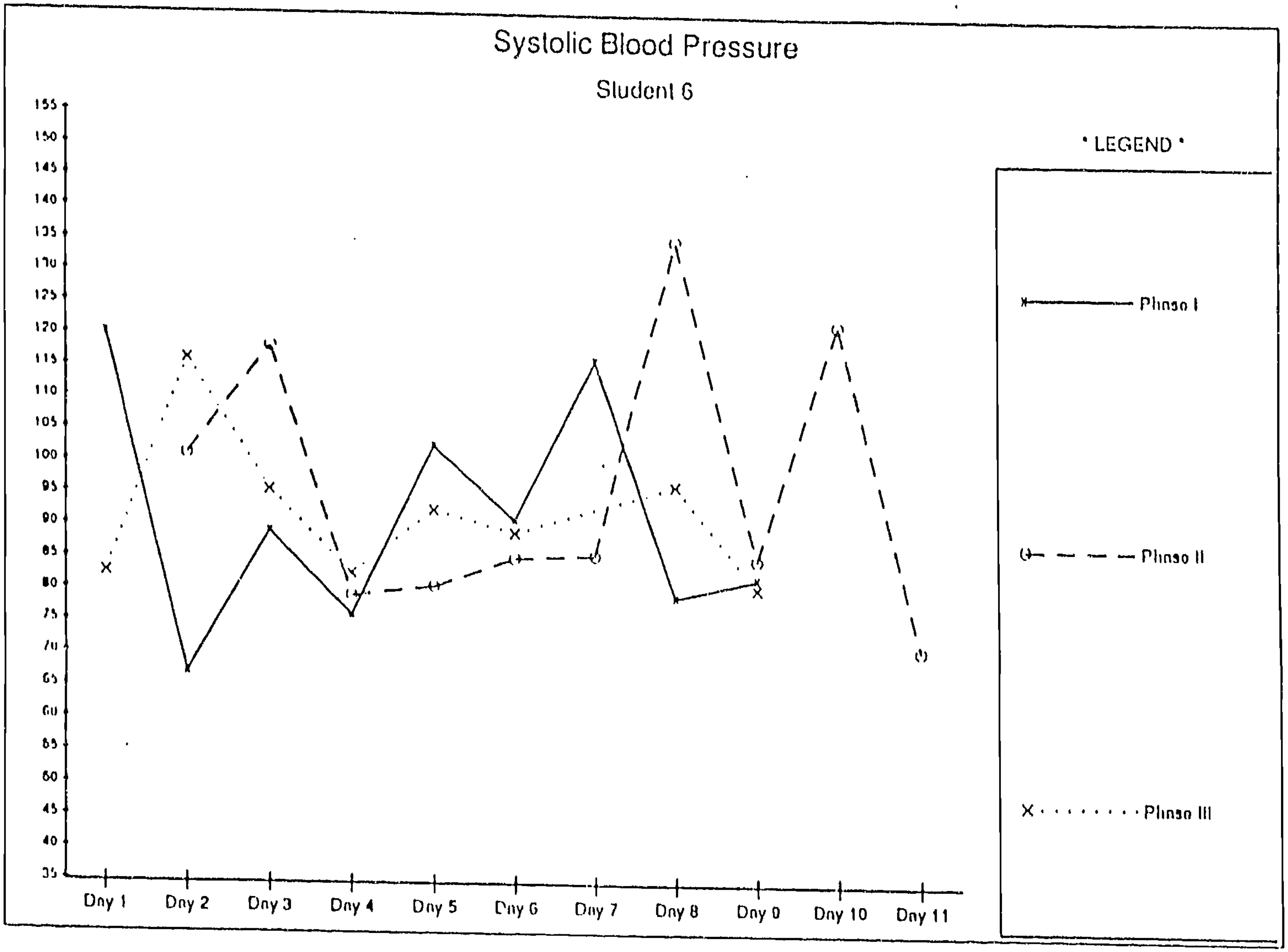
...Y AVAILABLE

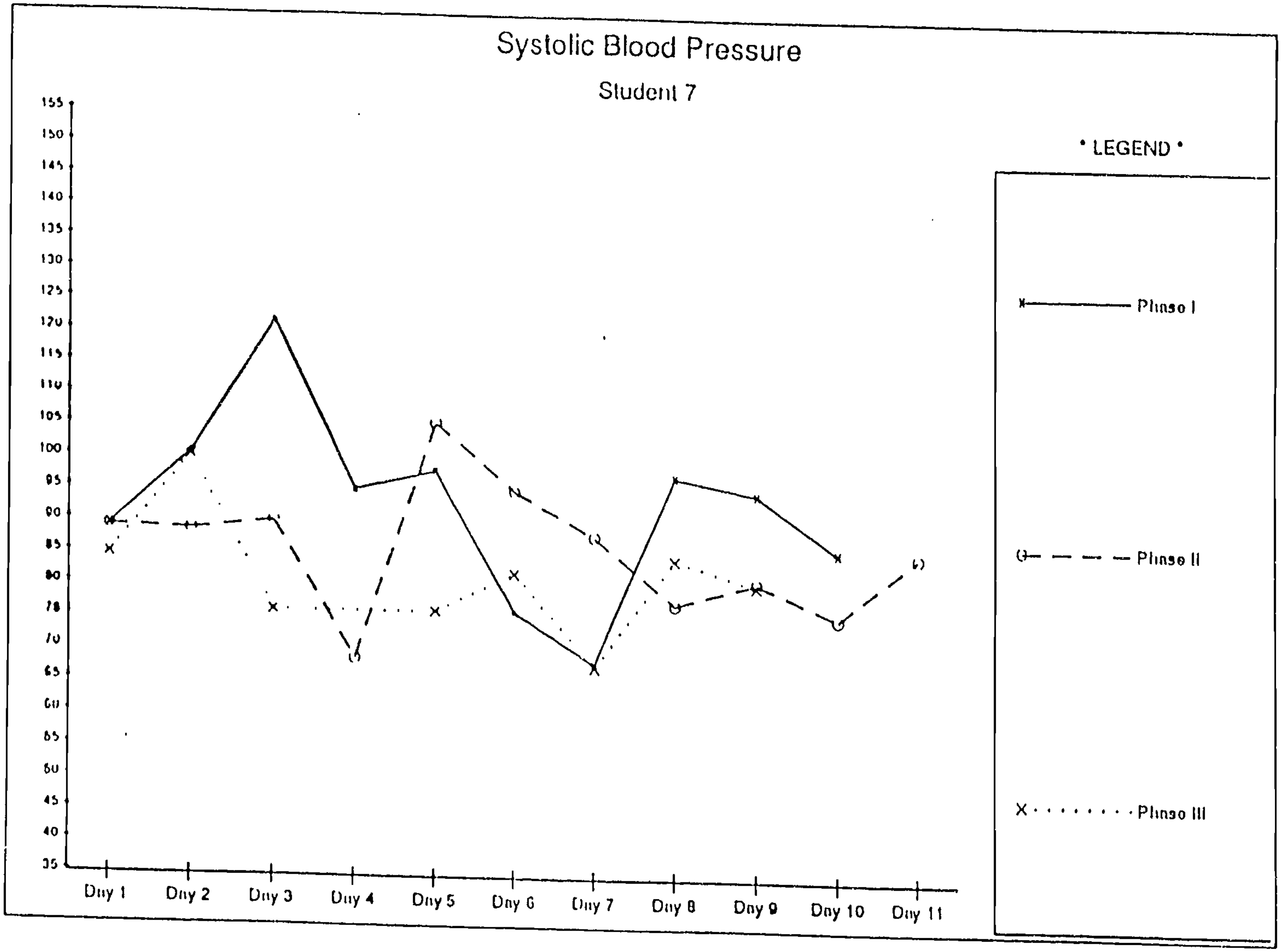


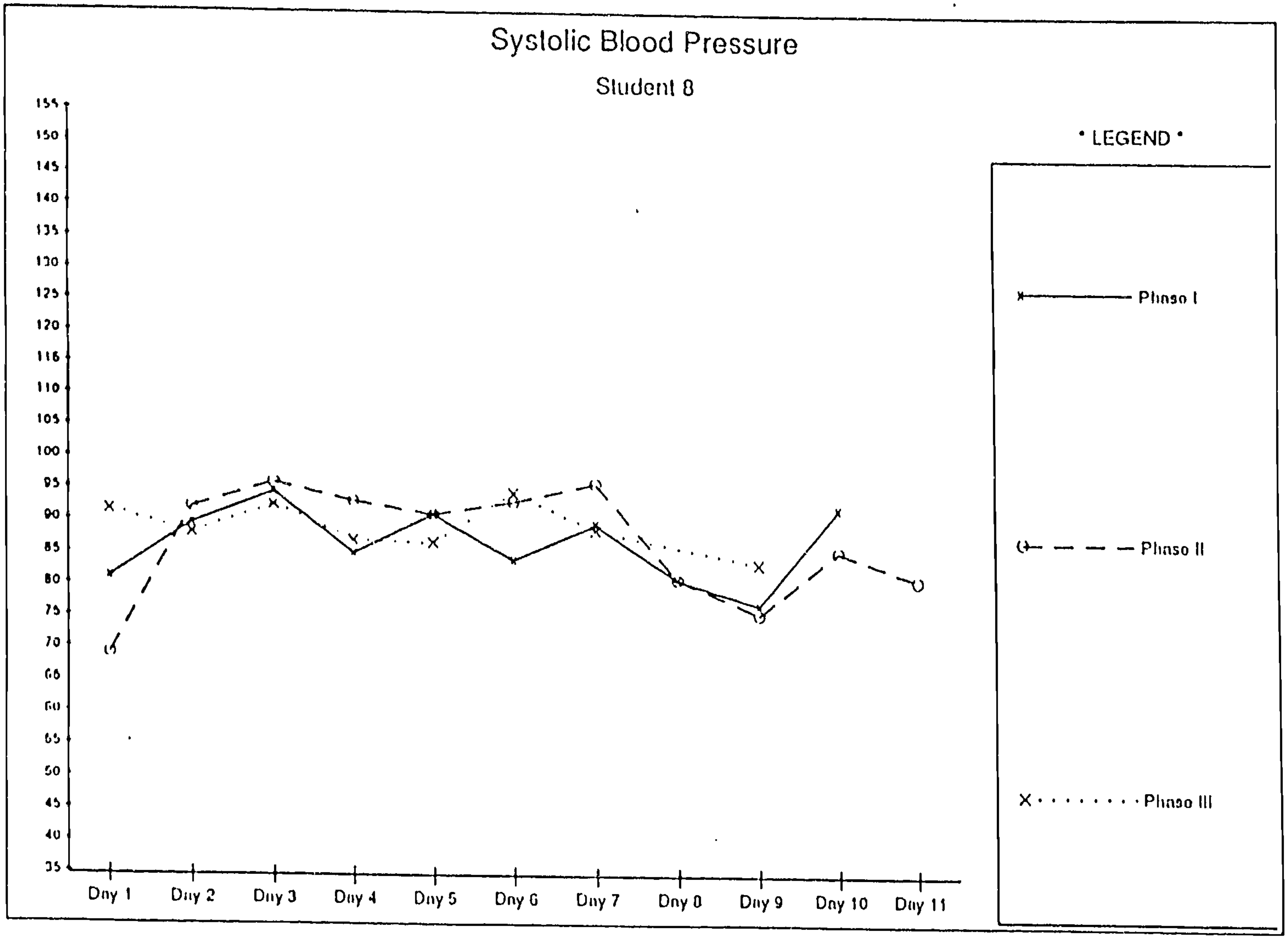
Systolic Blood Pressure
Student 3
• LEGEND •
Phase I
Phase II
Phase III
Day 1
Day 2
Day 3
Day 4
Day 5
Day 6
Day 7
Day 8
Day 9
Day 10
Day 11
155
150
145
140
135
130
125
120
115
110
105
100
95
90
85
80
75
70
40
35


Systolic Blood Pressure
Student 4
155
150
145
140
135
130
125
120
115
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
Day 1
Day 2
Day 3
Day 4
Day 5
Day 6
Day 7
Day 8
Day 9
Day 10
Day 11
• LEGEND •
Phase I
Phase II
Phase III


Systolic Blood Pressure
Student 5
155
150
145
140
135
130
125
120
115
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
Day 1
Day 2
Day 3
Day 4
Day 5
Day 6
Day 7
Day 8
Day 9
Day 10
Day 11
• LEGEND •
Phase I
Phase II
Phase III

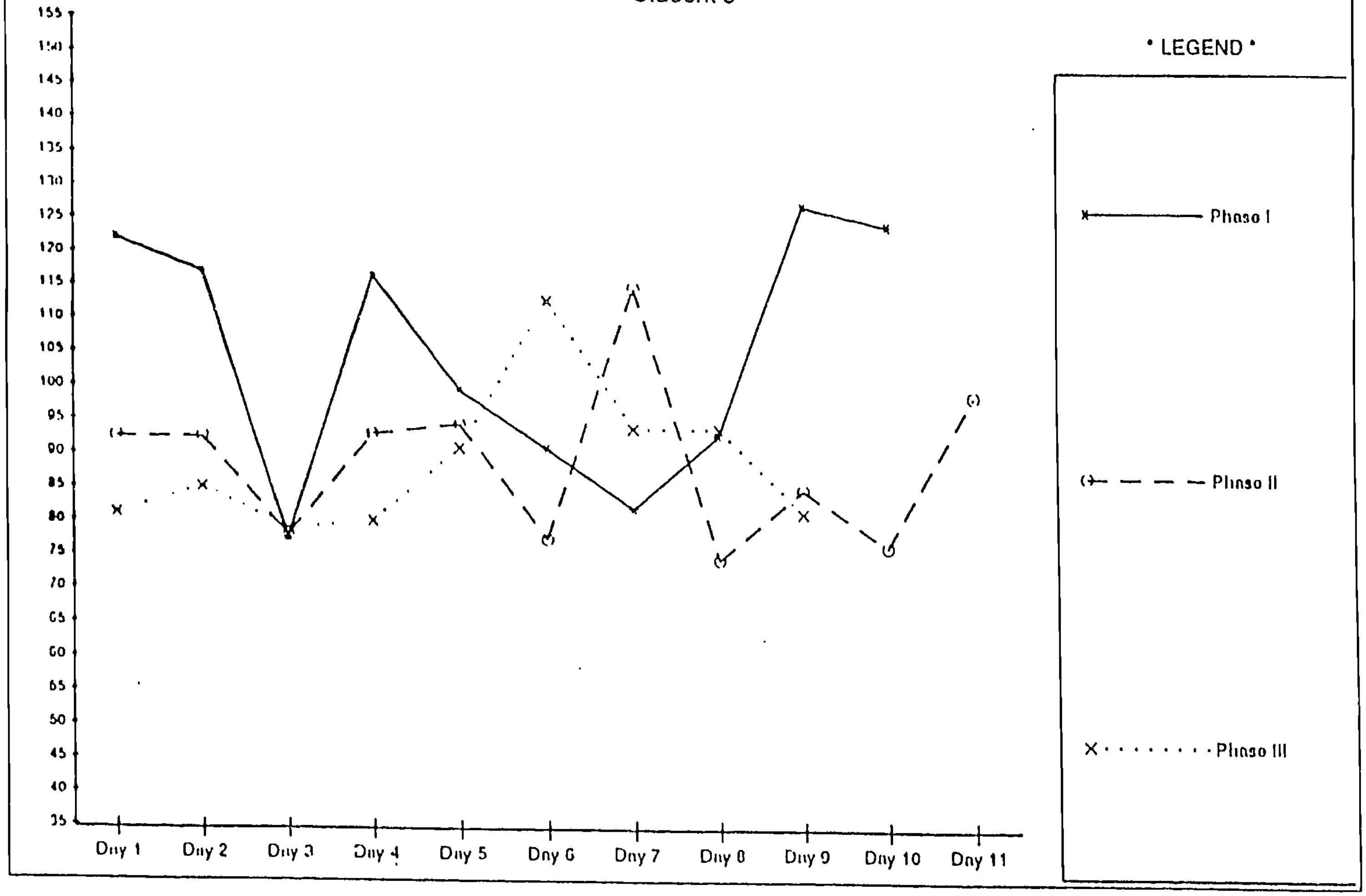

Systolic Blood Pressure
Student 6
155
150
145
140
135
130
125
120
115
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
Day 1
Day 2
Day 3
Day 4
Day 5
Day 6
Day 7
Day 8
Day 9
Day 10
Day 11
* LEGEND *
Phase I
Phase II
Phase III

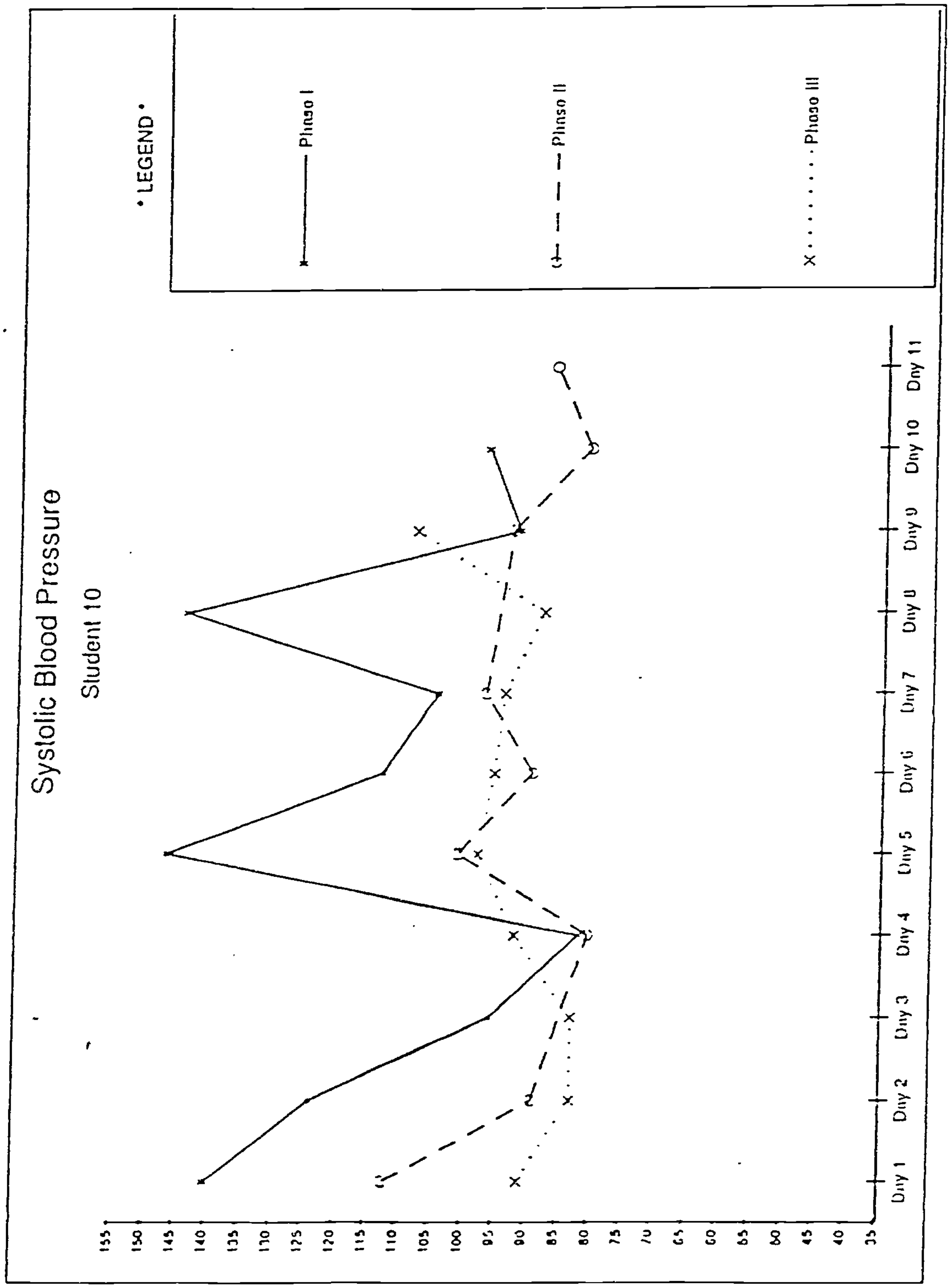

Systolic Blood Pressure
Student 7
155
150
145
140
135
130
125
120
115
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
Day 1
Day 2
Day 3
Day 4
Day 5
Day 6
Day 7
Day 8
Day 9
Day 10
Day 11
* LEGEND *
Phase I
Phase II
Phase III


Systolic Blood Pressure
Student 8
155
150
145
140
135
130
125
120
115
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
Day 1
Day 2
Day 3
Day 4
Day 5
Day 6
Day 7
Day 8
Day 9
Day 10
Day 11
• LEGEND •
Phase I
Phase II
Phase III

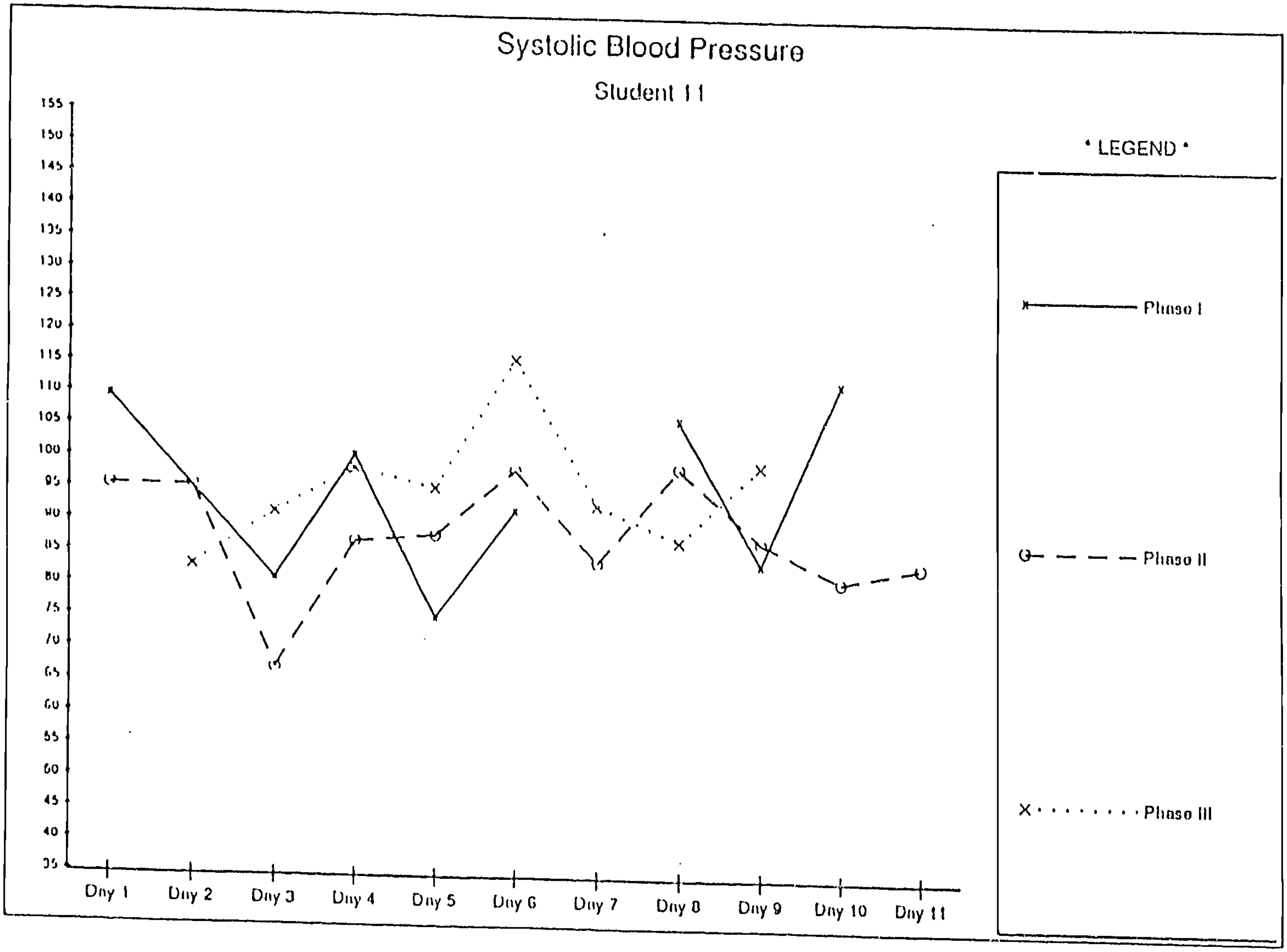
Systolic Blood Pressure

Student 9

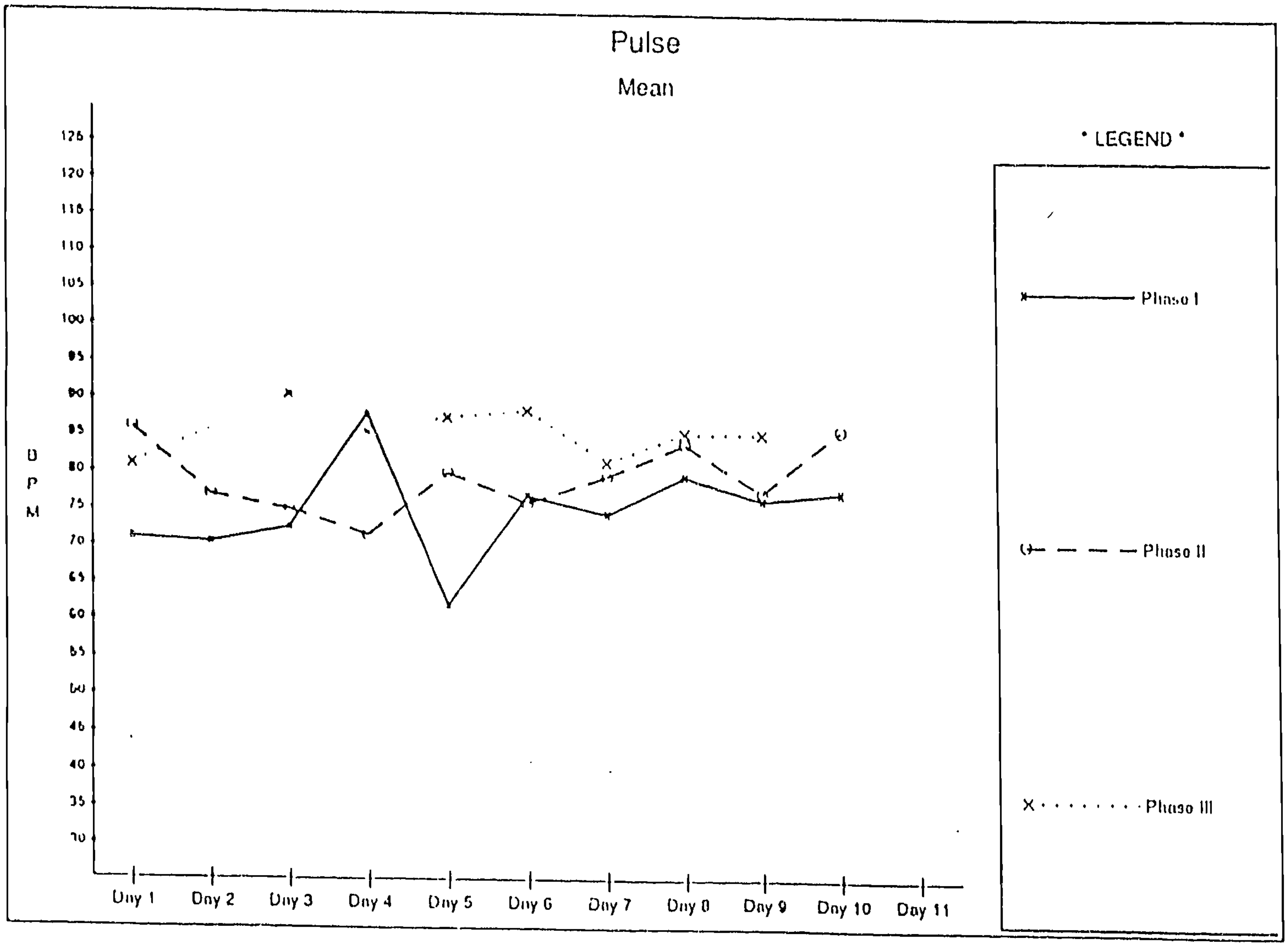




BEST COPY AVAILABLE

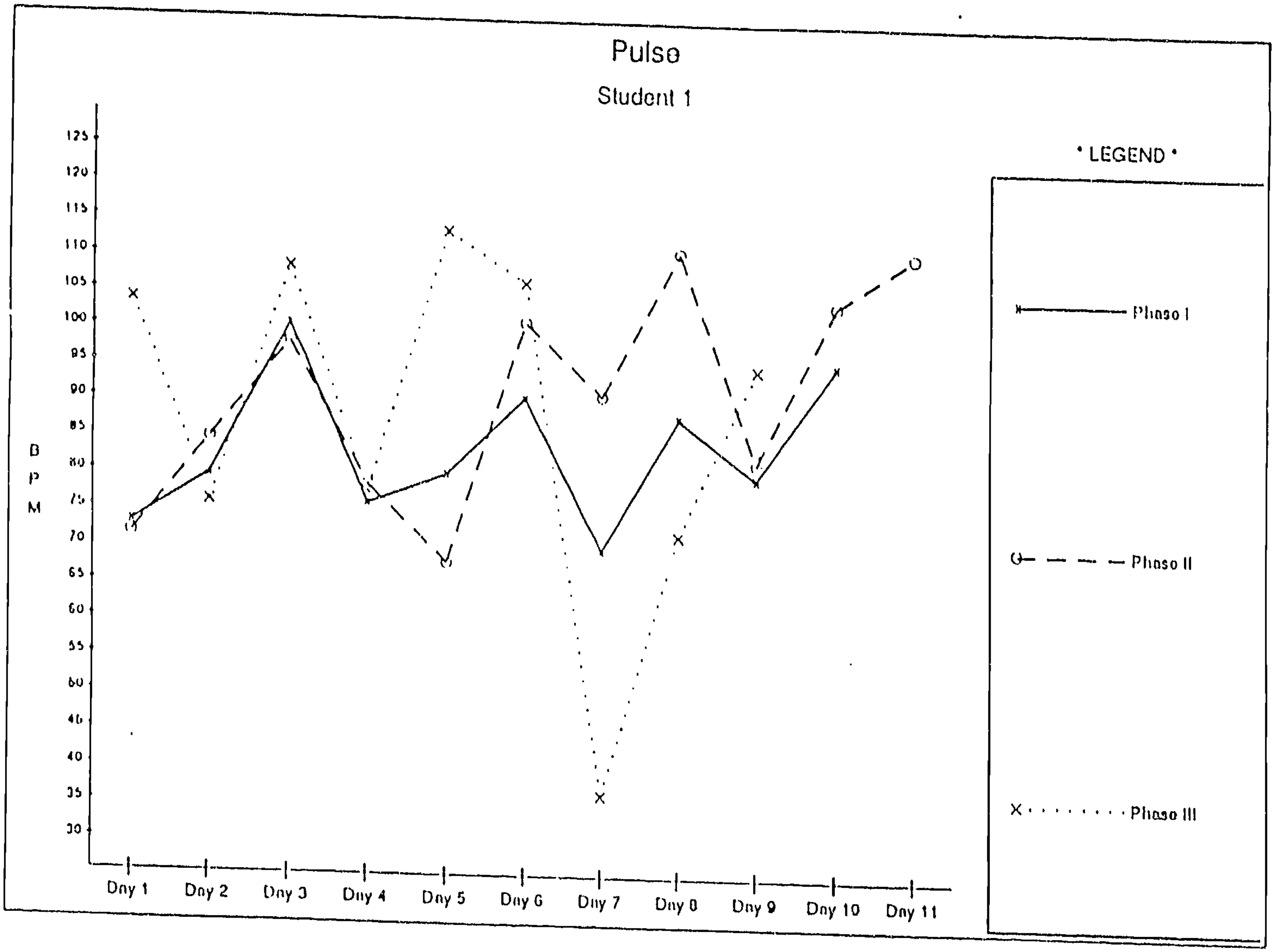


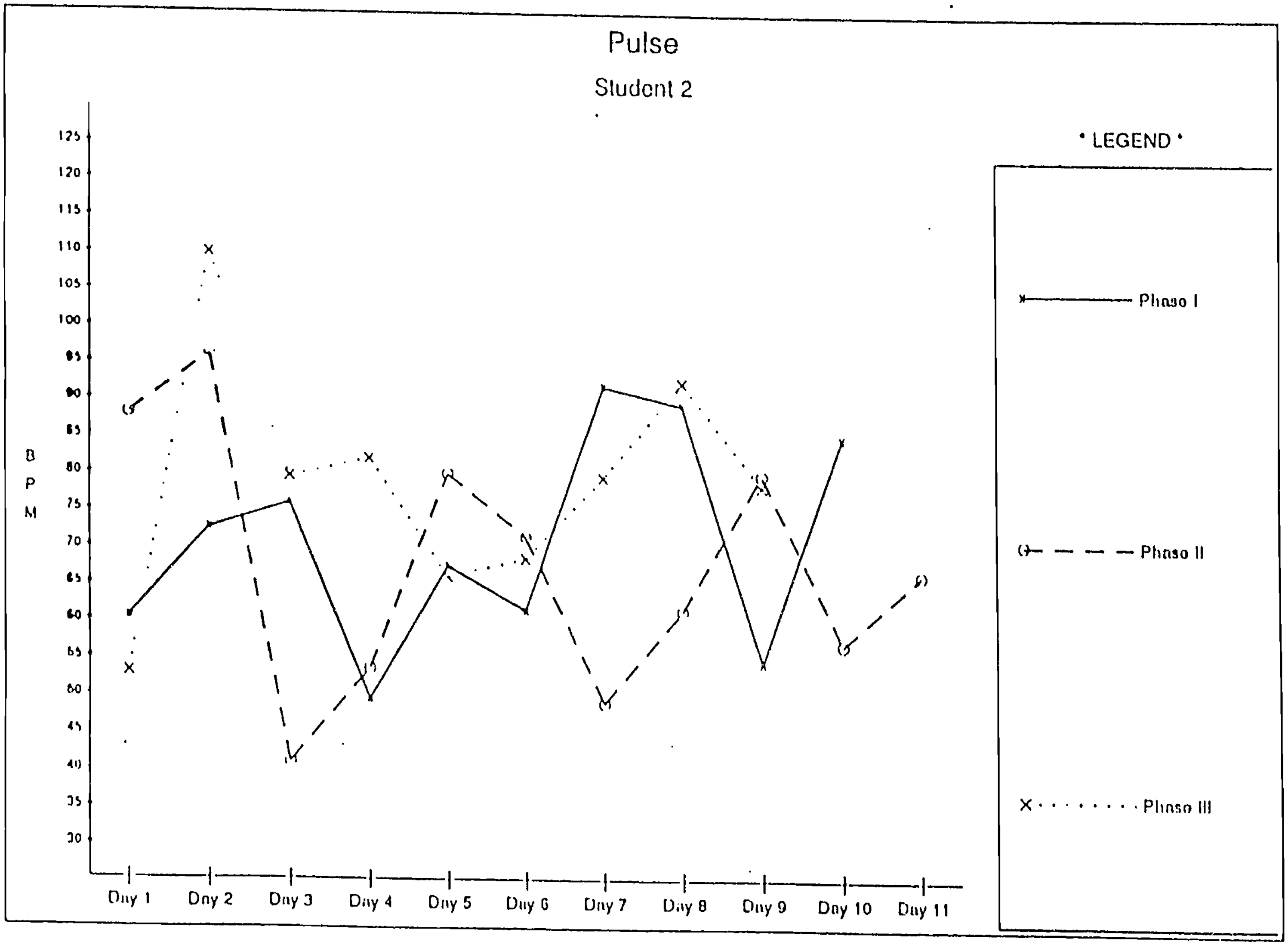
Systolic Blood Pressure
Student 11
155
150
145
140
135
130
125
120
115
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
Day 1
Day 2
Day 3
Day 4
Day 5
Day 6
Day 7
Day 8
Day 9
Day 10
Day 11
* LEGEND *
Phase I
Phase II
Phase III



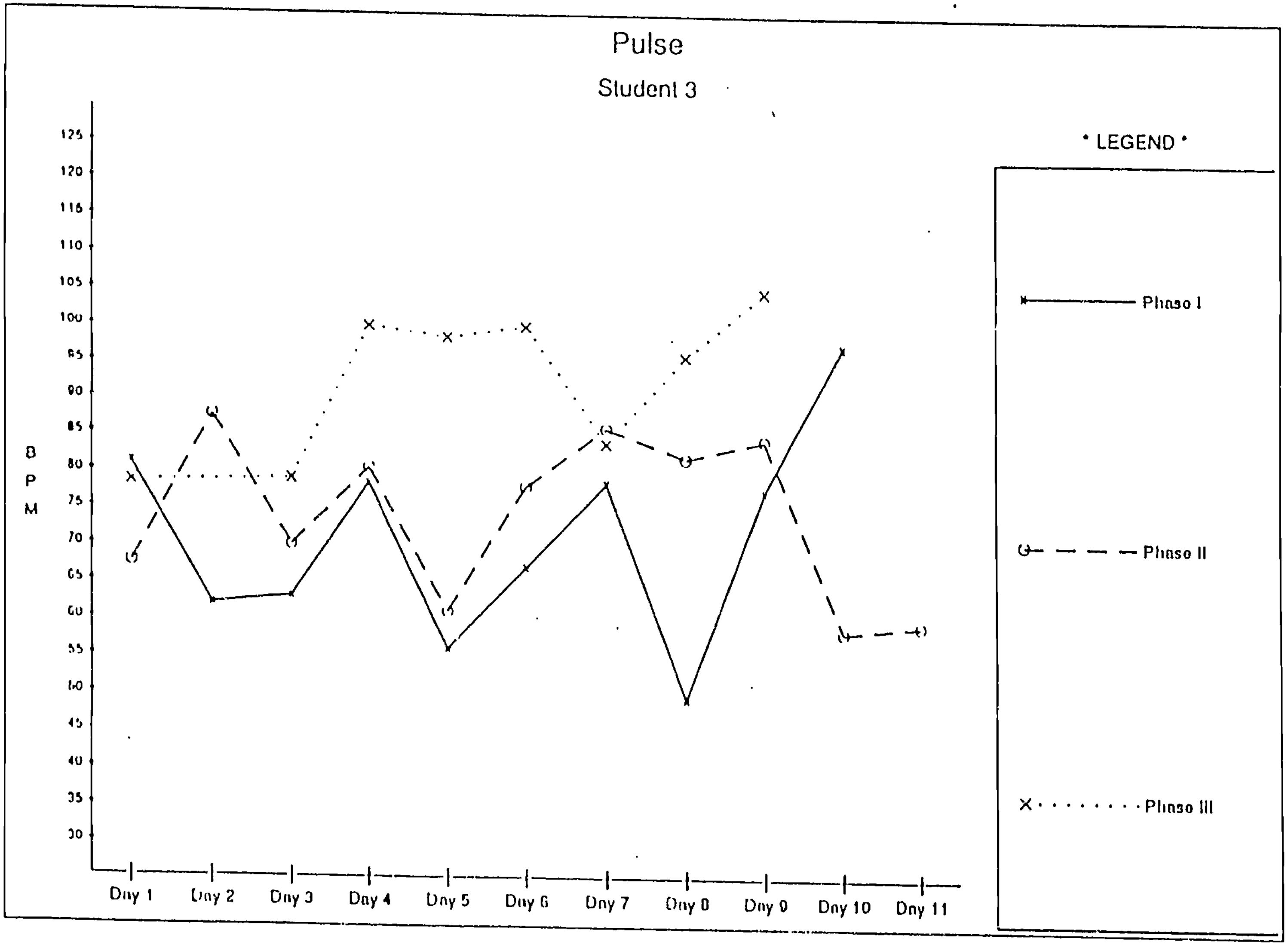
161

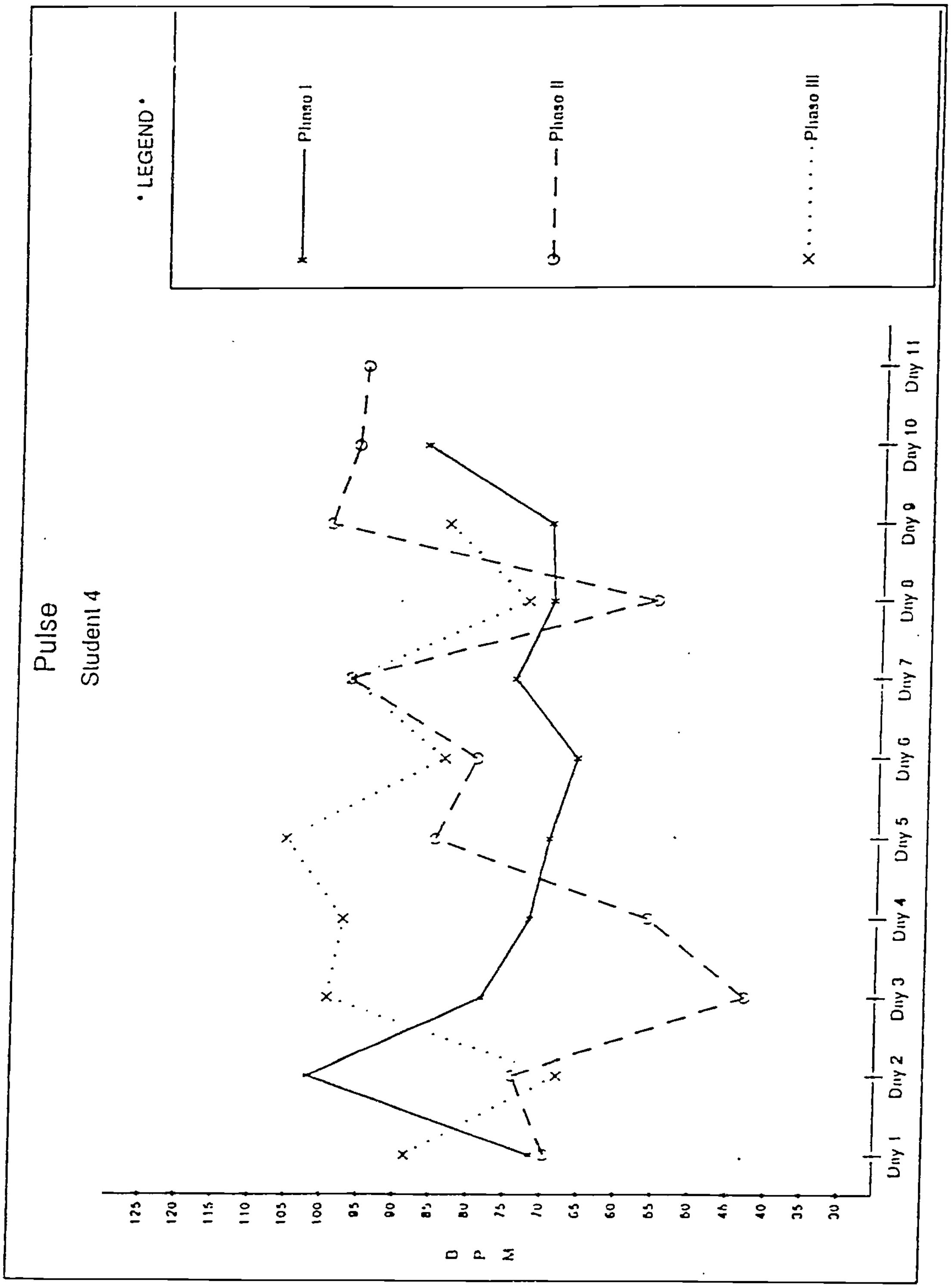
BEST COPY AVAILABLE

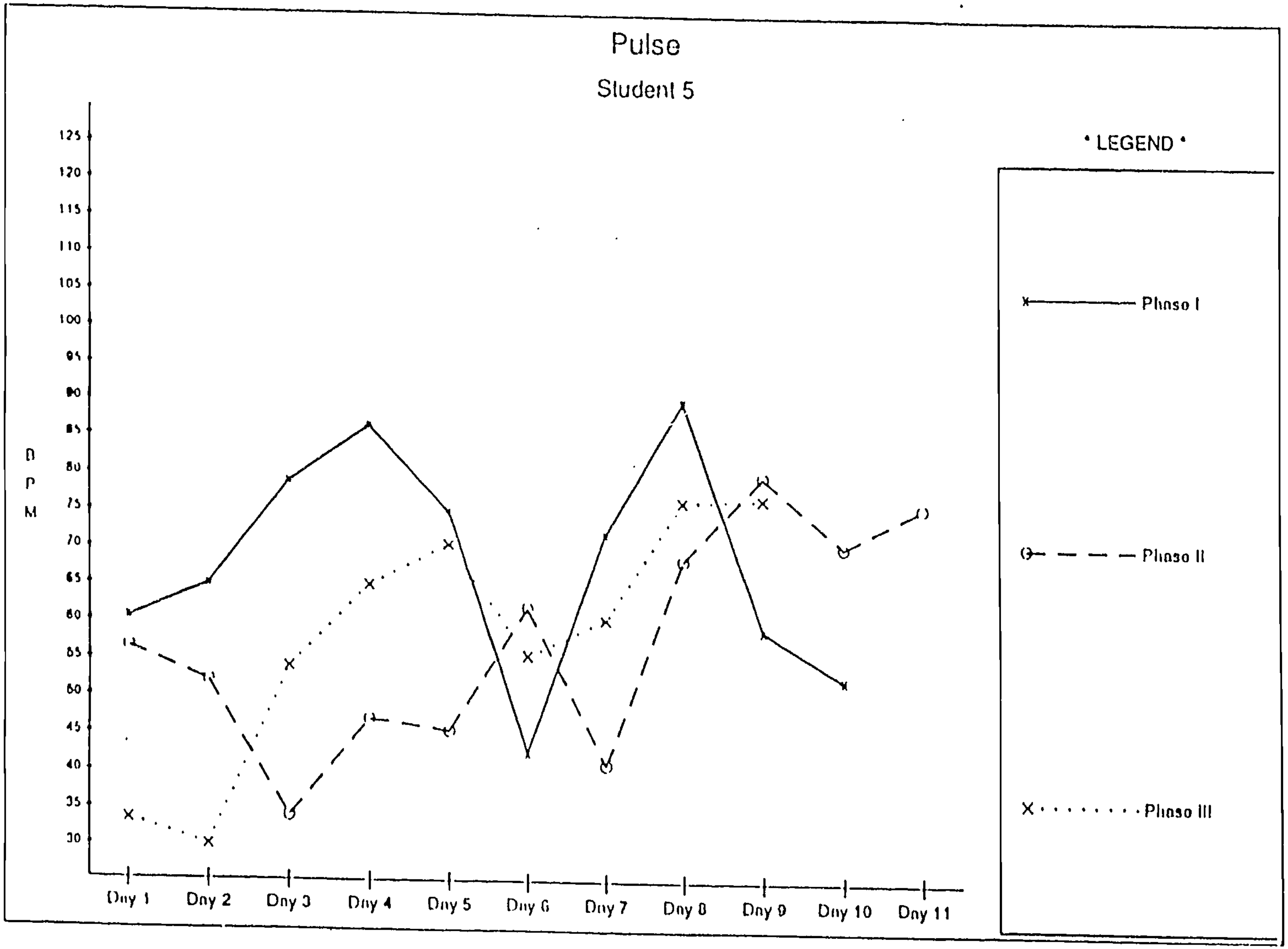

Pulse
Student 1
125
120
115
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
B
P
M
Day 1
Day 2
Day 3
Day 4
Day 5
Day 6
Day 7
Day 8
Day 9
Day 10
Day 11
• LEGEND •
Phase I
Phase II
Phase III

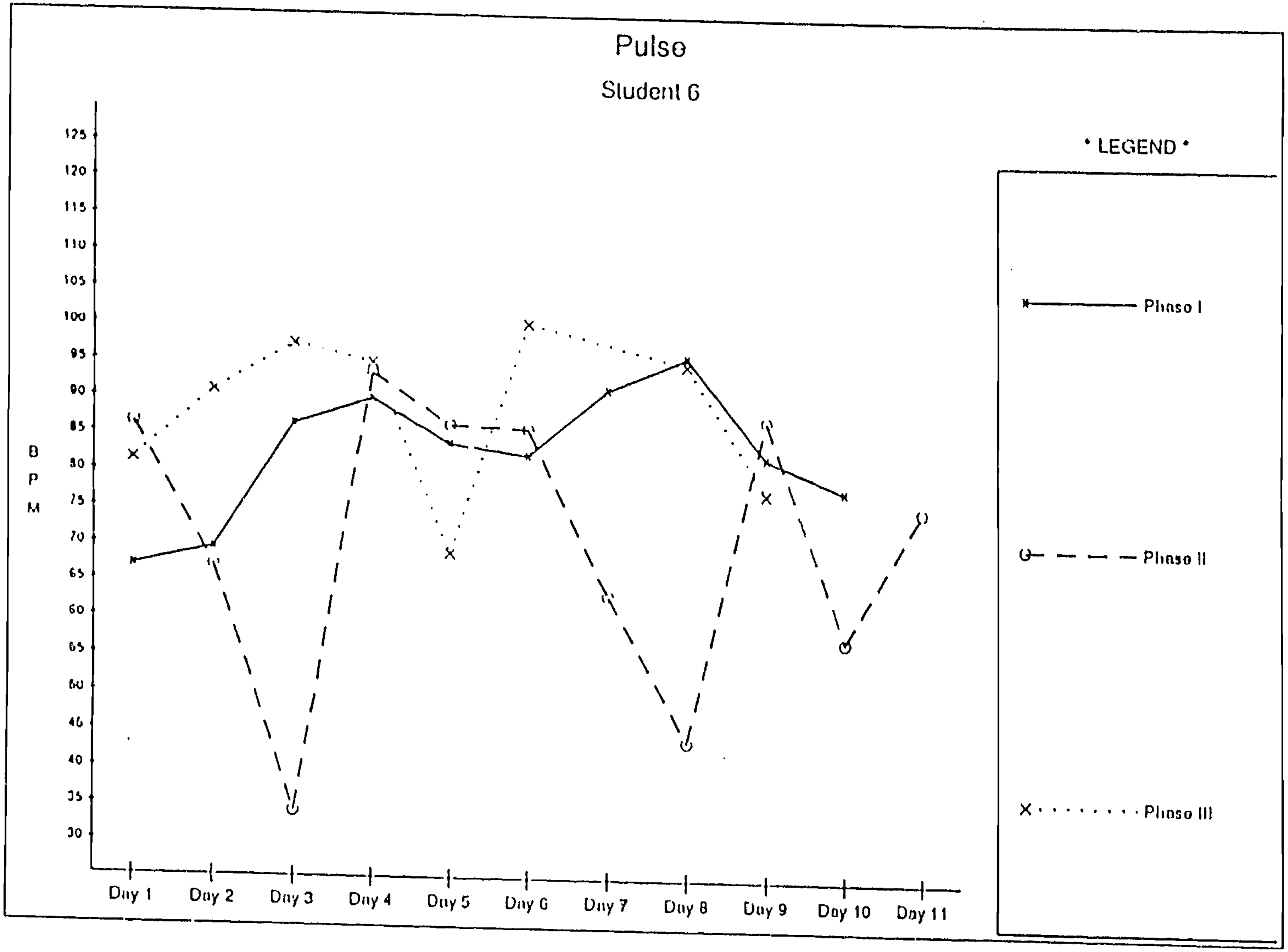


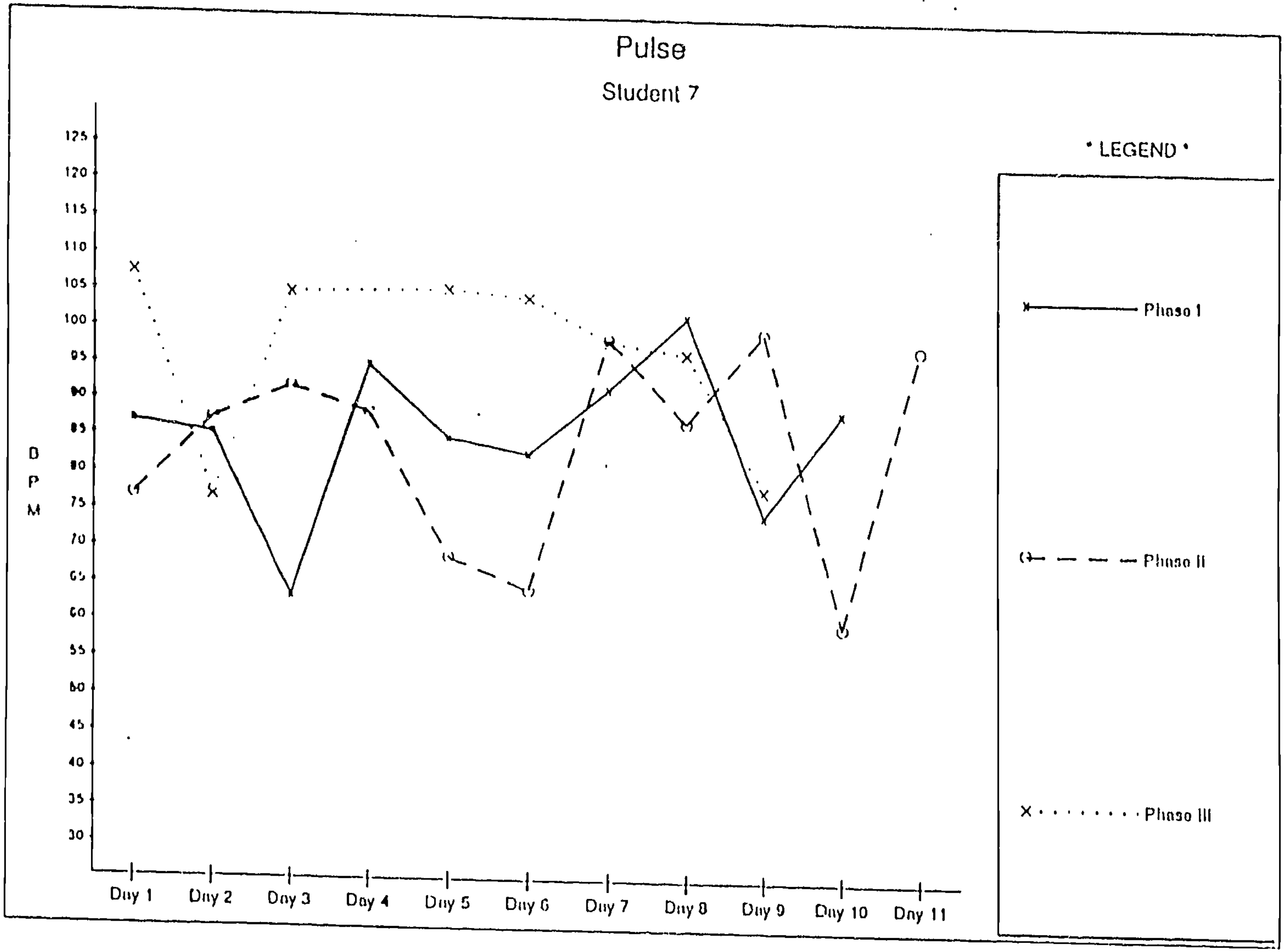
Pulse
Student 2
B P M
125
120
115
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
Day 1
Day 2
Day 3
Day 4
Day 5
Day 6
Day 7
Day 8
Day 9
Day 10
Day 11
• LEGEND •
Phase I
Phase II
Phase III


Pulse
Student 3
B P M
125
120
115
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
Day 1
Day 2
Day 3
Day 4
Day 5
Day 6
Day 7
Day 8
Day 9
Day 10
Day 11
• LEGEND •
Phase I
Phase II
Phase III


Pulse
Student 4
• LEGEND •
Phase I
Phase II
Phase III
B
P
M
125
120
115
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
Day 1
Day 2
Day 3
Day 4
Day 5
Day 6
Day 7
Day 8
Day 9
Day 10
Day 11

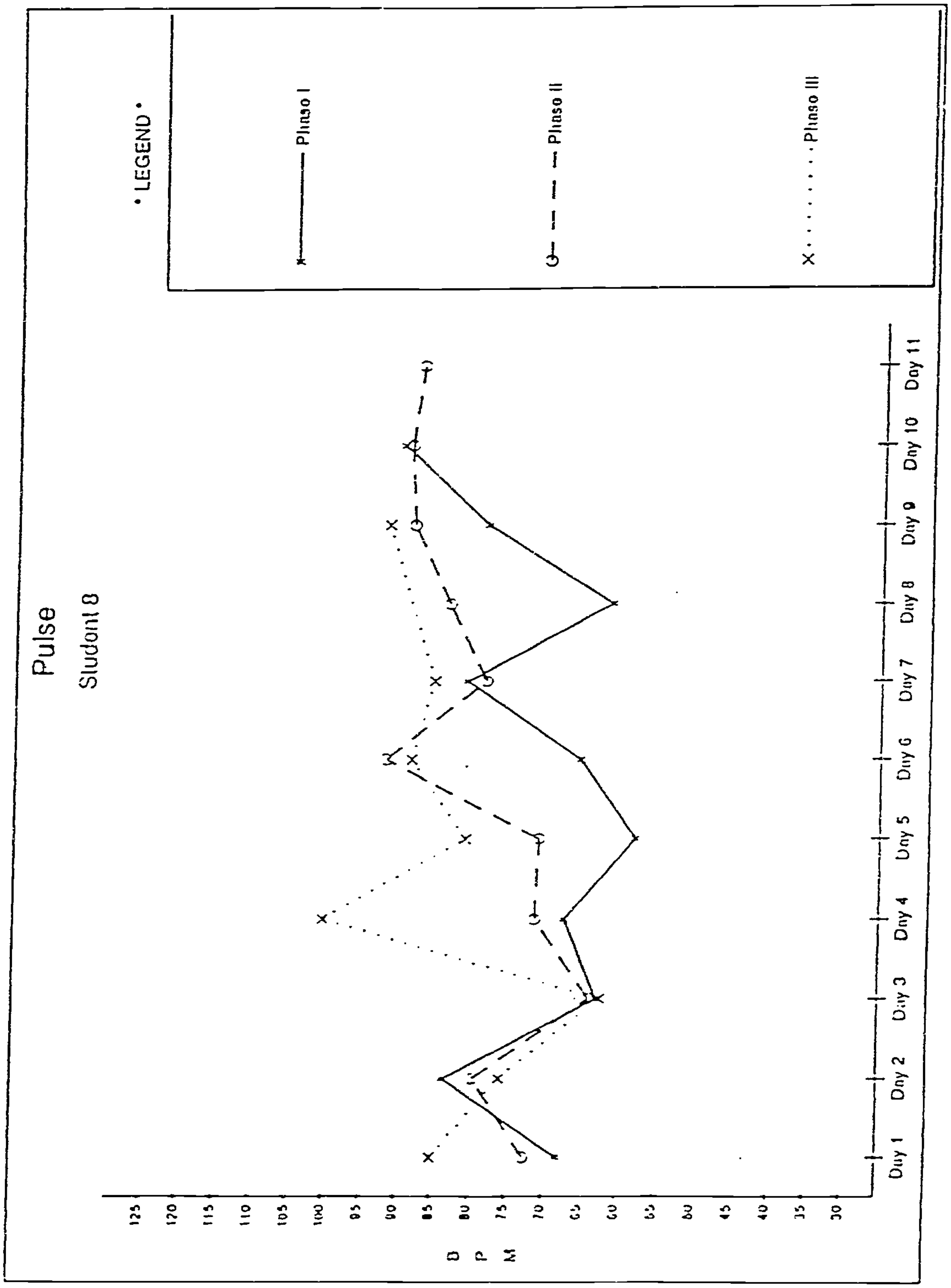

Pulse
Student 5
BPM
125
120
115
110
105
100
90
85
80
75
70
65
60
55
50
45
40
35
30
Day 1
Day 2
Day 3
Day 4
Day 5
Day 6
Day 7
Day 8
Day 9
Day 10
Day 11
• LEGEND •
Phase I
Phase II
Phase III

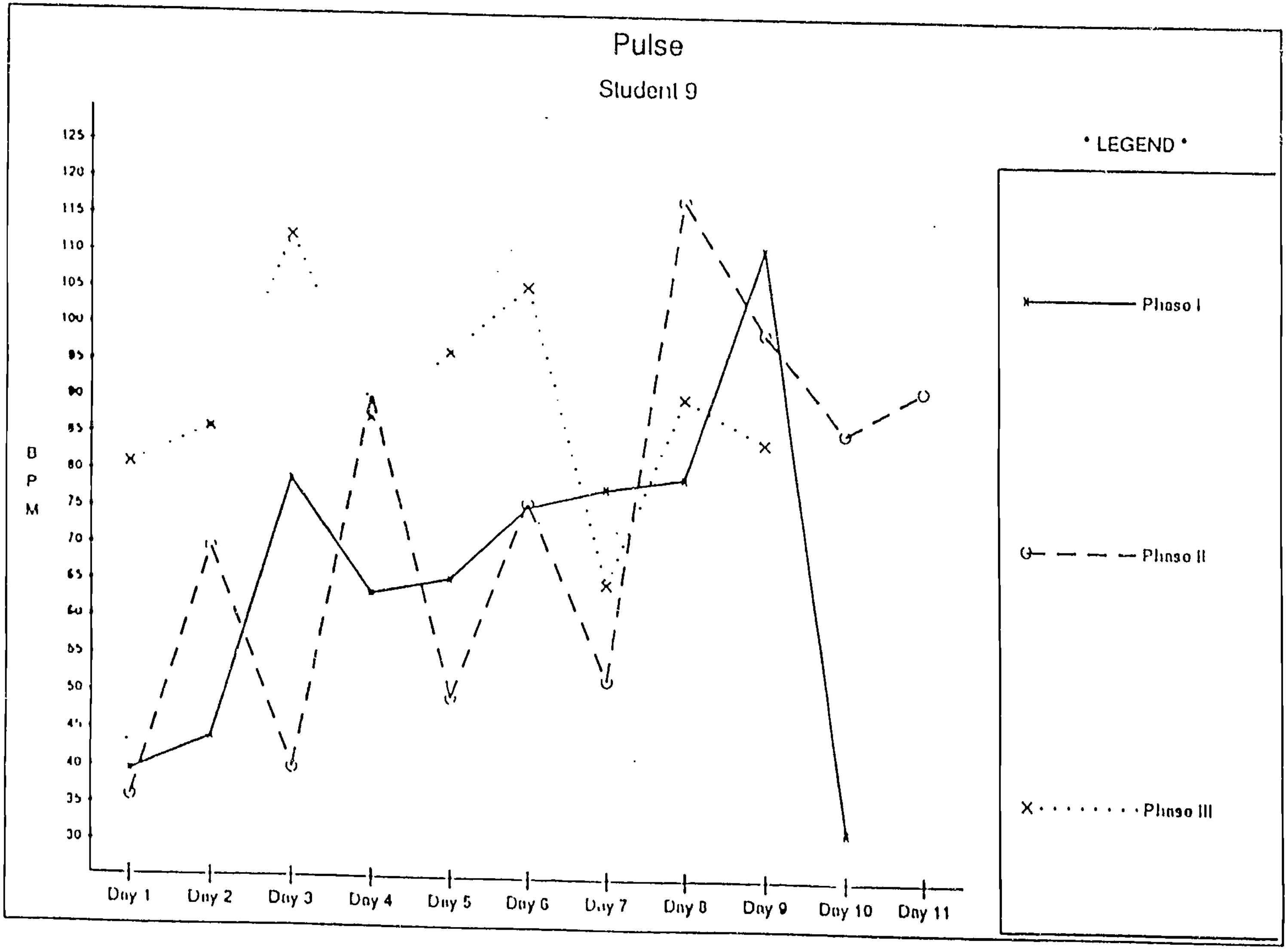

Pulse
Student 6
BPM
125
120
115
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
Day 1
Day 2
Day 3
Day 4
Day 5
Day 6
Day 7
Day 8
Day 9
Day 10
Day 11
• LEGEND •
Phase I
Phase II
Phase III

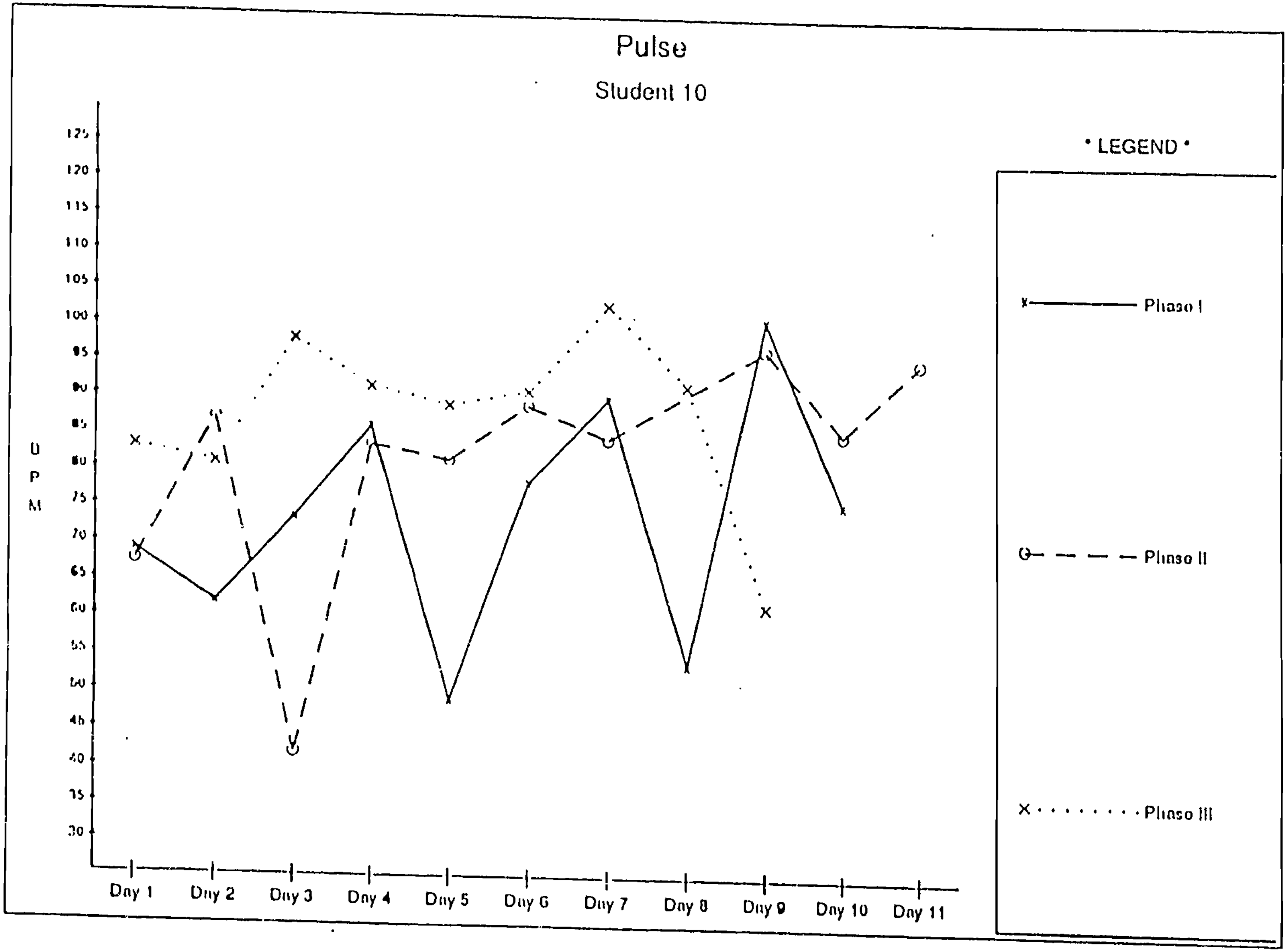

Pulse
Student 7
125
120
115
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
B
P
M
Day 1
Day 2
Day 3
Day 4
Day 5
Day 6
Day 7
Day 8
Day 9
Day 10
Day 11
* LEGEND *
Phase I
Phase II
Phase III

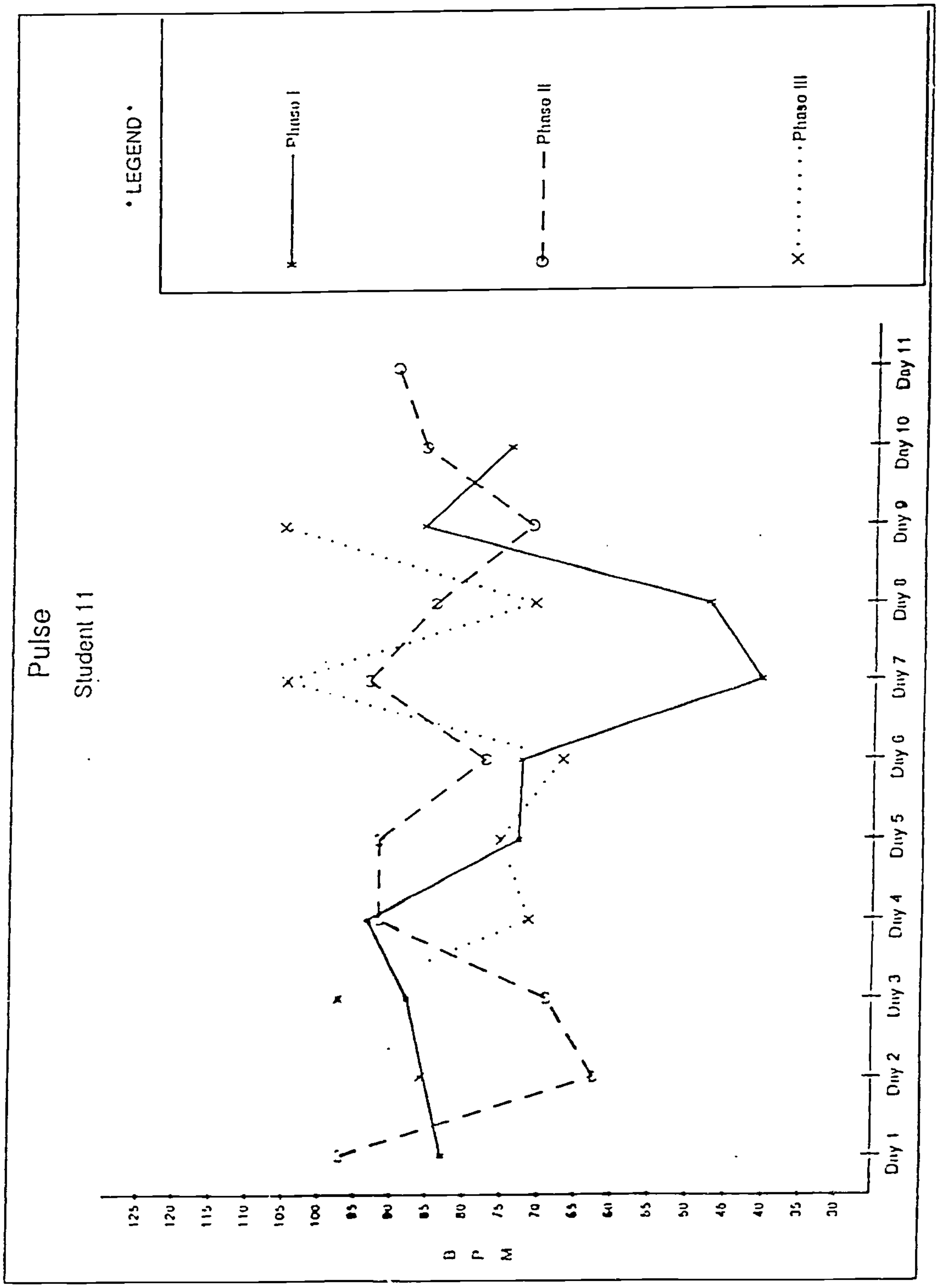
174

175


Pulse
Student 8
• LEGEND •
Phase I
Phase II
Phase III
B P M
125
120
115
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
Day 1
Day 2
Day 3
Day 4
Day 5
Day 6
Day 7
Day 8
Day 9
Day 10
Day 11


Pulse
Student 9
B
P
M
125
120
115
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
Day 1
Day 2
Day 3
Day 4
Day 5
Day 6
Day 7
Day 8
Day 9
Day 10
Day 11
• LEGEND •
Phase I
Phase II
Phase III


Pulse
Student 10
125
120
115
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
B
P
M
Day 1
Day 2
Day 3
Day 4
Day 5
Day 6
Day 7
Day 8
Day 9
Day 10
Day 11
• LEGEND •
Phase I
Phase II
Phase III


Pulse
Student 11
• LEGEND •
Phase I
Phase II
Phase III
B P M
125
120
115
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
Day 1
Day 2
Day 3
Day 4
Day 5
Day 6
Day 7
Day 8
Day 9
Day 10
Day 11