5-2011

International study program for indoor environmental research

Stoil Pamoukov
University of Nevada, Las Vegas

INTERNATIONAL STUDY PROGRAM FOR INDOOR ENVIRONMENTAL RESEARCH

by

Stoil Pamoukov

Bachelor of Science in Mechanical Engineering
University of Nevada, Las Vegas
2009

A thesis submitted in partial fulfillment of
the requirements for the

Master of Science in Mechanical Engineering
Department of Mechanical Engineering
Howard R. Hughes College of Engineering

Graduate College
University of Nevada, Las Vegas
May 2011

THE GRADUATE COLLEGE

We recommend the thesis prepared under our supervision by

Stoil Pamoukov

entitled

International Study Program for Indoor Environmental Research

be accepted in partial fulfillment of the requirements for the degree of

Master of Science in Mechanical Engineering
Department of Mechanical Engineering

Douglas Reynolds, Committee Chair

Brian Landsberger, Committee Member

Darrell Pepper, Committee Member

Gwen Marchand, Graduate Faculty Representative

Ronald Smith, Ph. D., Vice President for Research and Graduate Studies
and Dean of the Graduate College

May 2011

ABSTRACT

International Study Program for Indoor Environmental Research

by

Stoil Pamoukov

Dr. Douglas Reynolds, Examination Committee Chair
Professor of Mechanical Engineering
University of Nevada Las Vegas

This study examined the effect on student performance, perception and mood caused by different physical classroom environmental conditions. Three classroom physical environmental conditions were investigated; room temperature, light intensity and sound level. A two phase pilot study was performed where these conditions were compounded into one and two levels were selected in such a way to create a normal and extreme classroom physical environment. A total of 154 undergraduate UNLV students participated in the two phase pilot laboratory study in which they completed tasks related to reading and listening to an oral presentation of a passage of high density technical information. The test subjects' performance scores and survey responses to the classroom physical environmental conditions and their mood were compared between the normal and extreme classroom environments.

The Phase I study involved the test subjects reading the test passage. There was no significant difference in their responses to how their task performance and attention to the task were affected by the normal and extreme classroom environments. There was no statistical difference in the test scores between the group exposed to the normal classroom environment and the group exposed to the extreme classroom environment. In addition, there were also no reported differences in comfort levels and mood between the

two test groups. A root cause analysis identified several possible factors that could have contributed to these results. These included: insignificant difference in comfort levels between the two test groups, the university student test group was capable of filtering out the negative effects of the extreme test environment, low test instrument sensitivity, low statistical power, and the absence of a motivation factor to give the reading test passage a fair effort.

In the Phase II study the test subjects completed a task in which they viewed an oral presentation of the same test passage used in Phase I. For the oral presentation, significant differences were found to exist in the test subjects' test performance, comfort levels, irritability, and perception of how the environment affected their task performance and attention to the task. The test subjects in the Phase II study were more susceptible to the negative effects of the extreme classroom physical environmental condition.

The effect size which was identified in Phase II study was small and does not justify performing a full factorial laboratory study for investigating the effects of classroom temperature, lighting and sound on student learning performance. A root cause analysis identified the university student test group and the lack of the motivation factor as possible causes that could have influenced the effect size which was detected. A useful way to somewhat isolate the influence of each parameter on the output would be to replicate the Phase II pilot study three times in the extreme test condition while each time one of the parameters is set to its normal levels. Following this test, the next phase of the study would be to replicate the laboratory pilot study in actual K-12 classroom setting for both the reading and oral presentation of an appropriate age-level test passage.

ACKNOWLEDGEMENTS

I would like to thank my advisors and research team members, Dr. Reynolds, Dr. Marchand, and Dr. Landsberger for their support and assistance throughout this process. They provided me with the tools and guidance that were essential to successfully complete this study and this thesis.

I would like to thank my family and friends for their immense support and encouragement throughout my whole life. I am extremely fortunate to have always had their approval and blessing in everything I do. Without them, I would not be the person I am today.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

1.1 Introduction

The U.S. Department of Education and the General Accounting office reported that substandard physical environments related to thermal comfort, ventilation, acoustics, and lighting, exist in 43-58% of U.S. K-12 Schools [1]. Over 14 million students in the U.S. attend school in buildings with substandard indoor environmental (IEQ) conditions [1]. The objective of the International Study Program for InDoor Environmental Research (I-SPIDER) is to identify and quantify relationships that exist between classroom physical environmental conditions and student learning and perception of their classroom physical environment. Another objective of the program is to develop casual models that will yield predictable levels of improvement in student cognition and learning performance when the substandard conditions are improved.

The I-SPIDER initiative is multi-phase research program that will include both a laboratory study and a field study. Prior to performing the full laboratory study, which would involve a large number of factorial test runs for the different levels of the classroom parameters associated with room temperature, lighting intensity and sound level, a pilot study was performed. The main purpose of the pilot study was to determine whether or not the selected student learning performance measurement instruments and classroom physical parameter experimental protocols can be used to identify relationships between the classroom physical environment and student learning performance. A two phase pilot study was conducted in the spring and fall 2010 semesters in a controlled laboratory setting, located in the Center for Mechanical & Environmental Systems

Technology at UNLV. This thesis describes the two phase pilot study which was performed.

1.2 Goals and Objectives of the Pilot Study

- Determine weather or not engineering and learning performance measurment and assessment protocols can be used to identify relationships between measured classrrom physical environment parameters and student learning performance in a controlled laboratory setting,
- Determine weather a full or partial factorial laboratory study is justified based on the results of the pilot study,
- Determine the most optimal way to investigate the effect of classroom physical environment assiciated with thermal comfort, lighting intensity and sound levels on student learning performance in the following phases of the study, and
- Make recommendations for further studies.

1.3 Limitations of the Pilot Study

- The student learning performance study was conducted only in a controlled laboratory setting, and was limited to reading the test passage in Phase I and an oral presentation in Phase II.
- The classroom environment parameters that were investigated were limited to parameters associated with temperature, noise level, and lighting intensity. The extreme condition sound source was limited to noise associated with a room

ventilator fan. The extreme condition lighting source was limited to one type of fluorescent lighting.

- Since the three classroom physical environment parameters were compounded to create two classroom environmental conditions, it was not possible to extract individual parameter effects on student learning performance.
- The pilot study test group was limited to undergraduate student volunteers at UNLV. The intellectual make-up of the university student test group in the pilot study was reasonably homogeneous. The intellectual capabilities of the students were sufficient to be admitted to a university.
- No information was collected with regard the test subjects' grade point average and their previous knowledge of the topic of the test passage.
- The student learning performance measuring instrument and the environmental survey were specifically developed for this study and have not been validated by other studies.
- Maximum number of available students who could participate as test subjects was around 100 per semester.

CHAPTER 2

REVIEW OF RELATED LITERATURE

2.1 Background

In today's political and social world there are many discussions surrounding the U.S. educational system. Beginning in the early 1990's, this debate moved to the public forefront due to the growing perception that the U.S. K-12 school system was failing to adequately educate children. A child's potential for long term professional and social development is highly dependent on the quality of his/her K-12 educational experience. This potential can be reduced if the child is consistently attending schools with substandard classroom physical learning environments [2].

Under the Clinton Administration, the U.S. Department of Education, made the topic on the effects of classroom environmental conditions on student cognition and learning a center debate. The investigations that followed were primarily organized along two separate lines: (1) educational methodology and implementation (Interpersonal Factors) and (2) environmental factors within the classroom learning environment (Physical Factors). Most of the classroom studies have been defined along these two lines of investigations. While these studies have been developed from the same intellectual context and objectives, they are separated by a conceptual gap that results from difference in language and terminology, investigation protocols, types of data collected, how the data is analyzed, etc [2].

2.2 Overview of Current Conditions within K-12 Schools

Substandard indoor environmental quality (IEQ) conditions exist in many classrooms throughout the U.S. The U.S. General Accounting Office reported that 63% of students in the U.S. attended schools where at least one building component was in need of extensive repair, overhaul, replacement, or that contained environmentally substandard conditions. This fact equates to over 14 million students in the U.S. who are attending schools with substandard classroom IEQ conditions [1].

In 1999 a report by the National Center for Education Statistics on the condition of public school facilities collected information on satisfaction with six different environmental conditions: lighting, heating, ventilation, indoor air quality, acoustics or noise control, and physical security of buildings. "43% of the schools reported that at least one of the six environmental factors was in unsatisfactory condition and approximately two-thirds of those schools had more than one environmental condition in unsatisfactory condition" [3]. The U.S. Department of Education reported the following statistics in their surveys of 9,563 educational facilities and schools that substandard conditions were found related to: noise – 18-32%, ventilation – 26-32%, heating – 23%, indoor air quality – 22%, lighting – 20%. The estimated cost for correcting the reported IEQ conditions is $117-127 billion [3]. A report by the national center for energy management and building technologies concludes that: (1) U.S. schools are relatively old with median age of 35.5 years; (2) higher then recommended occupant density; (3) tight budgets have resulted in poor maintenance, high ambient noise levels, poor lighting conditions, high concentration of pollutants, and low indoor comfort; and (4) new technologies that are common to commercial buildings have not been adopted by or used in most schools [4].

Substandard conditions can diminish the quality of the child's educational experience and impair the development of the memory within the brain, especially among younger children. Unfavorable conditions may also affect the performance of the teacher in teaching students. Eventually attending schools with substandard environmental conditions may negatively affect the child's potential for long term professional and social development [2].

A key obstacle for schools to improve their facilities is the substantial cost [1]. The tight budgets result in delayed or poor maintenance, classrooms often have low indoor comfort performance, high ambient and intermittent noise levels, poor lighting conditions, and high concentration of pollutants [5]. Therefore, the schools have to prioritize which problem areas to focus on. For this reason research and data is needed that indicates which renovations would result in the highest improvement in students comfort and learning performance.

2.3 Review of Previous Studies

There are many published articles that document the affects of classroom environmental conditions on student performance and comfort levels. Many environmental conditions have been investigated such as thermal comfort, relative humidity, ventilation, lighting, noise, and others. Studies indicate that changes in classroom temperature affect student cognitive performance [6,7,8,9,10]. Classroom lighting effects on student performance studies show that appropriately designed classroom lighting reduces distraction and results in an increase in student test scores [11,12,13,14]. Teachers believe high classroom background noise levels impair academic performance [15], and reading and language based memory is particularly vulnerable to noise exposure in children [16,17]. According to the U.S. Architectural and Transportation Barriers Compliance Board, "High levels of background noise, much of it from heating and cooling systems, adversely affect learning environments, particularly for young children, who require optimal conditions for hearing and comprehension." Poor acoustics are also a particular barrier for children with hearing loss [18].

Previous studies of the learning environment have been also mostly been concerned with either teaching methodologies and techniques or strictly the physical factors of the environment. The problem with those studies along these general lines has been the difference in language and terminology, investigation protocols, types of data collected, how these data are processed etc [2]. Many of the differences arise from fact the many studies are conducted by a team with a background from the same discipline, such as education, engineering, architecture etc. These reasons have been a major weakness that has resulted in many overarching conclusions and sometimes even anecdotal studies.

Many of the studies also base their findings mostly on responses to surveys by the teachers and the students. Such information is necessary to get an idea of the students' and teachers' perception of how the environment affects their performance; however, it is insufficient to show any relationships between classroom physical environments and student learning performance. The studies that were able to detect an effect of the environment on student cognition and learning do not present models that describe how improvements in classroom conditions will result in quantitatively predictable improvements in student cognition, learning performance, self reported affect, and attendance [2].

Multi-parameter controlled laboratory studies which considers the effects of classroom environmental conditions associated with thermal comfort, sound and lighting on student learning performance, has not been previously completed or published. Staffan Hygge states in his study “Not many well-controlled studies on noise and learning have been reported [17]. A critical review article of the literature concludes that little, strongly designed research between indoor pollutants, thermal conditions and human performance and attendance is available [19]. Major literature reviews by Daisey and Angell [20], Daisey, Angell, and Apte [21], and Mendell and Heath at the Lawrence Berkley National Laboratories [19] support this observation. The National Research Council, in its report, “Green Schools- Attributes for Health and Learning”, concluded that nearly all classroom built environment design guidelines are based on anecdotal information [22].

Casual models, which currently do not exist, that yield quantitative predictable levels of improvements in mood and learning performance when classroom learning environments are improved are required. Such information is imperative for optimally allocating limited budgeted resources that will result in most improvements in student comfort and performance.

There is a big justification and demand for classroom environmental effect information since over 14 million K-12 students attend schools in the US with substandard classroom physical learning environments. The I-SPIDER team is composed of Ph.D. level members from the Colleges of Education and Engineering within UNLV. The whole study initiative is determined to close the conceptual gap between most previously conducted studies by developing casual models that yield quantitative predictable levels of improvements in student cognition and learning performance when classroom physical learning environments are improved. The pilot study was an essential part of this process. It was used to determine the direction of the study as well as to figure out the most optimal method and testing instruments for the following phases of the study.

2.4 Cognition and Learning Cause and Effect Models

Working and long-term memory are involved in the intake, processing, storing and retrieval of information. Initially new information is processed in the working memory and it is eventually transferred to and stored in the long-term memory. The working memory has limited capacity. Therefore, if the working memory is preoccupied in processing external noises and perceived negative changes in the environmental conditions (thermal comfort, sound, lighting, etc.), fewer working memory resources will be available to focus on the learning process [2]. In contrast to working memory, long term memory is thought to have unlimited capacity. Figure 2.1 outlines how new information is stored in the memory.

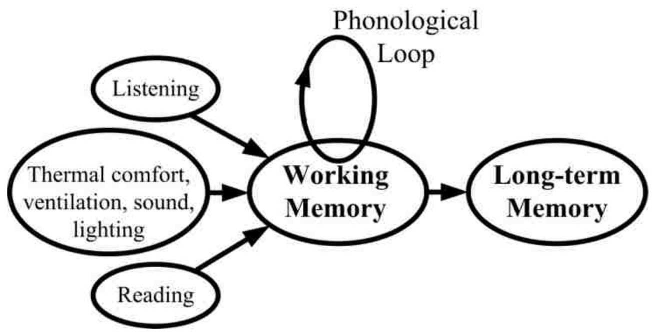


Figure 2.1 Memory model [23]

Listening to speech or reading a text is initially processed in the working memory. Comprehending the material from a new speech or reading a new text is a complex process which involves information that has been recently processed as well as information that has been previously stored in the working memory. Processing such information in substandard environmental conditions places a burden on the working memory and possibly impairs to ability to transfer the new information from working to long term memory [23,24]. The degree to which substandard environmental conditions affect each type of learning task is different. During this study the physical environmental effects are going to be investigated for reading new materials and listening to new materials.

2.5 Learning Styles

There are three basic types of learning styles: visual, auditory and kinesthetic. Most people learn through a combination of the three. However, most people usually have a clear preference or strength at one of the learning styles [2]. Students with different learning styles may react differently to the physical environmental conditions in a classroom.

Auditory learners would rather listen to the new information. These people typically learn by listening, enjoy dialogues and recite information out loud. Auditory learners generally remember names better than faces. They are easily distracted by noise in the study environment and often must work in relatively quiet environment.

Visual learners learn best by observing visual demonstrations. They prefer reading problems, looking at graphics and using notes and lists to organize their thoughts. They may have difficulty focusing while listening to information. Visual learners typically remember faces better than names. They are also more distracted by movements rather than noise.

Kinesthetic learners best learn by "doing" or "hands on" experience. They undertake new task and solve problems through physical activities that involve trial and error exploration. Kinesthetic learners typically have higher levels of energy and sitting still while learning information could be difficult for them. They are mostly distracted by activities within their immediate area.

2.6 Acute Versus Chronic Exposure

When investigating the effects of classroom physical environment on student learning performance, a distinction should be made between acute and chronic exposure. Both types of exposure to noise have an effect on the working memory. For example, impairment of the working memory occurred when students were tested in noisy versus less noisy environment [16,17]. Children who were chronically exposed to aircraft noise also had impaired recall memory of a text compared to students without the noise [17]. It is not known whether this impairment of the working memory was due to the same or different processes. A hypothesis of these processes is that: acute noise temporarily affects the working memory; however, after a period of silent time, a full recovery of the memory capacity is achieved. If the recovery time, however, is not sufficiently long, the working memory will still operate on less than an optimal level. It is not known whether this hypothesis related to noise exposure is valid for thermal comfort and lighting.

It is reasonable to also expect a certain recovery time when classroom conditions related to thermal comfort and lighting are improved. If, for example, the HVAC system is repaired to provide from bad to good indoor air quality, it is not reasonable to expect the students learning performance to step increase on the next day. The progression toward improvement will be most likely gradual. However, it is not known how long it will take. In a Munich airport study, it took 6-18 months after the noise had been removed for the students' working memory to be considered optimally working [17]. Studies are needed to document the recovery times after chronic exposures to substandard classroom environmental conditions.

CHAPTER 3

METHODOLOGY

3.1 Design of Experiment

The scope, inputs and outputs of the pilot study are defined in this chapter. Prior to performing the experiment the testing protocol was carefully and thoroughly planned and the main external noise factors that can influence the results were identified and minimized. This was completed by using some of the design of experiment tools that are shown below.

3.1.1 Energy Transformation Diagram

An energy transformation diagram (ETD) is a method for visualizing essential dynamics of the system under study. The energy transformation diagram considers certain inputs of a process and relates those inputs to desired outputs. The system parameters are specified by the research team and different levels of the system parameters are investigated to determine how they influence the outputs. The diagram also considers non-controllable outside influences which are referred to as noise factors [25]. The general layout of the diagram is presented in Figure 3.1. The following paragraphs and figures explain how this method was applied to the design of experiment for this pilot study.

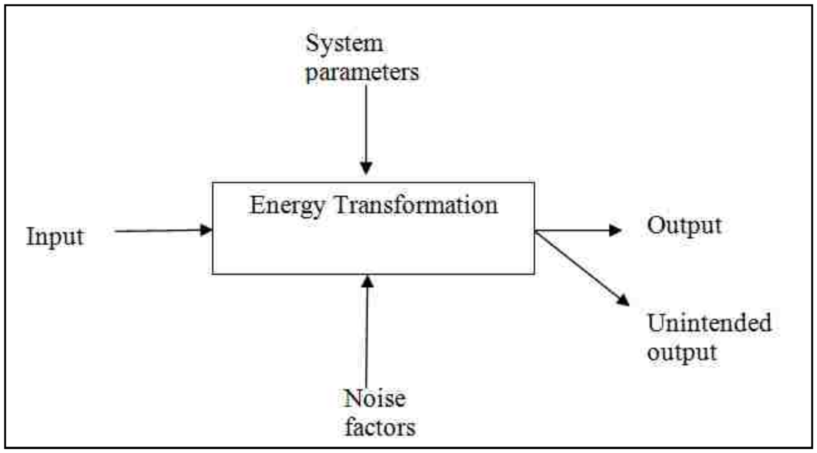


Figure 3.1 General layout of the ETD

Learning is a complex process. Therefore, for simplification and better understanding, two energy transformation diagrams similar to the one shown above were used. The first part, shown in Figure 3.2 deals with the process in which the information presented by the teacher is being heard and seen by the students. This is an essential part of the learning process. The students will have difficulty learning if they have trouble hearing or seeing the material presented. Therefore, for this first energy transformation diagram, the inputs are the lecture materials presented, and the outputs are the students' ability to hear and see the lecture.

There are many reasons for the information not to properly reach the students. The energy transformation diagram separates them into two categories; system parameters and noise factors. The system parameters include but are not limited to variables such as lighting, noise, size of the classroom etc. The noise factors deal more with individual differences that are more difficult or impossible to account for, such as teacher performance, the students' hearing or seeing abilities etc. The noise and lighting affects in this case are at such levels that impair the hearing or seeing ability of the students. This study investigates these factors; however, they are at lower levels, in order to determine their impact on attention and working memory. That is part of the second part of the learning process, which is shown in Figure 3.3.

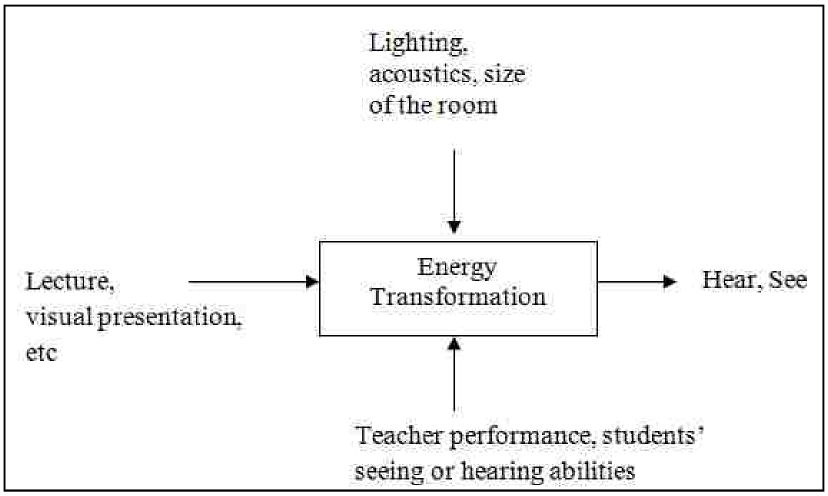


Figure 3.2 First part of the learning process described in terms of the ETD

After the students have been presented with the new information and they were able to clearly see and hear it, then they are able to commit the material to memory. Thus, the outputs of Figure 3.2 become the inputs to Figure 3.3. The output of Figure 3.3 can be considered to be how much of the lecture material is committed to memory. Many parameters can be investigated, such as temperature, acoustics, ventilation, and lighting that can possibly affect this output. There are external noise factors that can also influence the output, some of which include student mood, motivation, intelligence etc. This diagram is shown in Figure 3.3.

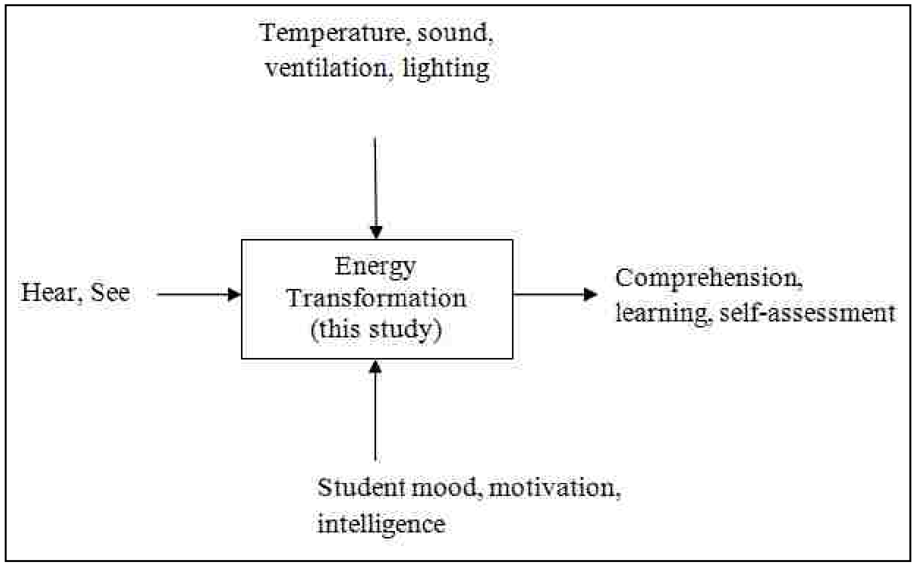


Figure 3.3 Second part of the learning process described in terms of the ETD

The system parameters in this study were not set at levels where they would obstruct the students' ability to hear and see the study material. Therefore, for this study the first energy transformation can be skipped and the experiment can be represented by the second energy transformation diagram. The different components of the diagram as they relate to the pilot study are described individually below.

3.1.2 Output

The outputs of interest in the pilot study were the test subjects' performance on the reading test and the survey responses. Sentence verification technique (SVT) [26] was the instrument that was used to measure the participants' recollection of the reading passage and the video lecture. The SVT scores were analyzed to identify the impact of the test room physical environment on the test subjects' learning performance for the given task.

Demographics survey, environmental survey, test anxiety survey [27] and positive affect and negative affect (PANAS) survey [28] were administered in this pilot study. The survey responses were used to determine:

- if the test subjects had similar test anxiety levels and demographics between the test groups associated with the normal and extreme classroom physical environmental conditions,
- how the test subjects associated with the two classroom physical environmental conditions viewed their classroom environment, and
- how the two classroom physical environmental conditions affected the mood of the test subjects.

The instruments that were used to measure the outputs are described in the Instrumentation and Data Collection section, and they are also included in the appendix. The results and analysis of the outputs are described in Chapter 4.

3.1.3 Parameter Selection and Levels

The system parameters of the energy transformation diagram are the physical environment conditions that were varied in order to determine their affect on the output. The parameters that were investigated in this study are shown in Table 3.1.

Table 3.1 System Parameters

Parameters
1. lighting intensity levels
2. sound levels
3. temperature level

In the pilot study, the three parameters were compounded together, and the test subjects were exposed to two different levels. The parameter levels were selected to create a normal and an extreme physical environment condition. The levels in the normal condition were the standards' recommended levels related to thermal comfort, lighting intensity and sound level for optimal comfort in a classroom [29,30,31]. The levels in the extreme condition were selected to be slightly outside of the comfort zone for the three parameters. The parameter levels used in Phase I are show in Table 3.2.

Table 3.2 Parameter Levels in the Phase I Tests

	Parameters		
Condition	Temperature	Sound Level	Lighting Intensity Level
Normal	72 deg F	35 dBA	500 lux
Extreme	80 deg F	65 dBA	2500 lux

For the Phase II tests the volume of the oral presentation was set at 70 dBA for both test conditions. A suround sound system was used to provide even distribution of the sound level across the test room. In order for the speech to be intelligible in the extreme condition, the test room sound level was decreased to 60 dBA. With a 10 dBA signal-to-noise ratio between the lecture and test room sound levles, there was no problem for the test subjects to clearly hear the lecture. The rest of the parameters were kept at levels shown in Table 3.2. The parameter levels that were used in Phase II are show in Table 3.3.

Table 3.3 Parameter Levels in the Phase II Tests

	Parameters			Oral Presentation Sound Level
Condition	Temperature	Sound Level	Lighting Intensity Level	
Normal	72 deg F	35 dBA	500 lux	70 dBA
Extreme	80 deg F	60 dBA	2500 lux	

3.1.4 Noise Factors

Similar to all experiments, noises were present in the I-SPIDER study. These were external variables that the research team had little or no control over. To account for the noises, a researcher usually tests under different noise conditions or tries to minimize them as much as possible. In the I-SPIDER study, the main noises, which were reduced, dealt with the classroom physical environmental conditions and the individual differences of the test subjects.

The noises associated with the classroom physical environment were associated with creating, and maintaining the uniformity of the parameter levels in the test room during each experimental session. Non-uniform physical environment, and not being able to accurately monitor and control the environmental test parameters were noises that were greatly reduced in the test laboratory. The laboratory where the pilot study was conducted is capable of accurately controlling, monitoring, and recording the physical environmental test parameters.

The lights, speakers and diffusers were placed in the test room to create a uniform physical environment at each test subject station. A few different design options were considered before making the final selection. The levels of the parameters were measured at each station before conducting the study with the appropriate measuring instruments. They were again verified right before each test session to ensure that the parameters were at their specified levels that there was uniformity of the levels among each station.

The test laboratory's state-of-the art instrumentation and controls have the capability to accurately monitor and control the test room physical environment. During each test session, there was always a research team member present in the laboratory test room to monitor the test subjects, and there was a team member in the control room to verify and ensure that the test parameters were kept at their intended levels. Detailed description of the laboratory is given in the Laboratory Set Up section.

The experimental noise referred to as individual differences between the test subjects dealt with factors, such as students' intelligence, background knowledge on the test passage topic, and motivation. Two different subject pools were used that created a more diverse sample. To ensure that the affect of their individual differences was accounted for and minimized, random assigning to one of the two physical environmental conditions was used. After the study, based on the responses to the demographic questions and the test anxiety survey, it was verified that the two groups were evenly divided. This process and the exact demographics of the two groups are described in the Test Subjects section.

3.2 Data Collection Instruments

The test instruments in the pilot study were completed on laptop computers. Computer software was developed by Academic Technologies Inc specifically for this study. The software consisted of the test instruments described below. A router connected the computers to a secure server located in the Center for Mechanical & Environmental Systems Technology at UNLV. The software program was loaded onto the server. That server was set up to only allow access to the testing software; there was no internet access. The system was tracking and recording the responses of each participant according to their unique identification number.

The software was easy to use and it guided the test subjects from one section to the next. They had to enter their assigned unique identification number to begin the test. The test subjects were aware that their personal information will not be linked to their score and responses. They completed a general demographic questions followed by test instructions and in order to proceed the test subjects had to click that they understood the test instructions. A practice passage was then given on a different topic than the test passage. The practice passage was aimed at exposing the test subjects to how the reading will be presented, how to navigate from one passage to the next and also become familiar with the interface of the software.

The practice passage was followed by the test reading passage, the reading test, and three surveys. The test subjects completed a test anxiety survey, an environmental survey, and a positive and negative effect survey. The surveys were investigating different information that included the test subjects' anxiety levels during exams, current feelings and emotions, environment perception and reasons that could have affected their performance on the given task. The study instruments are described individually below and shown in the order at which they were presented by the testing software. The testing instruments are also included in the appendix.

The Phase II study utilized the same instruments with the only difference that the reading test passage was presented in the form of a video lecture. For the purpose the testing software was modified by removing both practice and reading test passages. The video lecture was shown at the beginning of the experiment and then the test subjects completed the rest of the study on the laptop computers. On the laptop computers, the test subjects were presented with the same demographics questions, SVT test, and surveys. The test subjects were instructed to not start the testing software until the video lecture was finished. Figure 3.4 presents the initial screen of the testing software in both Phase I and II.

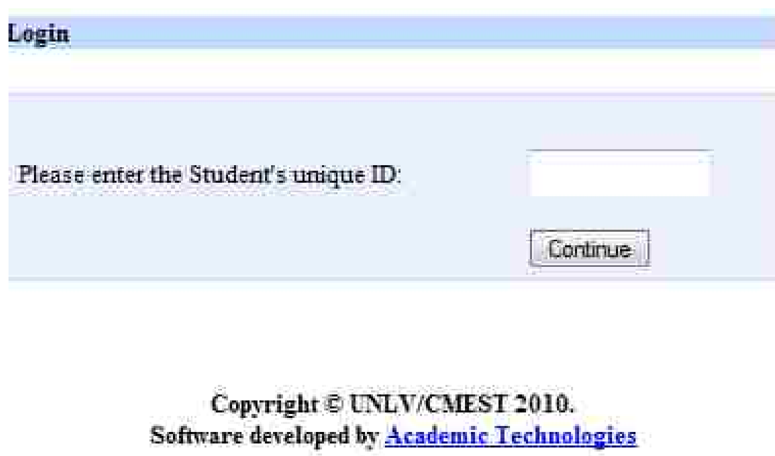
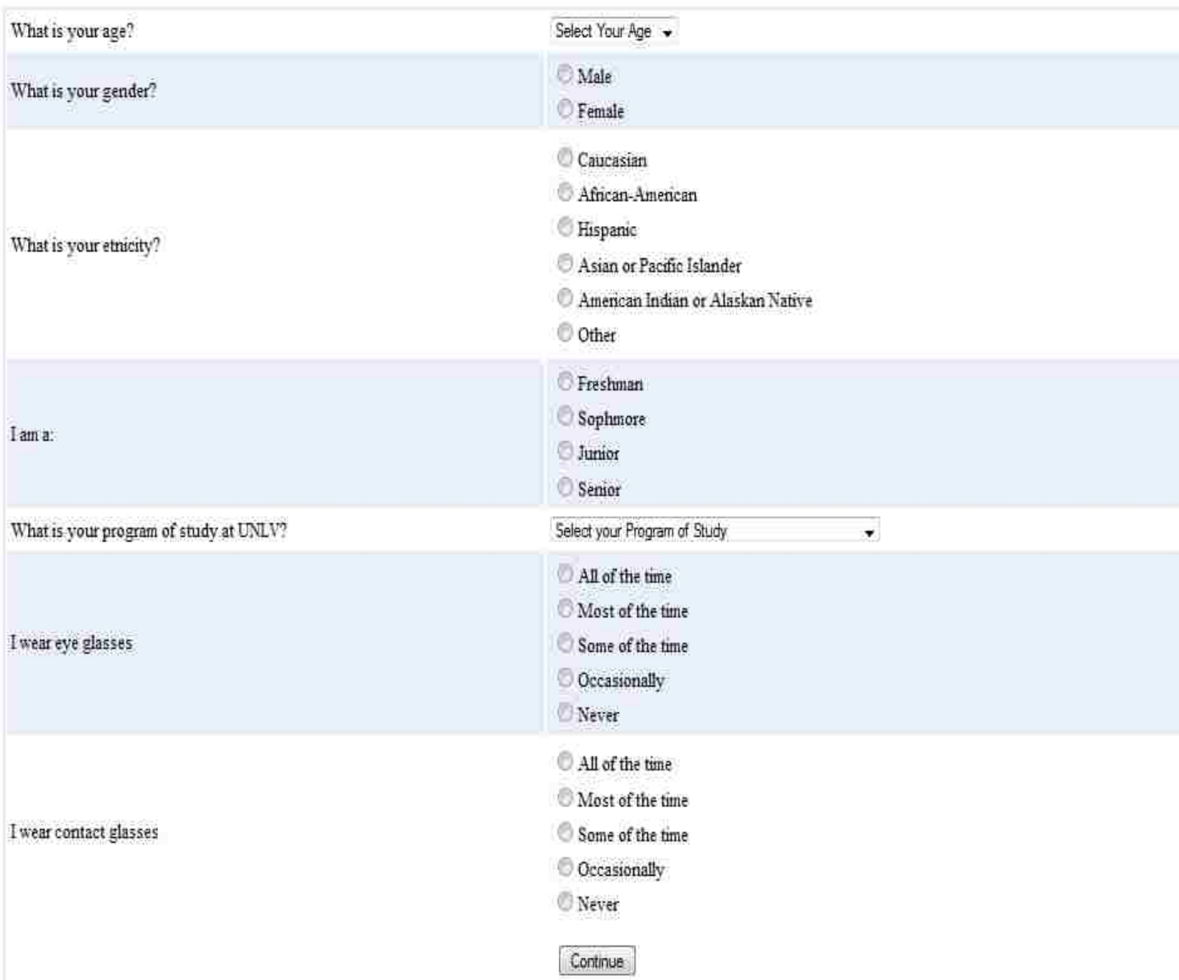


Figure 3.4 Testing software screenshot of the first screen

3.2.1 Demographic Questions

The test subjects were asked general demographic questions, such as age, gender, race, major and others. The demographic questions were specifically developed for this study. The same demographic questions were given in Phase I and II studies. The demographic questions and responses are presented in the Test Subjects section. A screenshot of the demographic survey as it appeared on the laptop computers is shown in Figure 3.5



What is your age?	Select Your Age
What is your gender?	Male Female
What is your etnicity?	Caucasian African-American Hispanic Asian or Pacific Islander American Indian or Alaskan Native Other
I am a:	Freshman Sophmore Junior Senior
What is your program of study at UNLV?	Select your Program of Study
I wear eye glasses	All of the time Most of the time Some of the time Occasionally Never
I wear contact glasses	All of the time Most of the time Some of the time Occasionally Never Continue

Figure 3.5 Test Software Screenshot of the Demographics Questions

3.2.2 Test Passage

There were two reading tasks in the Phase I study, a practice reading passage, and the reading test passage. The texts were presented in segments of 34 words. Only one section was presented on the computer screen at a time and test subjects had to advance to the next one by clicking a button on the bottom of the page. Once they moved forward they were not able to go back to a previous section. The segments were presented in proper punctuation and syntax.

Prior to the test reading passage, the test subjects were given a practice reading passage. An edited version of an article from Michael H. Chase entitled "The Matriculating Brain" [32] was used. The practice reading had a total of 10 segments. The reading test passage was a slightly modified version of a chapter from Rachel Carson's acclaimed book, "The Sea Around Us" [33]. The test passage was designed to take about 30 minutes for a college level reader. The text contained information on the various minerals found in the ocean, names of famous oceanic explorers, and discussions of the ever more sophisticated types of machines used in undersea exploration and research. The test passage was information dense and relatively difficult to comprehend even for college students. Figure 3.6 and Figure 3.7 show the instructions and a segment of the reading test passage respectively.

In the Phase II study there was no practice passage and the reading passage was presented in the form of an oral presentation. Using the distance education services, a research team member was recorded reading the same passage from Rachel Carson's book "The Sea Around Us". A female speaker clearly and intelligibly read the test passage. The oral presentation was of good visual and audio quality.

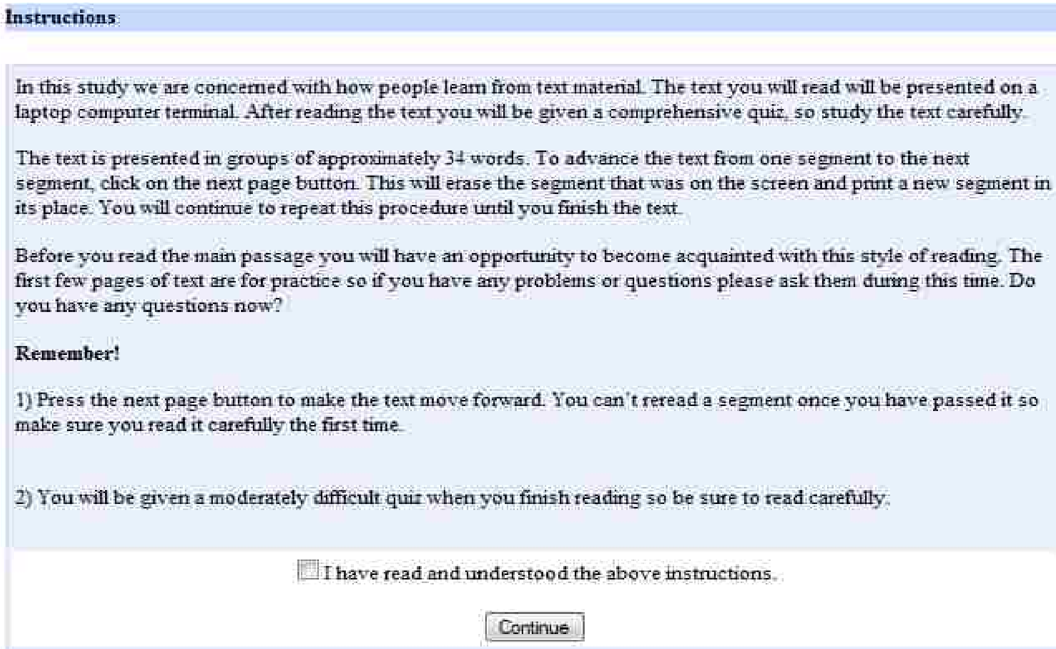


Figure 3.6 Testing software screenshot of the reading instructions

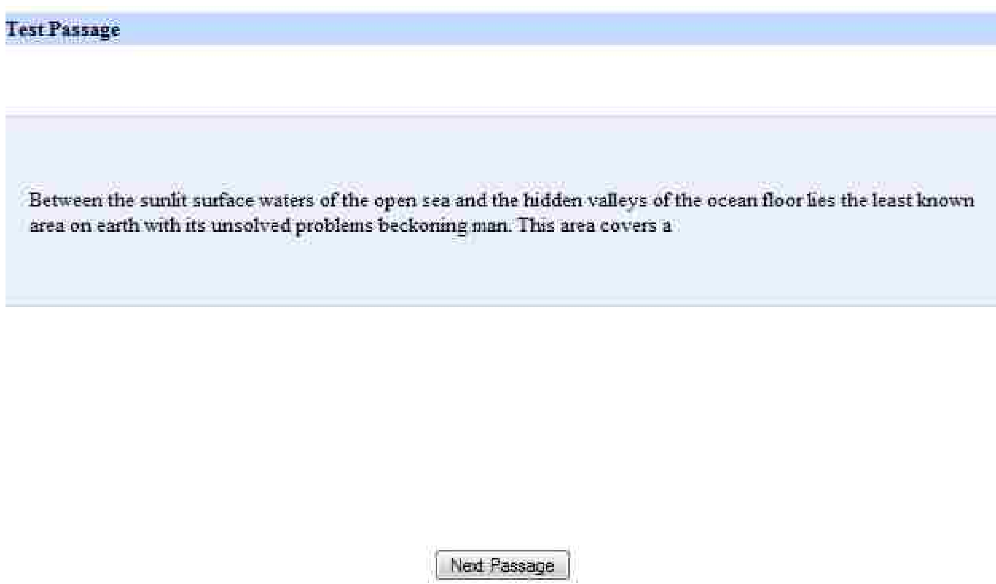


Figure 3.7 Testing software screenshot of the reading test passage

3.2.3 Positive Affect and Negative Affect Scale (PANAS)

The Positive Affect and Negative Affect Scale (PANAS) [28] was used in Phase I and II studies as an indicator of students' mood and well-being. This is a two mood factor survey in which the Positive Affect (PA) reflects the degree to which somebody feels active, alert, and enthusiastic; and the Negative Affect (NA) gives an indication of negative mood states, including fear, guilt, anxiety, and anger. The mood survey could be used for different time intervals such as at this moment, today, this week, this year. For the purpose of this study the instructions specifically stated that those are feelings and emotions at the present moment.

The correlation between the positive and negative affect scales ranges from -0.12 to -0.23; thus, for the two scales approximately 1% to 5% of their variances overlap. These values are significantly lower than those of many other short PA and NA scales [28]. It has been shown that the PANAS scales exhibit a significant level of stability in their findings and also to be a reliable, valid and efficient means for measuring the positive and negative affects of mood [28].

The survey consisted of 20 positive and negative affect descriptors. The test subjects indicated the extent to which they were feeling a certain emotion at the present time on a 5 point scale. The points on the scale ranged from very slightly or not at all to extremely. The PANAS survey and responses are presented in the Survey Responses sections in Chapter 4 for the Phase I and II tests. The instructions and the first 10 items of the survey as they were presented in the testing software are shown in Figure 3.8.

Positive and Negative Affect Scale

This scale consists of a number of words that describe different feelings and emotions. Read each item and then mark the appropriate answer in the space next to that word. Indicate to what extent you feel this way right now, that is, at the present moment. Use the following scale to record your answers.

1 = Very slightly or not at all, 2 = A little, 3 = Moderately, 4 = Quite a bit, 5 = Extremely

	Very slightly or not at all	**A little**	**Moderately**	**Quite a bit**	**Extremely**
	1	2	3	4	5
interested	○	○	○	○	○
distressed	○	○	○	○	○
excited	○	○	○	○	○
upset	○	○	○	○	○
strong	○	○	○	○	○
guilty	○	○	○	○	○
scared	○	○	○	○	○
hostile	○	○	○	○	○
enthusiastic	○	○	○	○	○
proud	○	○	○	○	○

Figure 3.8 Testing Software Screenshot of the PANAS

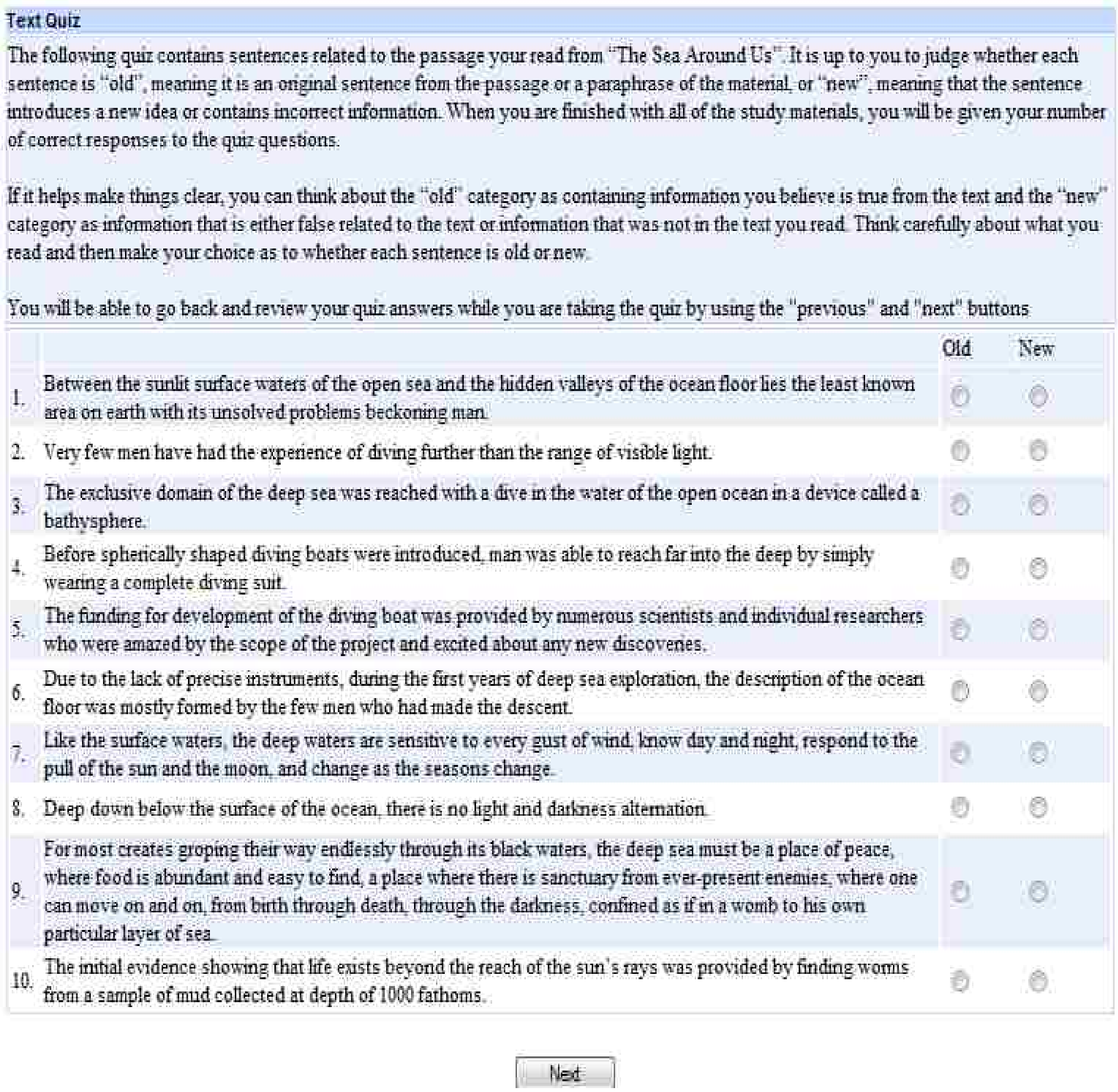
3.2.4 Sentence Verification Technique (SVT)

The test subjects in the pilot study were given the same sentence verification technique (SVT) [26] in Phase I and II tests. The SVT is a test for comprehension that could be adapted to any reading assignment or oral presentation. In SVT there are four types of sentence questions, such as originals, paraphrases, meaning changes, and distractors. Originals are exact copy of a phrase from the reading or oral presentation. Paraphrases have most of the words changed but have the same meaning as phrase from the reading or oral presentation. A meaning change item contains many of the same words but has a different meaning and a dictractor item concerns the same topic; however, it has different words and meaning than the reading or oral presentation.

The test subjects had to decide if the phrases are “old” or “new” to the reading test passage or oral presentation. “Old” sentences were the same or had the same meaning the as the test passage sentences (originals and paraphrases). “New” sentences had different meaning than the test passage (meaning changes and distractors) [26]. The testing software recorded each response, graded it and also gave a total score for each test subject.

A 40 item SVT task was developed specifically over the test material to which the test subjects were exposed to either in a form of reading or oral presentation. There was an equal number of “old” (true) and “new” (false) types of questions. There was also an equal number of each of the types of questions, such as, originals, paraphrases, meaning changes or distractors.

The testing software displayed 10 questions per page with the instructions shown in all of the four pages. The test subjects had to respond to all question in order to go to the next page; however, they were able to go back to previous pages and change their answers if they decided to do so. A screen shot of the instructions and the first 10 questions are show in Figure 3.9, and the whole SVT is included in the appendix.



Text Quiz

The following quiz contains sentences related to the passage your read from "The Sea Around Us". It is up to you to judge whether each sentence is "old", meaning it is an original sentence from the passage or a paraphrase of the material, or "new", meaning that the sentence introduces a new idea or contains incorrect information. When you are finished with all of the study materials, you will be given your number of correct responses to the quiz questions.

If it helps make things clear, you can think about the "old" category as containing information you believe is true from the text and the "new" category as information that is either false related to the text or information that was not in the text you read. Think carefully about what you read and then make your choice as to whether each sentence is old or new.

You will be able to go back and review your quiz answers while you are taking the quiz by using the "previous" and "next" buttons

		Old	New
1.	Between the sunlit surface waters of the open sea and the hidden valleys of the ocean floor lies the least known area on earth with its unsolved problems beckoning man.		
2.	Very few men have had the experience of diving further than the range of visible light.		
3.	The exclusive domain of the deep sea was reached with a dive in the water of the open ocean in a device called a bathysphere.		
4.	Before spherically shaped diving boats were introduced, man was able to reach far into the deep by simply wearing a complete diving suit.		
5.	The funding for development of the diving boat was provided by numerous scientists and individual researchers who were amazed by the scope of the project and excited about any new discoveries.		
6.	Due to the lack of precise instruments, during the first years of deep sea exploration, the description of the ocean floor was mostly formed by the few men who had made the descent.		
7.	Like the surface waters, the deep waters are sensitive to every gust of wind, know day and night, respond to the pull of the sun and the moon, and change as the seasons change.		
8.	Deep down below the surface of the ocean, there is no light and darkness alternation.		
9.	For most creates groping their way endlessly through its black waters, the deep sea must be a place of peace, where food is abundant and easy to find, a place where there is sanctuary from ever-present enemies, where one can move on and on, from birth through death, through the darkness, confined as if in a womb to his own particular layer of sea.		
10.	The initial evidence showing that life exists beyond the reach of the sun's rays was provided by finding worms from a sample of mud collected at depth of 1000 fathoms.		

Next

Figure 3.9 Testing software screenshot of the SVT questions

3.2.5 Test Anxiety Survey

The test anxiety survey [27] involved questions about the general test taking behavior of the subjects. This survey was used to determine whether or not the two test groups can be considered even in terms of their test anxiety levels. The test subjects had to respond to twenty statements about their test taking habits. The same anxiety survey was given in Phase I and II studies. In Figure 3.10 is a screen shot of the testing software test anxiety instructions and first 10 questions. The whole survey is included in the appendix.

Directions:

A number of statements which people have described themselves given on the following page. Read each statement and then circle the appropiate number to the right of the statement to indicate how you **generally** fell:

1 = Almost Never, 2 = Sometimes, 3 = Often, 4 = Almost Always

There are no wrong or right answers. Do not spend too much time on one statement but give the answer which seems to describe how you generally feel.

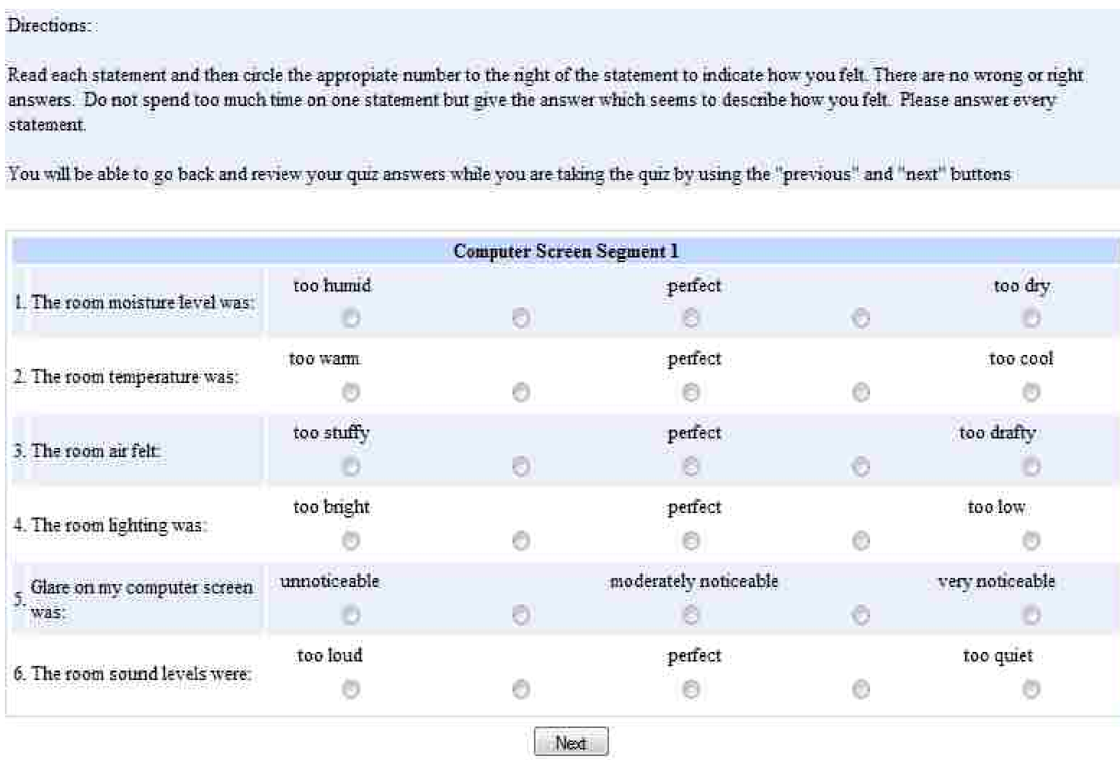
Please answer every statement.

		1 **Almost Never**	2 **Sometimes**	3 **Often**	4 **Almost Always**
1.	I feel confident and relaxed when taking tests	○	○	○	○
2.	While taking examinations I have an uneasy, upset feeling	○	○	○	○
3.	Thinking about my grade in a course interfeces with my work on tests	○	○	○	○
4.	I freeze up on important exams	○	○	○	○
5.	During exams I find myself thinking about whether I'll ever get through school	○	○	○	○
6.	The harder I work at taking a test, the more confused I get	○	○	○	○
7.	Thoughts of doing poorly interfere with my concentration on tests	○	○	○	○
8.	I feel very jittery when taking an important test	○	○	○	○
9.	Even when I'm well prepared for a test, I feel very nervous about it	○	○	○	○
10.	I start feeling very uneasy just before getting a test paper back	○	○	○	○

Figure 3.10 Testing software screenshot of the test anxiety survey

3.2.6 Environmental Survey

The environment survey was developed specifically for this study, and consisted of set of questions on about the test room environment. There were three parts to the survey. The first one was about how the test subjects perceived the classroom. The possible responses ranged from 1-5, where 1 was the high end of the parameters (too warm, too loud etc.), 3 was a perfect environment and 5 was the low end of the parameters (too cool, too quiet, etc). A screen shot of that part of the environmental survey is shown in Figure 3.11.



Directions:

Read each statement and then circle the appropiate number to the right of the statement to indicate how you felt. There are no wrong or right answers. Do not spend too much time on one statement but give the answer which seems to describe how you felt. Please answer every statement.

You will be able to go back and review your quiz answers while you are taking the quiz by using the "previous" and "next" buttons

Computer Screen Segment 1					
1. The room moisture level was:	too humid		perfect		too dry
2. The room temperature was:	too warm		perfect		too cool
3. The room air felt:	too stuffy		perfect		too drafty
4. The room lighting was:	too bright		perfect		too low
5. Glare on my computer screen was:	unnoticeable		moderately noticeable		very noticeable
6. The room sound levels were:	too loud		perfect		too quiet

Next

Figure 3.11 Testing software screenshot of the first part of the environmental survey

The second part of the environmental survey involved questions about the comfort of the furniture and equipment, such as desk, chair, and computer in the laboratory. There was also a question regarding the general comfort level in the test room. The test subjects indicated their comfort levels regarding each aspect in the test room on a scale ranging from very comfortable to very uncomfortable. In this part of the survey the test subjects were also able to type their comments about their experience during study. The test subjects' responses and comments were used to determine and compare their comfort levels between the two test room physical environmental conditions. The comments are shown in the appendix. Figure 3.12 displays the second part of the environmental survey as it appeared on the testing software.

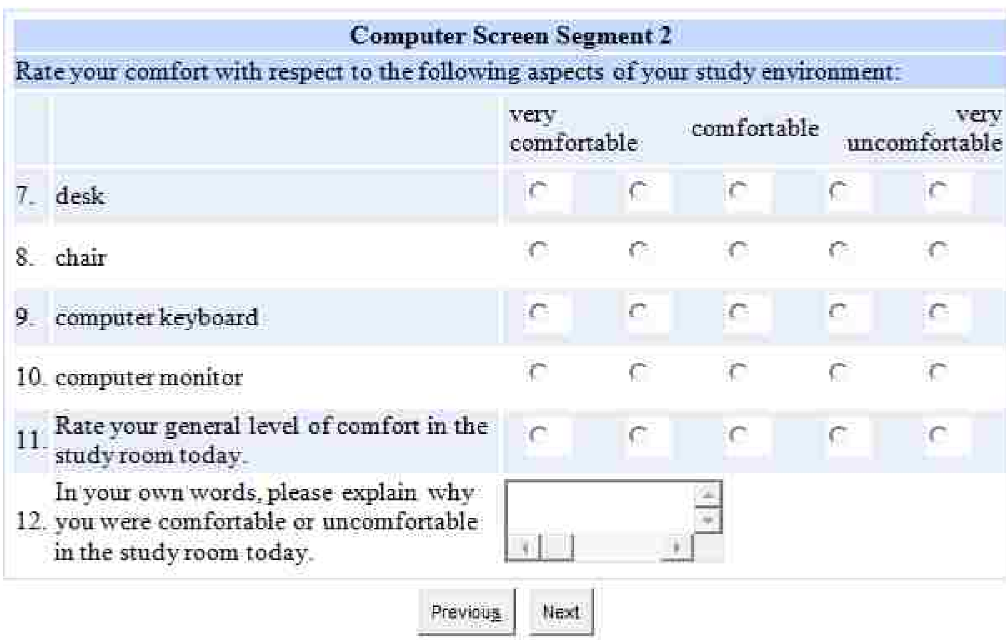
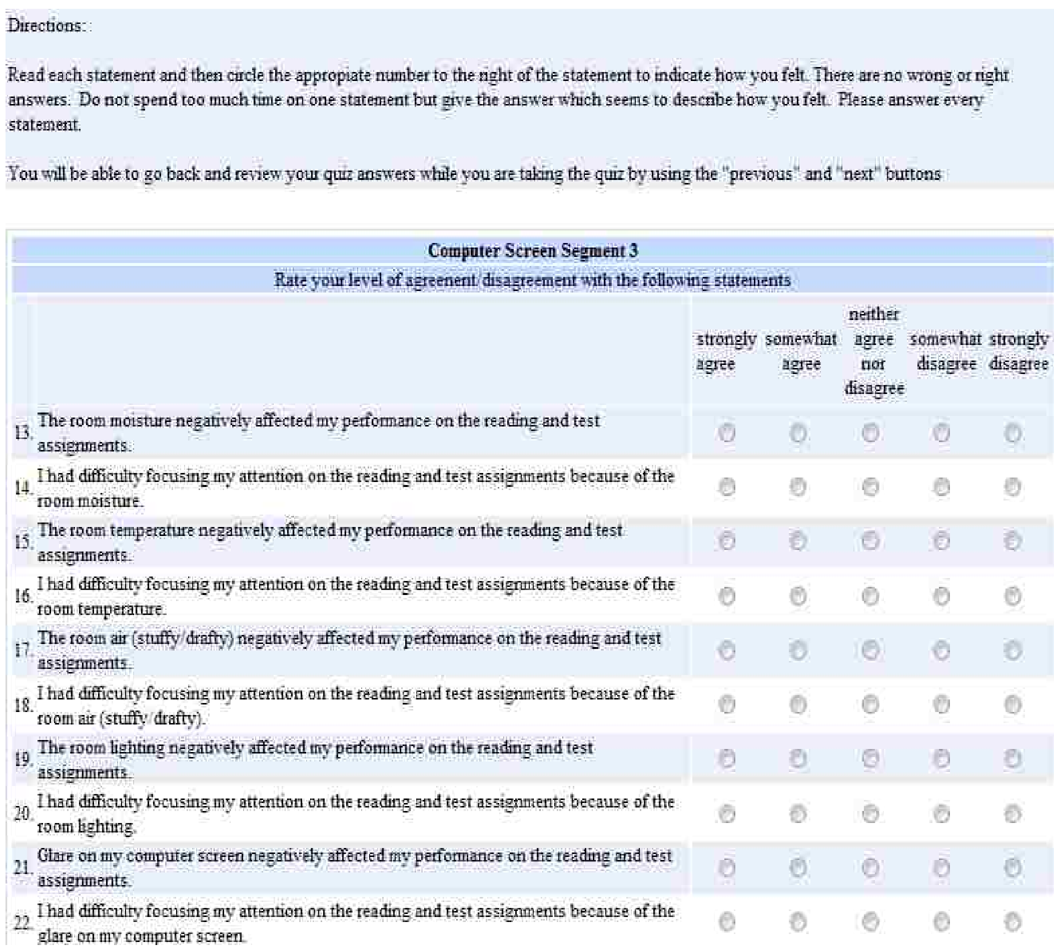


Figure 3.12 Testing software screenshot of the second part of the environmental survey

The last part of the environment survey dealt with factors that could have negatively affected the test subjects' performance during the study. A number of causes were given to which test subjects had to indicate their level of agreement/disagreement. The statements included questions about thermal comfort, noise levels, lighting, moisture, and glare as possible reasons that could have negatively affected the test subjects. For each possible cause there were two questions one regarding the test subjects' task performance and one regarding their attention to the task. Part of the survey is shown in Figure 3.13 as it was presented to the test subjects.



Directions:

Read each statement and then circle the appropiate number to the right of the statement to indicate how you felt. There are no wrong or right answers. Do not spend too much time on one statement but give the answer which seems to describe how you felt. Please answer every statement.

You will be able to go back and review your quiz answers while you are taking the quiz by using the "previous" and "next" buttons

Computer Screen Segment 3

Rate your level of agreement/disagreement with the following statements

		strongly agree	somewhat agree	neither agree nor disagree	somewhat disagree	strongly disagree
13.	The room moisture negatively affected my performance on the reading and test assignments.	○	○	○	○	○
14.	I had difficulty focusing my attention on the reading and test assignments because of the room moisture.	○	○	○	○	○
15.	The room temperature negatively affected my performance on the reading and test assignments.	○	○	○	○	○
16.	I had difficulty focusing my attention on the reading and test assignments because of the room temperature.	○	○	○	○	○
17.	The room air (stuffy/drafty) negatively affected my performance on the reading and test assignments.	○	○	○	○	○
18.	I had difficulty focusing my attention on the reading and test assignments because of the room air (stuffy/drafty).	○	○	○	○	○
19.	The room lighting negatively affected my performance on the reading and test assignments.	○	○	○	○	○
20.	I had difficulty focusing my attention on the reading and test assignments because of the room lighting.	○	○	○	○	○
21.	Glare on my computer screen negatively affected my performance on the reading and test assignments.	○	○	○	○	○
22.	I had difficulty focusing my attention on the reading and test assignments because of the glare on my computer screen.	○	○	○	○	○

Figure 3.13 Testing software screenshot of the third part of the environmental survey

3.3 Laboratory Set Up

The pilot study was conducted in the Ventilation and Acoustics Systems Technology (VAST) laboratory within the College of Engineering. This is a unique state of the art room where temperature, ventilation, acoustics and lighting can be accurately controlled and measured. This room has floor dimensions of 21 feet by 31 feet and a ceiling height of 10 feet. The laboratory is equipped with both a traditional air distribution (CAD) system and UFAD system, and it can be easily reconfigured between the two systems. The laboratory can be set up as an office space, meeting room, a classroom, or a hotel suite. For this study the test room was arranged to simulate a classroom as described below. Within this classroom environment, student attention and learning were measured in response to the different physical environmental conditions. Some of the laboratory precision measuring capabilities as related to this study include [34]:

- Temperatures at multiple walls, floor, ceiling, under-floor, and above the ceiling airspace locations;
- Airflow, temperature, humidity in the supply and return ductwork plenums;
- Energy inputs from interior room, room lighting, and energy consumption of the HVAC system.

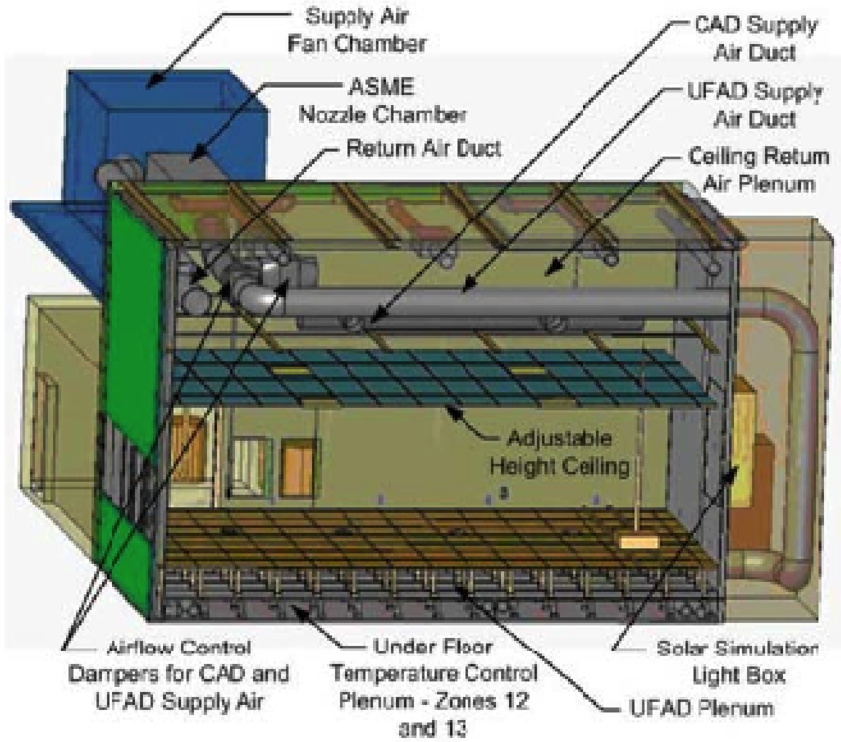


Figure 3.14 Side View of the UNLV VAST Lab [34]

The instrumentation and equipment are capable of working together in order to create isothermal conditions in the VAST lab. A central computer is used to control, monitor and record the conditions of the laboratory. The custom written LabView program simultaneously monitors the test room conditions and instrument performance. Figure 3.15 and Figure 3.16 show the interface of the software monitoring the sensors, supply duct parameters, and the temperatures at different locations. The central computer is located in the control room, which is adjacent to the experimental room. In this study there was a research team member in the experimental room during the whole duration of each test as well as a research team member in the control room monitoring the central computer.

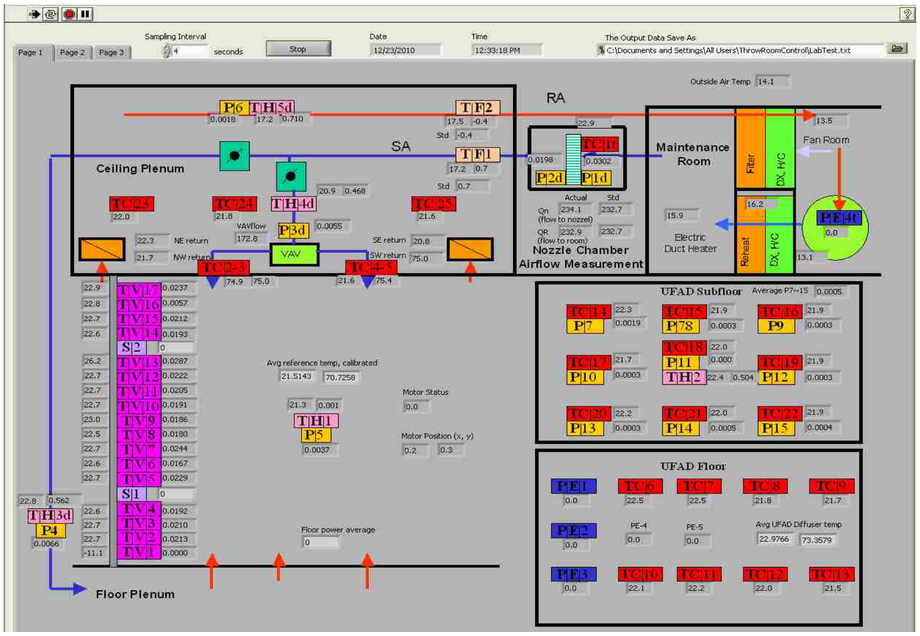


Figure 3.15 LabView main interface for monitoring test room conditions

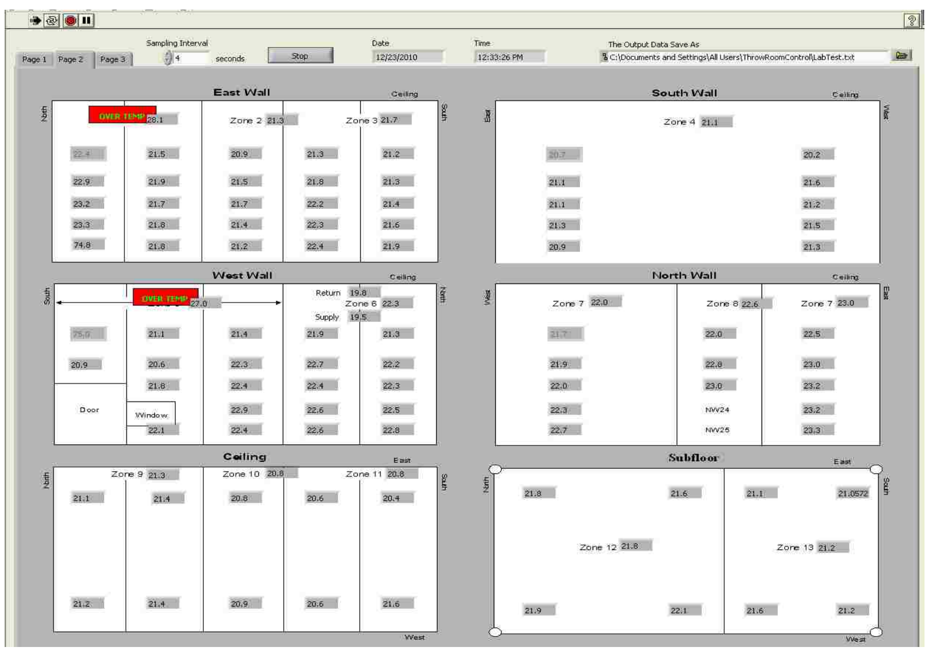


Figure 3.16 Lab View interface for monitoring the laboratory walls temperatures

The lighting intensity levels and the sound levels were measured with hand held devices. Konica Minolta illuminance meter T-10 was used to measure the lighting levels. This is a multi-function digital illuminance meter with detachable receptor head. This meter has an extremely large measuring range of 0.01 to 299,000 lx with automatic range switching and a large, backlit LCD. This portable meter allowed for measurements at every test station to ensure that the levels are within the specified range. The instrument is powered by standard AA-size batteries. The accuracy of the meter is ±2%±1 digit of the displayed value [35]. The Konica Minolta meter that was used for this study is shown in Figure 3.17.

Figure 3.17 Konica Minolta illuminance meter T-10

The sound levels were measured using SVANTEK 958 four channel, 20 kHz real time, sound and vibration analyzer. The SVAN 958 can perform sound measurements with accuracy of Type 1. The instrument is capable of measuring sound by the use of four independent microphones. The analyzer gives the user a possibility to obtain Leq, LMax, LMin, LPeak, Spl, SEL with different weighing filters in the same time [31]. The analyzer is equipped with 32 MB of internal memory. The total dynamic range of the instrument is 17dBA RMS – 140 dBA Peak, with 50 mV/Pa microphone sensitivity. The frequency range is 0.5 Hz – 20 kHz [36]. The SVAN 958 with the prepolarized condenser microphone that was used for this study is shown in Figure 3.18.

Figure 3.18 Svantek 958 four channel sound and vibration analyzer

The VAST lab has white 4 feet by 8 feet wall boards on the walls. White panels cover the gaps for the instrumentation wire and cables between the boards. The floor is covered with gray 2 feet by 2 feet floor tiles. The ceiling has typical 2 feet by 4 feet white ceiling panels. There are two windows on the back side of the study room overlooking the control room. After modifications and furnishing the laboratory very closely resembled a typical classroom. Figure 3.19, Figure 3.20, Figure 3.21 show pictures of the experimental test room.

3.3.1 Devices Used to Achieve the Physical Environmental Parameter Levels

In the VAST Lab various studies take place, and in order to simulate a classroom the test room was modified and furnished. To be able to simulate the two conditions additional lights, diffusers, and ceiling speakers were installed.

Figure 3.19 VAST lab before modification

Figure 3.20 VAST lab as a classroom in the Phase I tests

Figure 3.21 VAST lab for the Phase II tests

3.3.1.1 Lighting

In order to achieve the specified lighting intensity levels, the test room was equipped with a total of 10 fluorescent light fixtures and 8 flood lights. 2 feet by 4 feet 32Watt T8 fluorescent ceiling fixtures shown in Figure 3.22 were installed in the ceiling. 4 Sylvania T8 fluorescent bulbs were used in each fixture. The bulbs were available in many variations of the lighting spectrum. After considering “cool white” or “natural white” bulbs, “cool white” bulbs shown in Figure 3.23 were selected as a better option to create both physical environmental conditions. The flood lights shown in Figure 3.24 were used to achieve the light levels for the extreme condition. They were evenly placed along the walls on the ceiling. The lights were placed in such a way to produce the most uniform light intensity levels throughout the room. The ceiling diagram in Figure 3.28 shows their locations.

Figure 3.22 The fluorescent ceiling fixture used in this study

Figure 3.23 Sylvania cool white T8 bulbs

Figure 3.24 Flood lights

3.3.1.2 Acoustics

To achieve the specified sound levels four Armstrong Applaus series ceiling speakers were installed in the ceiling. The speakers were 2 feet by 2 feet and they were drop down in the ceiling in the place of the ceiling panel. These speakers were selected for their design, performance and ease of installation. The speakers are designed to blend into the ceiling so they cannot be noticed. The speakers are rated at 30W each and they have very broad sound dispersion. They have a maximum of sound pressure level of 98 dB at 1 meter and sensitivity of 84 dB. There are three available tap settings at 7.5W, 15W, and 30W; the 15W setting was used [37].

The speakers were evenly spaced to create uniform sound levels throughout the test room. The sound levels were measured with the sound meter described above at each station to verify that the levels were according to specification. The speakers were connected to an amplifier in the control room. All of the cables were run above the ceiling and behind the wall panels so there were no visible cables. The speakers were controlled from the main computer in the control room. The extreme condition sound was associated with a room ventilator fan. The sound source had slight tonal characteristic and a broad sound spectrum. This ventilator fan recording was looped and played throughout the whole experiment in the extreme test room physical environmental conditions. One of the ceiling speakers that was used in the pilot study is shown in Figure 3.25.

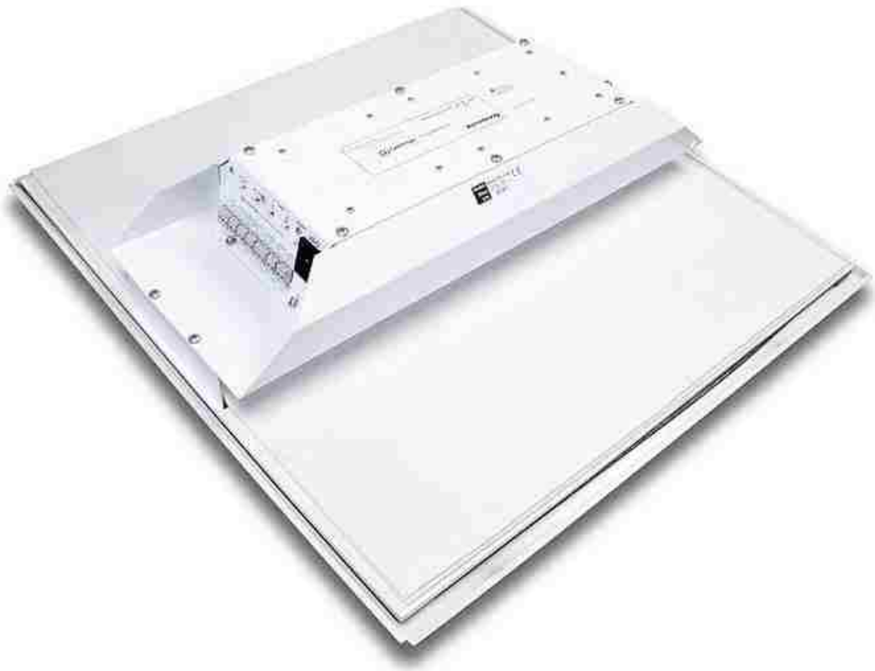


Figure 3.25 Armstrong ceiling speaker [37]

3.3.1.3 Temperature

The conditioned air was supplied by two diffusers. 12 inch by 12 inch Krueger SHR/5SHR series diffusers were used [38]. The diffusers that were selected had 4 way throw in order to produce uniform discharge air patterns on all sides. Diagrams of the layout of the ceiling are shown in Figure 3.27 and Figure 3.28 for the normal and the extreme test room physical environmental conditions respectively. One of the Kruger diffusers that was used is shown in Figure 3.26.

Figure 3.26 Kruger diffuser used for the study

3.3.2 Creating the Test Room Physical Environmental Conditions

The lights, speakers and diffusers described above made possible to set and maintain the specified environmental parameter levels. Below is a description of which ones were used to create the normal and extreme physical environmental conditions.

3.3.2.1 Creating the Normal Test Room Physical Environmental Condition

To create the normal physical environmental condition four of the fluorescent light fixtures were used, the speakers were turned off and the temperature was set and maintained at 72 degrees Fahrenheit. Figure 3.27 indicates the location of the lights and diffusers that were used. The lights that are in yellow and the diffusers that are in blue were used to achieve the specified levels and create uniform conditions at each test subject station. The flow rate from the diffusers was adjusted to produce sound level to the specified level of 35dBA.

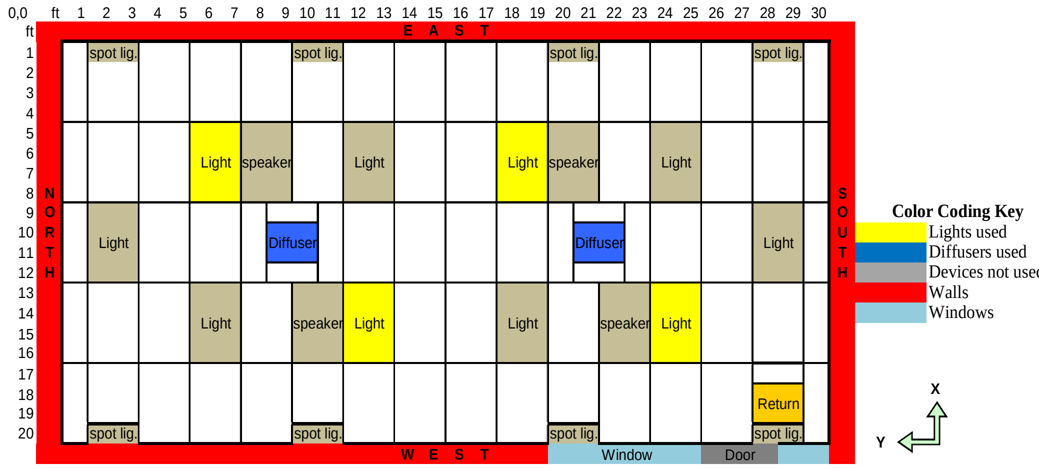


Figure 3.27 Diagram of the ceiling in the test room during the normal physical environmental condition tests in Phase I and II

3.3.2.2 Creating the Extreme Test Room Physical Environmental Condition

To create the extreme physical environmental condition all of the lights and speakers were turned on, and the temperature was set and maintained at 80 degrees Fahrenheit. A recording of a ventilator fan was played through the speakers. This is a typical noise that could be present in a classroom with bad heating ventilating and air conditioning system. Combining the recording with the noise from the diffusers it appeared as if the noise originated from an actual defective unit rather than being artificially created. Concluding from the comments the test subjects did not detect that the noise was being played through speakers as many of them referred to it as the noise from the air conditioner. Figure 3.28 displays the location of all the devices that were used to create the extreme test room physical environmental conditions in the Phase I and II study.

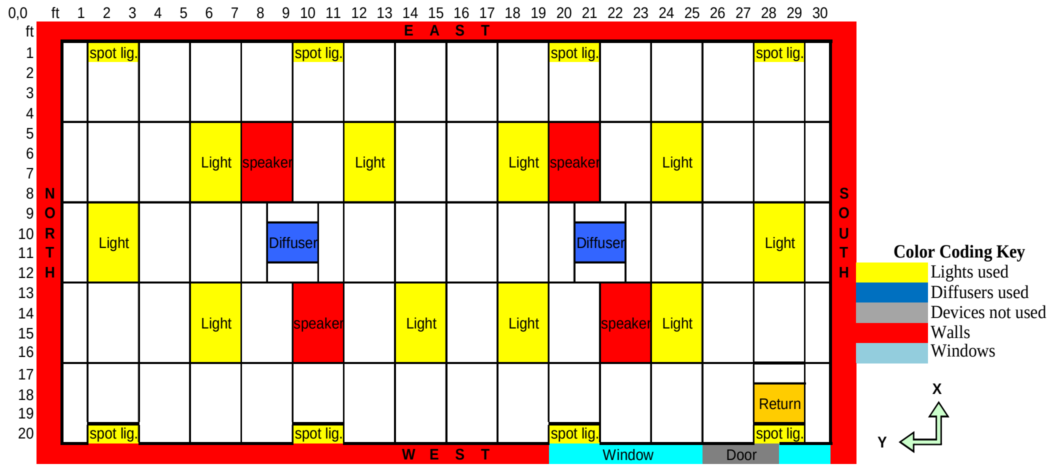


Figure 3.28 Diagram of the ceiling of the test room during the extreme physical environmental conditions tests in Phase I and II

3.3.3 Furniture and Electronic Equipment in the Test Room

3.3.3.1 Tables and Chairs

Sixteen tables and chairs were purchased for the study; they are shown in Figure 3.29 and Figure 3.30. The tables were 4 feet by 2 feet and were set at a medium height at 29 inches from the ground. There was one table per station. The chairs were regular classroom chairs with padded seats. The same furniture, equipment and classroom arrangement was used in Phase I and II studies. The tables and chairs were arranged in four rows with four testing stations per row with the exception of the front row which was set up with three testing stations. The test subjects were able to indicate their comfort levels and comment about the furniture and equipment of the study room in the second part of the environmental survey.

Figure 3.29 Chairs used for the Phase I and II studies

Figure 3.30 Tables used for the Phase I and II studies

3.3.3.2 Computers

Sony Vaio laptop computers were used for the Phase I and II studies. The laptops were equipped with a 14 inch display, Intel processor, 4GB of RAM, 500GB storage capacity and a Windows 7 operating system [39]. They computers were set up on network and they communicated with the server via wireless router.

Figure 3.31 Laptop computers used in the study

3.3.3.3 Television

A 55" Samsung LED HDTV was used in the Phase II study to display the video lecture. The video lecture was created by the university's distant education services. A research team member was recorded reading the test passage. The television was mounted at an elevated position in the front of the test room where the high quality video lecture was easily seen from everywhere in the test room.

Figure 3.32 55” Samsung LED HDTV used in the Phase II study [40]

3.3.3.4 Surround Sound

For the Phase II study the classroom was wired with SONY component surround sound system with DVD player. The speakers were placed around the room to create more uniform sound levels.

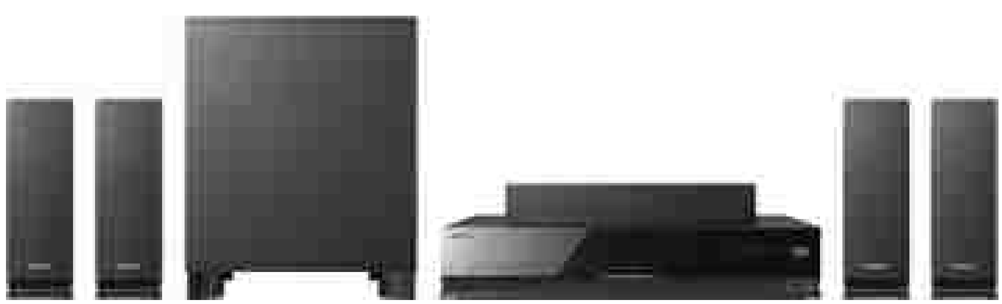


Figure 3.33 SONY DVD player with surround sound system [39]

3.4 Experimental Protocol

The procedures that were closely followed to conduct the pilot study are described below. Because of the slight difference in the protocols from the Phase I to Phase II studies they are explained separately.

3.4.1. Phase I Experimental Protocol

The physical environmental conditions in the test room were set at least an hour prior to each testing session in order for the environment to stabilize. Once the test subjects started arriving to the room, they were signed in by the researcher, given their unique identification number and allowed to select a work station where they waited until the test started. At the scheduled time, the researcher gave further instructions for completing the study and general laboratory rules and the test subjects were then able to begin. The participants were reminded that they are participating in a study that is investigating reading on computers. They were told to read the passage carefully because a difficult test will follow the reading task. In addition, the test subjects were given instructions as to how the text is presented, and how they should advance through the test. The instructions which were read to the test subjects at the beginning of each testing session are included in the appendix.

To start the testing software the participants first had to enter their unique ID number on the laptop. On the second screen, the test subjects were given the demographic survey. In the survey, they have to enter their gender, age, major at UNLV and respond to several other questions. In screen three, the test subjects were presented with the reading instructions with which they had to agree/confirm in order to move forward. In the following screens, the test subjects were presented the practice reading passage. The passage consisted of 10 screens, and the participants had to click “Proceed to Reading Section” when they were finished. The reading test passage then followed.

The test passage consisted of a 4500 words that were broken down to 34 word segments. Each of the segment was displayed on separate screen, and the test subjects had to proceed to the next segment clicking on the “proceed to the next page” button. The system was tracking the time in miliseconds it took the test subjects to move from one segment to the next.

Following the reading test passage the participants completed the mood survey (PANAS). This survey was followed by the sentence verification technique (SVT) comprehension test. After the SVT comprehension test, the test anxiety questionnaire and the environmental survey followed. After the test subjects completed all of the testing instruments their SVT score appeared on the computer screen. At that point they knew they were finished with the experiment and upon checking out with the researcher they were able to leave the testing room. This process was done quietly with as little as possible distraction to the other test subjects.

3.4.2 Phase II Experimental Protocol

As performed in the in the Phase I study, in the Phase II study the physical environmental conditions in the test room were set at least an hour prior to a testing session. Prior to the arrival of the test subjects each laptop was set to the initial screen of the testing software. As the participants started to arrive they were checked in by the researcher, allowed to choose any seat and instructed to wait further instructions. At check in the test subjects were given their individual identification number which was required to start the testing software. At the scheduled time no one else was allowed in the study room and the researcher gave further instructions.

The test subjects were instructed that they will be presented with a video lecture on the televesion and that a difficult test based on the information from the lecture will follow. The test subjects were also instructed that they cannot use the laptop computers until the video lecture is finished. The full instructions that were read to the participants at the beginning of each testing session are included in the appendix. If there were no questions at the end of the instructions, the researcher strated the video and took his seat at the back of the room.

Once the video lecture finished the students started the testing software by entering their unique identification number on the first screen. The testing software was modified for the Phase II study by having the reading passages removed. The software guided the participants through the demographics questions, sentence verification task and the surveyes similarly to the Phase I study. After completing the testing instruments the test subjects' SVT scores appeared on the screen and upon checking out with the researcher they were able to leave the test room.

CHAPTER 4

FINDINGS OF THE STUDY

The pilot study was conducted in two phases where the main difference between the two was the method of presenting the information. In the Phase I study, completed in the April 2010, the test subjects obtained the information for the SVT test by reading a passage on the laptop computers. In the Phase II study, completed in November 2010, the test subjects were shown an oral presentation of the same material. The parameter levels in both phases were the same with the exception of a slight change in the noise level of Phase II. The SVT scores and survey responses in Phase I and II were analyzed for differences between the two built test room physical environmental conditions. The findings of the pilot study are presented separately for the Phase I and II studies. Prior to analyzing the results the characteristics of the test subjects were examined.

4.1 Test Subjects

Two subject pools of student volunteers were used for the Phase I and II studies: one from the College of Education and one from the College of Engineering at the University of Nevada, Las Vegas. The subject pools were primarily composed of freshman and sophomore undergraduate engineering students and upper division educational psychology students. Having participants from two completely different colleges not only increased the overall number of test subjects, but also created a test sample with greater diversity in terms of educational and cultural backgrounds and made even the male-to-female ratio.

4.1.1 Recruitment of Test Subjects

For the purpose of the Educational Psychology students, this study partially fulfilled research requirements related to their coursework. For the engineering students, a choice was given between participating in the study or doing an additional homework assignment. Educational Psychology students were presented with this study as one of their options through the electronic Experiment Management System, with instructions to send a research team member an email to sign up to participate in the I-SPIDER study. Engineering students were given the same information during their courses and also instructed to contact the research team member via email. The study ad is attached in the appendix. Recruitment lasted for 3 weeks in the spring 2010 semester for the Phase I tests and 3 weeks in the fall 2010 semester for the Phase II tests.

During the consent process, the test subjects were informed that the purpose of the study is to understand reading and attention in a controlled classroom physical environment. They were not given more details about the study. The students were unaware of the physical environmental parameters that were investigated and the conditions that were created for the study.

For the purpose of assigning credit for participation and assigning students to test groups, student names were collected, but their names were not linked to the actual data collected. Preserving anonymity was implemented in order to protect the privacy of the test subjects. This was an important part for the IRB approval. Rather than personal information, student responses were only linked to a unique identifier assigned by the lab attendant. The test subjects were notified about the minimum risks involved in the study, and that the room physical environment may feel slightly uncomfortable. Before proceeding to participate in any research activities (e.g., completing research instruments), the test subjects read the consent form and acknowledged understanding of the research process, their rights as research subjects (e.g., voluntary participation and the right to withdraw from the study at any time), and who to contact for comments/questions. Also the contact information (i.e., telephone number and e-mail address) of all researchers was given. The consent form is included in the appendix.

4.1.2 Assigning to Test Conditions

After the deadline for registration for the study had passed, no other volunteers were allowed to sign up for the study. In order to reduce the affect of individual differences, such as level of intelligence, background knowledge and motivation on the output, random sampling was used to assign the students to a test condition.

Random sampling is a commonly used method in selecting and or assigning test subjects to groups. Since this study consisted of volunteers only random assigning was used. Simple random assigning was performed in order for each participant to have an equal chance of being assigned to one of the two test room environmental conditions for the Phase I and II studies. The random number generator function in Excel was used. Following that, the test times were selected.

Four test sessions were conducted in each environmental test condition in Phase I, and three were conducted in Phase II. The available testing times were sent to the randomly assigned test subjects for each condition. The test subjects notified the researcher, indicating which of the available test times they were able to attend.

4.1.3 Phase I Demographics of Test Subjects

A total of 85 students participated in the study, 43 in the normal test room physical environmental condition and 42 in the extreme environmental condition. Table 4.1 shows the time, days and how many test subjects participated in each testing session.

Table 4.1 Phase I study dates, times and number of test subjects

Session	Normal Condition	Time	Participants	Session	Extreme Condition	Time	Participants
1	4/14/2010	5:00 PM	10	1	4/15/2010	8:00 AM	7
2	4/20/2010	10:00 AM	9	2	4/20/2010	5:00 PM	15
3	4/21/2010	8:00 AM	9	3	4/21/2010	5:00 PM	11
4	4/23/2010	10:00 AM	15	4	4/23/2010	3:00 PM	9

From Table 4.2, it can be observed that the demographics of the two test groups were fairly similar. The distributions for age, gender and major were very close between the two environmental test conditions. The average age, the number of males and females were almost the same between test subjects in the two test room physical environmental conditions. There was also very similar number of engineering and education students. The number of test subjects who wore glasses and contacts was almost the same between the two test groups. The extreme test group had seven more seniors. However, the higher number of upperclassmen students did not affect the results; their average scores were consistent with the ones from the lowerclassmen students. Therefore, based on the demographics questions it was concluded that the test groups were evenly divided between the two test room physical environmental conditions.

Table 4.2 Phase I demographics of the test subjects

Age						
Normal (average)	22.5					
Extreme (average)	22.2					
Gender	**male**	**female**				
Normal (number of participants)	24	19				
Extreme (number of participants)	25	17				
Ethnicity	**Caucasian**	**African-American**	**Hispanic**	**Asian or Pacific Islander**	**American Indian or Alaskan Native**	**Other**
Normal (number of participants)	18	1	9	8	1	6
Extreme (number of participants)	27	3	8	4	0	0
Class Standing	**Freshman**	**Sophomore**	**Junior**	**Senior**		
Normal (number of participants)	14	14	13	2		
Extreme (number of participants)	10	13	10	9		
Major	**Education**	**Engineering**	**Other**			
Normal (number of participants)	16	23	4			
Extreme (number of participants)	16	20	6			
I wear eye glasses	**All of the time**	**Most of the time**	**Some of the time**	**Occasionally**	**Never**	
Normal (number of participants)	5	3	10	6	19	
Extreme (number of participants)	4	4	7	9	18	
I wear contact lenses	**All of the time**	**Most of the time**	**Some of the time**	**Occasionally**	**Never**	
Normal (number of participants)	1	7	4	2	29	
Extreme (number of participants)	2	9	1	3	27	

4.1.4 Phase II Demographics of the Test Subjects

The demographics of the test subjects from the Phase II study and information about the testing are shown in the Table 4.3 and Table 4.4. Table 4.4, indicates that the average age of the test subjects in the normal test room physical environmental condition was slightly higher than the participants in the extreme condition. However, after reviewing the scores, it was concluded that there was no significant difference in the performance between the older and younger test subjects for the normal physical environmental condition.

In terms of the other parameters, the test subjects were fairly evenly divided between the two test room physical environmental conditions. The number of males and females was nearly the same, and the ethnicity distribution of the participants was also very similar between the two test conditions. In terms of the class standing, the number of lowerclassmen and upperclassmen and the area of study of the test subjects were also fairly similar. The responses were also very similar in terms of the number of test subjects who wore classes and contacts. Based on the available demographics information it was concluded that the test subjects of the Phase II study were fairly evenly divided between the two test conditions. Table 4.3 shows the times, dates and number of test subjects in the Phase II experimental sessions.

Table 4.3 Phase II study dates, times and number of test subjects

Session	Normal Condition	Time	Participants	Session	Extreme Condition	Time	Participants
1	11/192010	11:45 AM	13	1	11/18/2010	4:00 PM	11
2	11/22/2010	4:00 PM	13	2	11/19/2010	3:15 PM	12
3	11/23/2010	8:00 AM	8	3	11/22/2010	10:00 AM	12

Table 4.4 Phase II demographics of the test subjects

Demographic Questions

Age						
Normal (average)	24					
Extreme (average)	22.2					
Gender	**male**	**female**				
Normal (number of participants)	22	12				
Extreme (number of participants)	22	13				
Ethnicity	**Caucasian**	**African-American**	**Hispanic**	**Asian or Pacific Islander**	**American Indian or Alaskan Native**	**Other**
Normal (number of participants)	20	1	5	6	0	2
Extreme (number of participants)	18	0	5	7	1	4
Class Standing	**Freshman**	**Sophomore**	**Junior**	**Senior**		
Normal (number of participants)	4	17	10	3		
Extreme (number of participants)	11	14	6	4		
Major	**Education**	**Engineering**	**Other**			
Normal (number of participants)	10	19	5			
Extreme (number of participants)	12	20	3			
I wear eye glasses	**All of the time**	**Most of the time**	**Some of the time**	**Occasionally**	**Never**	
Normal (number of participants)	6	3	4	9	12	
Extreme (number of participants)	5	3	4	6	17	
I wear contact lenses	**All of the time**	**Most of the time**	**Some of the time**	**Occasionally**	**Never**	
Normal (number of participants)	3	4	1	3	23	
Extreme (number of participants)	3	3	1	1	27	

4.1.5 Excluding Test Subjects from the Analysis

The results were examined for obvious indications of test subject's lack of effort on the assigned tasks. A general criterion was developed for excluding a test subject's SVT scores who clearly exhibited such performance. Those who fit the criteria were removed from the data in order to reduce their affect on the results. The test subjects that fit the criteria are listed in Table 4.5. For a test subject to be removed from the analysis he or she had to fit at least at least one of the criteria:

- Criteria 1: Two standard deviations below the time average for completing the reading assignment. Such times would be considered outliers and it is statistically acceptable to be removed from the data. Completing the reading that quick indicates that the person rushed through the reading without trying to retain the information required for the SVT test. Two standard deviations below the time average equated to 10.9 minutes in the normal test room physical environmental condition and 10.5 minutes in the extreme condition. For the Phase II tests this criteria was not used since all the test subjects viewed the oral presentation; thus, no time data was available for that phase.
- Criteria 2: A student answered ten or more questions consecutively with the same response. The SVT test was presented on the computer screen ten questions at a time. Therefore, having the same response for all the questions on the screen is an indication that the test subject just filled in answers in order to quickly complete the test without giving it a fair effort.

Table 4.5 Test subjects that were removed from the analysis in the Phase I study

Test Subject ID Number	Environmental Condition	SVT Score (for a total of 40)	Criteria for removal	Details
119	Normal	21	1	8.2 minutes to read the test passage
139	Normal	19	2	12 and 10 of the same SVT responses in a row
149	Normal	21	2	29 of the same SVT responses in a row
340	Extreme	22	2	22 of the same SVT responses in a row

Table 4.5 lists the test subjects from the Phase I study that fit the criteria for exclusion and were not considered in the analysis. Three people from the normal test room environmental condition and one person from the extreme condition were removed. These test subjects clearly did not take the task seriously as one completed the reading well below the two standard deviation range and the rest answered a number of questions with the same response.

In the Phase II study, there was no time data for the presentation of the reading passage since every test subject had to view the video lecture rather than reading it at their own pace. Therefore, the first criteria for excluding test subjects from the analysis cannot be used. There were no participants who fit the second criteria; therefore, all of the test subjects in Phase II study were considered in the analysis

Observing the scores from Phase I and II studies, there is a good probability that there are other test subjects who did not take their participation seriously and could have simply guessed on the quiz. However, they did not fit the two criteria for exclusion and were not removed from the analysis simply because they performed poorly. This comes down to the topic of motivation which is discussed in the analysis and discussion section.

4.2 Phase I Findings

After the demographics of the test groups were shown to be fairly even between the two test room physical environmental conditions, the results of the study were examined. The findings of the Phase I study are presented first. The Phase I experimental results, analysis and discussion and root cause analysis are shown in this section. Following the Phase I results, analysis and discussion, the same procedure is performed for the Phase II tests.

4.2.1 Phase I Experimental Results

After the Phase I tests were performed, the outputs, which included the SVT scores and the responses from the three surveys, were examined. These results are presented in this section and analyzed in the Analysis and Discussion section.

4.2.1.1 Phase I SVT Results

The SVT test was the instrument that was used to determine the test subjects' comprehension of the reading test passage. The SVT was specifically developed for this study, and it was designed to be of medium difficulty for college level students. The PANAS survey was given after the reading test passage so the SVT test was not taken immediately after passage. The test subjects' SVT scores from Phase I are presented in this section and analyzed in the Analysis and Discussion section.

The test subjects' scores on the SVT are presented by the number of questions answered correctly. Since there were a total of 40 questions the highest possible score was 40. The scores are presented by the mean values and standard deviations as well as box plots for each test room physical environmental condition. Box plots are a convenient way of graphically portraying information through the use of five number summaries [41].

A five number summary includes the values for the sample minimum, first quartile, median, third quartile, and the sample maximum. This descriptive statistic provides information about the spread of the quartiles, the location of the median and the range of the data [41]. The sample minimum and maximum are the smallest and the largest SVT scores; those values are shown by the ends of the lines or whiskers that are coming out of the box. The median is the middle number when the scores are arranged in ascending order and it is shown by the band inside the box. The first and third quartiles are the medians of the data after the scores have been split in half by the median. The first quartile represents the lowest 25 percent or the 25^{th} percentile and the third quartile corresponds to the highest 25 percent or the 75^{th} percentile of the SVT scores. Those values are represented by the bottom and the top ends of the box respectively.

The SVT scores from each experimental session were examined individually prior to combining them for the respective test room physical environmental condition. The four testing sessions in each test room conditions were plotted together. Minitab software was used to create the descriptive statistics and the box plots. The SVT results from the normal and extreme test room physical environmental conditions are shown in Figure 4.1.

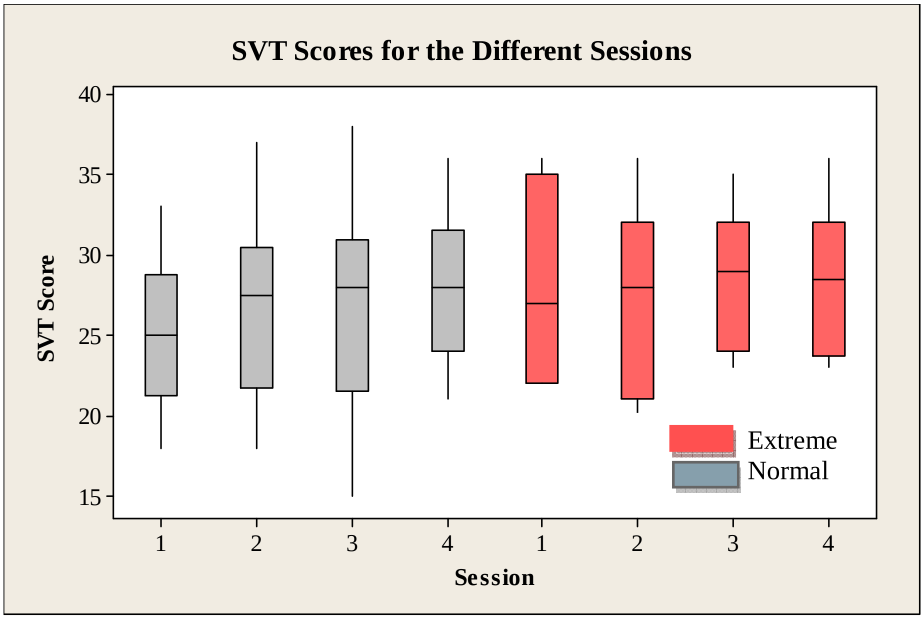


Figure 4.1 Phase I box plot for the SVT scores in the different test sessions in the normal and extreme test room environmental conditions

The results from each test session were combined for an overall statistical description in the respective test room environmental condition. After a few test subjects were removed from the analysis (described in the Test Subjects section), a total of 40 test subjects were considered in the normal test room environmental condition and 41 in the extreme condition. Table 4.6 displays the descriptive statistics such as the mean, standard deviation and the five number summary. This information is also graphically displayed by the box plot in Figure 4.2.

Table 4.6 Phase I total SVT results

Condition	N	Mean	Std Deviation	Minimum	Q1	Median	Q3	Maximum
Normal	40	26.850	5.419	15.000	23.000	27.500	31.000	38.000
Extreme	41	27.854	5.425	16.000	23.000	28.000	32.000	36.000

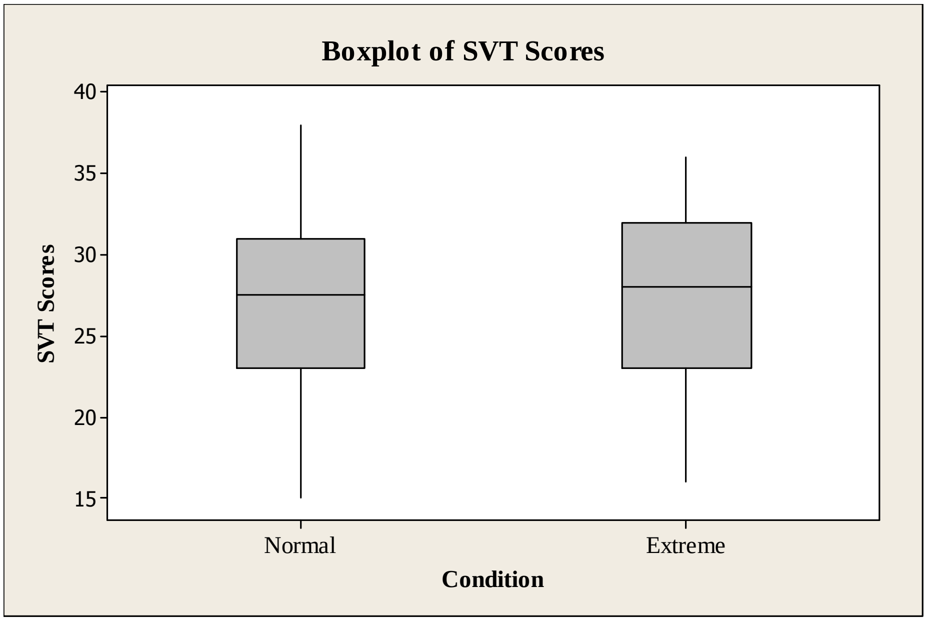


Figure 4.2 Phase I SVT results for the normal and extreme environmental test conditions

4.2.1.2 Phase I Surveys Responses

The average responses from the surveys were then examined. The surveys included the test anxiety survey, the environmental survey and the positive and negative affect scale. The responses are graphically presented next to each question for the two test room physical environmental conditions. On the tables below, the "o" indicates the location of the mean and the range, in which the brackets "[ ]" are enclosed, are the values for one standard deviation away from the mean. Next to each graphical presentation, the numerical value of the mean is listed in parenthesis followed by the standard deviation. The responses for each survey are displayed below and they are analyzed in the Analysis and Discussion section.

4.2.1.2.1 Phase I Test attitude survey responses.

Each question from the test attitude survey is shown with the responses from the normal and extreme test room physical environmental conditions. There are a total of 20 questions presented in two tables. The first 10 questions are show in Table 4.7 and questions 11-20 are shown in Table 4.8.

Table 4.7 Phase I test attitude survey questions 1-10

	Test Attitude Inventory	**Test Condition**	**Almost Never**	**Sometimes**	**Often**	**Almost Always**
			1	**2**	**3**	**4**
1	I feel confident and relaxed when taking tests					
		Normal	[--------------o----------------]			(2.49) ±1.03
		Extreme	[-----------o------------]			(2.33) ±0.82
2			**1**	**2**	**3**	**4**
	While taking examinations I have an uneasy, upset feeling	**Normal**	[--------------o--------------]			(2.07) ±0.96
		Extreme	[--------------o--------------]			(2.14) ±0.93
3			**1**	**2**	**3**	**4**
	Thinking about my grade in a course interferes with my work on tests	**Normal**	[--------------o--------------]			(2.30) ±0.99
		Extreme	[--------------o--------------]			(2.24) ±0.93
4			**1**	**2**	**3**	**4**
	I freeze up on important exams	**Normal**	[--------------o--------------]			(2.14) ±1.01
		Extreme	[-----------o-----------]			(1.79) ±0.75
5			**1**	**2**	**3**	**4**
	During exams I find myself thinkg about whether I'll ever get through school	**Normal**	[--------------o--------------]			(1.77) ±1.00
		Extreme	[-------------o-------------]			(1.83) ±0.88
6			**1**	**2**	**3**	**4**
	The harder I work at taking a test, the more confused I get	**Normal**	[------------o------------]			(1.79) ±0.80
		Extreme	[------------o------------]			(1.98) ±0.92
7			**1**	**2**	**3**	**4**
	Thoughts of doing poorly interfere with my concentration on tests	**Normal**	[----------o----------]			(1.91) ±0.81
		Extreme	[------------o------------]			(1.86) ±0.87
8			**1**	**2**	**3**	**4**
	I feel very jittery when taking an important test	**Normal**	[---------------o---------------]			(2.19) ±1.03
		Extreme	[--------------o--------------]			(2.14) ±1.00
9			**1**	**2**	**3**	**4**
	Even when I'm well prepared for a test, I feel very nervouse about it	**Normal**	[---------------o---------------]			(2.28) ±1.05
		Extreme	[-----------------o-----------------]			(2.43) ±1.13
10			**1**	**2**	**3**	**4**
	I start feeling very uneasy just before getting a test paper back	**Normal**	[------------o------------]			(2.28) ±0.88
		Extreme	[---------------o---------------]			(2.36) ±1.03

Table 4.8 Phase I test attitude survey questions 11-20

	Test Attitude Inventory	Test Condition	Almost Never	Sometimes	Often	Almost Always
			1	2	3	4
11						
	During tests I feel very tense	Normal	[--------------o--------------]			(1.95) ±0.95
		Extreme	[--------------o--------------]			(2.17) ±1.06
12			1	2	3	4
	I wish examinations did not bother me so much	Normal	[-----------------o-----------------]			(2.47) ±1.28
		Extreme	(2.76) ±1.23	[-----------------o-----------------]		
13			1	2	3	4
	During important tests I am so tense that my stomack gets upset	Normal	[-----------o-----------]			(1.56) ±0.85
		Extreme	[------------o------------]			(1.60) ±0.80
14			1	2	3	4
	I seem to defeat myself while working on important tests	Normal	[------------o------------]			(1.65) ±0.81
		Extreme	[-----------o-----------]			(1.60) ±0.83
15			1	2	3	4
	I feel very panicky when I take an important test	Normal	[--------------o--------------]			(1.91) ±1.04
		Extreme	[--------------o--------------]			(1.83) ±1.06
16			1	2	3	4
	I worry a great deal before taking an important examination	Normal	[-------------o-------------]			(2.28) ±0.98
		Extreme	[---------------o---------------]			(2.40) ±1.01
17			1	2	3	4
	During tests I find myself thinking about the consequences of failing	Normal	[--------------o--------------]			(2.09) ±0.97
		Extreme	[----------------o----------------]			(2.02) ±1.02
18			1	2	3	4
	I feel my heart beating very fast during important tests	Normal	[-------------o-------------]			(1.79) ±0.86
		Extreme	[-------------o-------------]			(1.71) ±0.89
19			1	2	3	4
	After an exam is over I try to stop worrying about it, but I can't	Normal	[-------------o-------------]			(1.81) ±0.88
		Extreme	[-------------o-------------]			(1.67) ±1.00
20			1	2	3	4
	During examinations I get so nervouse that I forget facts I really know	Normal	[--------------o--------------]			(2.12) ±1.00
		Extreme	[-------------o-------------]			(1.86) ±0.87

4.2.1.2.2 Phase I environmental survey responses.

The first part dealt with the test subjects' perception of the test room physical environment. The main questions of interest addressed to the environmental parameters of the study: temperature, noise level and lighting intensity. The second part of the environmental survey asked questions about the furniture and equipment, as well as a question about the overall comfort in the study room. The test subjects' comments are included in the appendix.

Table 4.9 Phase I first part of the environmental survey

The room moisture level was:		**too humid**		**perfect**		**too dry**
		1	2	3	4	5
	Normal			[-----o-----]		(3.05)±0.43
	Extreme			[-------------o-------------]		(2.79)±0.87
The room temperature was:		**too warm**		**perfect**		**too cool**
		1	2	3	4	5
	Normal				[-----------o-----------]	(3.63)±0.76
	Extreme		[------------o------------]			(2.26)±0.86
The room air felt:		**too stuffy**		**perfect**		**too drafty**
		1	2	3	4	5
	Normal			[---------o---------]		(3.21)±0.67
	Extreme		[-----------o-----------]			(2.17)±0.76
The room lighting was:		**too bright**		**perfect**		**too low**
		1	2	3	4	5
	Normal			[----------o----------]		(2.77)±0.61
	Extreme		[-------------o-------------]			(2.48)±0.86
Glare on my computer screen was:		**unnoticable**		**moderately noticable**		**very noticable**
		1	2	3	4	5
	Normal		[------------o------------]			(1.60)±0.90
	Extreme		[----------------o----------------]			(2.17)±1.08
The room sound levels were:		**too loud**		**perfect**		**too quiet**
		1	2	3	4	5
	Normal			[------------o------------]		(2.91)±0.81
	Extreme		[---------------o---------------]			(2.14)±0.81

Table 4.10 Phase I second part of the environmental survey

Rate your comfort with respect to the following aspects of your study environment:		**very comfortable**		**comfortable**		**very uncomfortable**
		1	2	3	4	5
Desk	Normal			[------------o------------]		(2.91)±0.89
	Extreme			[---------------o---------------]		(2.90)±1.1
Chair	Normal			[---------------o---------------]		(3.00)±1.02
	Extreme			[-----------------o-----------------]		(2.88)±1.27
Computer Keyboard	Normal			[-------------o-------------]		(2.65)±0.87
	Extreme			[------------o------------]		(2.57)±0.83
Computer Monitor	Normal			[-------------o-------------]		(2.60)±1.00
	Extreme			[------------o------------]		(2.64)±0.91
Rate your general level of comfort in the study room today.	Normal			[-------------o-------------]		(2.70)±0.89
	Extreme			[-------------o-------------]		(2.93)±1.09
In your own words, please explain why you were comfortable or uncomfortable in the study room today.						

The last part of the environmental survey dealt with factors that could have negatively affected the test subjects' task performance and attention to the task. The test subjects indicated their level of agreement/disagreement with the listed statements. The responses are split for each environmental parameter and are presented in Table 4.11, Table 4.12, Table 4.13, Table 4.14

Table 4.11 Phase I affect of temperature on the subjects' task performance and attention

Rate your level of agreenent/disagreement with the following statements		strongly agree	somewhat agree	neither agree nor dissagree	somewhat disagree	strongly disagree
		1	2	3	4	5
The room temperature negatively affected my performance on the reading and test assignments.	Normal	(3.65)±1.40		[--------------------o--------------------]		
	Extreme	(3.55)±1.47		[---------------------o---------------------]		
I had difficulty focusing my attention on the reading and test assignments because of the room temperature.	Normal	(3.72)±1.32		[--------------------o--------------------]		
	Extreme	(3.64)±1.43		[------------------o------------------]		
The room air (stuffy/drafty) negatively affected my performance on the reading and test assignments.	Normal	(3.86)±1.13		[---------------o---------------]		
	Extreme	(3.55)±1.47		[---------------------o---------------------]		
I had difficulty focusing my attention on the reading and test assignments because of the room air (stuffy/drafty).	Normal	(3.91)±1.13		[----------------o----------------]		
	Extreme	(3.45)±1.43		[-----------------o-----------------]		

Table 4.12 Phase I affect of noise on the test subjects' task performance and attention

Rate your level of agreenent/disagreement with the following statements		strongly agree	somewhat agree	neither agree nor dissagree	somewhat disagree	strongly disagree
		1	2	3	4	5
The room sound levels negatively affected my performance on the reading and test assignments.	Normal	(3.44)±1.28		[----------------o----------------]		
	Extreme	(3.26)±1.40		[--------------------o--------------------]		
I had difficulty focusing my attention on the reading and test assignments because of the room sound levels.	Normal	(3.51)±1.22		[------------------o------------------]		
	Extreme	(3.26)±1.45		[--------------------o--------------------]		

Table 4.13 Phase I affect of lighting on the test subjects' task performance and attention

Rate your level of agreenent/disagreement with the following statements		**strongly agree**	**somewhat agree**	**neither agree nor dissagree**	**somewhat disagree**	**strongly disagree**
		1	2	3	4	5
The room lighting negatively affected my performance on the reading and test assignments.	Normal	(3.88)±1.03		[---------------o---------------]		
	Extreme	(3.62)±1.41		[--------------------o--------------------]		
I had difficulty focusing my attention on the reading and test assignments because of the room lighting.	Normal	(4.02)±1.06		[-----------------o-----------------]		
	Extreme	(3.60)±1.43		[--------------------o--------------------]		
Glare on my computer screen negatively affected my performance on the reading and test assignments.	Normal	(4.07)±1.03		[---------------o---------------]		
	Extreme	(3.81)±1.27		[------------------o------------------]		
I had difficulty focusing my attention on the reading and test assignments because of the glare on my computer screen.	Normal	(4.07)±1.06		[---------------o---------------]		
	Extreme	(3.86)±1.30		[-----------------o-----------------]		

Table 4.14 Phase I affect of moisture on the test subjects' task performance and attention

Rate your level of agreenent/disagreement with the following statements		**strongly agree**	**somewhat agree**	**neither agree nor dissagree**	**somewhat disagree**	**strongly disagree**
		1	2	3	4	5
The room moisture negatively affected my performance on the reading and test assignments.	Normal	(3.86)±1.17		[------------------o------------------]		
	Extreme	(3.79)±1.16		[-----------------o-----------------]		
I had difficulty focusing my attention on the reading and test assignments because of the room moisture.	Normal	(4.09)±1.06		[---------------o---------------]		
	Extreme	(4.00)±1.10		[----------------o----------------]		

4.2.1.2.3 Phase I PANAS responses.

The Positive and Negative Affect Scale survey consisted of 20 words that describe different feelings and emotions. The test subjects had to indicate the degree to which they were experiencing each feeling at the time of the experiment. The average results are shown by two tables. The first 10 questions are presented by Table 4.15 and questions 11-20 are shown by Table 4.16

Table 4.15 Phase I PANAS affects 1-10

		Very slightly or not at all	A little	Moderately	Quite a bit	Extremely
		1	2	3	4	5
Interested	Normal	[---------------o---------------]				(2.93) ±1.18
	Extreme	[------------------o------------------]				(2.83) ±1.40
distressed	Normal	[-----------o-----------]				(1.88) ±0.93
	Extreme	[------------o------------]				(1.95) ±1.03
excited	Normal	[-------------o-------------]				(1.93) ±1.12
	Extreme	[---------------o---------------]				(2.00) ±1.21
upset	Normal	[-------o-------]				(1.35) ±0.72
	Extreme	[------------o------------]				(1.67) ±0.98
strong	Normal	[----------o----------]				(1.88) ±0.96
	Extreme	[------------o------------]				(1.98) ±1.14
guilty	Normal	[------o------]				(1.16) ±0.53
	Extreme	[---o---]				(1.10) ±0.30
scared	Normal	[-----o-----]				(1.14) ±0.41
	Extreme	[--------o--------]				(1.31) ±0.64
hostile	Normal	[-------o-------]				(1.23) ±0.57
	Extreme	[------------o------------]				(1.52) ±0.94
enthusiastic	Normal	[----------o----------]				(1.93) ±0.96
	Extreme	[---------------o---------------]				(2.17) ±1.25
proud	Normal	[---------------o---------------]				(1.86) ±1.19
	Extreme	[--------------o--------------]				(1.98) ±1.16

Table 4.16 Phase I PANAS affects 11-20

		Very slightly or not at all	A little	Moderately	Quite a bit	Extremely
		1	2	3	4	5
irritable	Normal	[-------------o-------------]				(2.09) ±1.09
	Extreme	[----------------o----------------]				(2.24) ±1.30
alert	Normal	[---------------o---------------]				(2.49) ±1.20
	Extreme	[---------------o---------------]				(2.10) ±1.12
ashamed	Normal	[-----o-----]				(1.09) ±0.37
	Extreme	[----o----]				(1.07) ±0.34
inspired	Normal	[-------------o-------------]				(2.14) ±1.08
	Extreme	[-----------------o-----------------]				(2.00) ±1.27
nervouse	Normal	[-------o-------]				(1.33) ±0.57
	Extreme	[---------o---------]				(1.48) ±0.83
determined	Normal	[-----------------o-----------------]				(2.53) ±1.33
	Extreme	[---------------o---------------]				(2.38) ±1.41
attentive	Normal	[------------------o------------------]				(2.72) ±1.22
	Extreme	[-----------------o-----------------]				(2.48) ±1.17
jittery	Normal	[------------o------------]				(1.56) ±0.85
	Extreme	[---------------o---------------]				(1.74) ±1.17
active	Normal	[----------------o----------------]				(2.19) ±1.20
	Extreme	[---------------o---------------]				(1.79) ±1.20
afraid	Normal	[-----o-----]				(1.12) ±0.32
	Extreme	[---------o---------]				(1.17) ±0.58

4.2.2 Phase I Analysis and Discussion of Results

The results presented above were analyzed for differences between the two test room physical environmental conditions. An ANOVA statistical analysis was used to compare the SVT scores and survey responses. Correlations between the SVT scores and different variables were also investigated. The reading times were analyzed for differences and for different reading patterns between the two test room physical environmental conditions. Minitab and Excel were used to analyze the results.

Prior to performing analysis, the two test groups were examined. In the Test Subjects section, the demographics of the participants were discussed. To further verify that the two test groups were evenly divided, the test anxiety survey results were studied. If there were significant differences in the responses between the two test conditions, that would be an experimental noise which could affect the results. Observing Table 4.7 and Table 4.8, it was concluded that the average responses were very similar for all of the questions between the two test room physical environmental conditions. For many of the questions, the responses very closely overlapped and there were no questions where the responses differed significantly. Based on this survey it was concluded that there were no significant differences in general test taking anxiety levels between the test subjects of the two test room physical environmental conditions. This is a further indication that the participants were evenly divided between the two test conditions.

4.2.2.1 Phase I Analysis of Variance

ANOVA was one of the methods used to analyze the data for this study. This statistical test is used to determine if two or more sample means are equal. The test uses F-distribution (probability distribution) function to compare the variation between the means to the variability within each sample [41]. This analysis was first used to determine if the mean SVT scores from all of the experimental sessions from the two test room physical environmental conditions can be considered to be from the same population. Then all of the SVT scores from the normal test room physical environmental condition and the extreme condition were analyzed for differences.

Prior to performing the analysis, the data were checked and verified for the ANOVA assumptions required to perform the test. Those included [41]:

- Independences of cases: all of the subjects were randomly assigned to conditions and sessions.
- Normal Distribution: normality test was performed on Minitab to confirm that the data were normally distributed.
- Equal Variances: variance test were performed on Minitab to verify the homogeneity of the variances between the different samples.

In order to perform the ANOVA analysis, the test hypothesis must be stated. There are two types of hypothesis. The analysis tests the null hypothesis, identified by the symbol Ho, is defined as: the means from all test groups are the same. The alternative hypothesis, identified by the symbol Ha, is defined as: there is at least one sample mean that is different. Minitab was used to perform the analysis. The P-values and the confidence interval (CI) graphs obtained from the software allow for direct conclusions whether to accept or reject the null hypothesis. An alpha significance level of 0.05, was selected which was compared to the p value. If the P-value was less than the significance level, the null hypothesis was rejected in favor of the alternative hypothesis, otherwise it was not be rejected [41].

4.2.2.1.1 Phase I ANOVA analysis between each test session.

ANOVA analysis was performed for the test sessions in the normal and the extreme condition test room physical environmental condition. The SVT scores from the four test sessions in both test conditions were analyzed for variances. One way ANOVA was performed with a significance level of 0.05. The null hypothesis Ho was stated as: the mean SVT scores between the different sessions in the same test condition are not significantly different. The alternative hypothesis Ha was stated as: at least one of the means is different. Figure 4.3 and Table 4.17 show the analysis results for the normal test room physical environmental condition.

Table 4.17 Phase I ANOVA results in the normal test condition test for sessions 1, 2, 3, 4

Source	DF	SS	MS	F	P
Factor	3	46.8	15.6	0.51	0.677
Error	36	1098.3	30.5		
Total	39	1145.1			

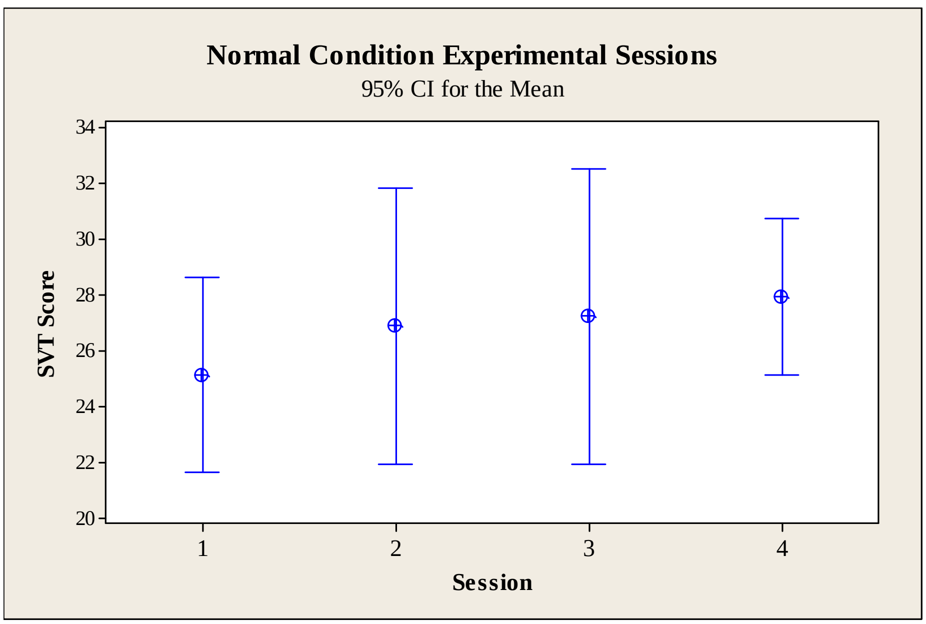


Figure 4.3 Phase I 95% CI plot for the SVT scores in the normal test condition

The P-value of 0.667 is greater than the alpha value; therefore, the null hypothesis cannot be rejected. The confidence interval graph for the means, shown in Figure 4.3, is a measure of the degree of reliability of the interval. This means that 95% of all samples would give an interval that includes the mean. Observing Figure 4.3, it was noted that the SVT scores closely overlap. This fact indicates that at 95% confidence we cannot say that the SVT scores are different. Therefore, based on the P-value and the confidence interval graph, the data from the different test sessions in the normal test room physical environmental condition can be considered to come from the same population. This allowed us to combine the SVT scores from the different test sessions under the normal test condition for further analysis.

The same analysis was performed for the four test sessions in the extreme test room physical environmental condition. The ANOVA hypotheses remained the same with Ho: the mean SVT scores between the different testing sessions are not significantly different. The alternative hypothesis Ha was stated as: at least one of the mean SVT scores is different. The analysis assumptions were checked and verified. The alpha significance value was kept at 0.05. The MINITAB results are shown in Table 4.18

Table 4.18 Phase I ANOVA results in the extreme test condition for sessions 1, 2, 3, 4

Source	DF	SS	MS	F	P
Factor	3	23.9	8	0.26	0.857
Error	37	1153.2	31.2		
Total	40	1177.1			

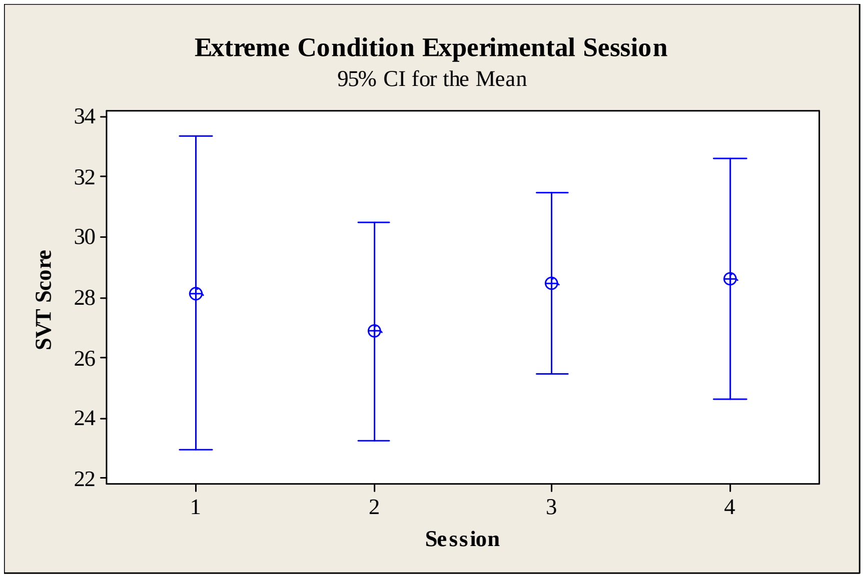


Figure 4.4 Phase I 95% CI plot for the SVT scores in the extreme test condition

In the extreme test room condition, the P-value is greater that the alpha level and the confidence interval graphs of the SVT scores from each test session greatly overlap. Therefore, for the extreme test room physical environmental condition it was concluded that the data from the four test sessions were from the same population. Thus, the SVT scores from test sessions were combined for the extreme test condition.

4.2.2.1.2 Phase I ANOVA analysis for the SVT scores between the two test conditions.

After the individual test sessions were examined and it was determined that they can be considered from the same population, the SVT scores were combined under their respective test room condition. ANOVA analysis was performed with a null hypothesis Ho stated as: there is no significant difference in the SVT scores between the two test room physical environmental conditions. The alternative hypothesis Ha was stated as:

that the SVT scores are different between the two test conditions. Alpha significance level of 0.05 was used. The ANOVA assumptions were verified prior to the analysis. The ANOVA results are shown in Table 4.19

Table 4.19 Phase I ANOVA results for the SVT scores between the two test conditions

Source	DF	SS	MS	F	P
Factor	1	20.4	20.4	0.69	0.407
Error	79	2322.2	29.4		
Total	80	2342.6			

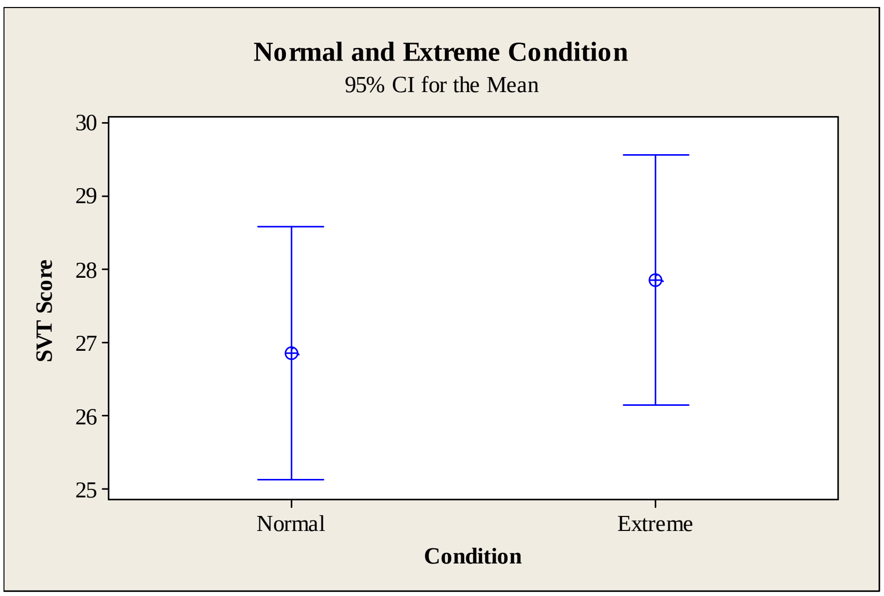


Figure 4.5 Phase I 95% CI graph for SVT scores between the two test conditions

Since the P-value is greater than the alpha level, the null hypothesis cannot be rejected that the SVT scores are different. Also, observing the confidence interval graph, the SVT scores between the two conditions greatly overlap. The P-value and the confidence interval graphs show that there was no difference in the SVT scores between the two test room physical environmental conditions. Therefore, it can be concluded that the two physical environmental conditions did not have a significant effect on the test subjects' performance for the given task. The responses from the environmental survey were then analyzed to determine how the test subjects perceived the test room physical environment.

4.2.2.1.3 Phase I ANOVA analysis of the environmental survey responses.

Since no difference was found in the SVT scores found between the two test conditions, the test subjects' responses on the environmental survey were compared. The test subjects were not aware of the physical environmental parameters that were being tested; therefore, it was of interest to determine if they perceived the test room environment as expected. The normal test room physical environmental condition levels were selected according to the standards' recommended levels for optimal comfort in a classroom. The extreme test room physical environmental condition levels were selected slightly outside of the comfort zone aimed at creating a reasonably uncomfortable environment. Therefore, it was expected the responses for the normal test condition on the environmental survey to be close to perfect and for the extreme test condition to be in the uncomfortable range. The test subjects' responses from the first part of the environmental survey are shown in Table 4.9.

From Table 4.20 it can be observed that the test subjects did not perceive the temperature in the test room exactly as it was intended. At the recommended 72 degrees Fahrenheit the test subjects in the normal test room physical environmental condition responded that they were a little bit cool. At 80 degrees Fahrenheit the test subjects in the extreme test condition indicated that they were just slightly hot. The absolute values of the differences from the test subjects' average responses to the perfect option (option 3 on the survey) were very close between the two groups; 0.63 in the normal test condition and 0.74 in the extreme test condition. ANOVA analysis indicated that there was significant difference in the test subjects' responses (P-value 0.00). However, this was due to the test subjects being slightly uncomfortable at the opposite sides of the temperature comfort zone.

Table 4.20 Phase I environmental survey temperature responses

The room temperature was:		too warm		perfect		too cool
		1	2	3	4	5
	Normal			[-----------o-----------]		(3.63)±0.76
	Extreme		[-------------o-------------]			(2.26)±0.86

The lighting responses were examined next. As it can be observed from Table 4.21 the responses for the normal test condition were close to the expected levels since they were mostly in the perfect range. The lighting responses in the extreme test condition indicated that the test subjects perceived the lighting was brighter; however, their responses were not at "extreme" levels as intended. A P-value of 0.094 indicated that there was no significant difference in the lighting responses between the two test room physical environmental conditions.

Table 4.21 Phase I environmental survey lighting responses

The room lighting was:		too bright		perfect		too low
		1	2	3	4	5
	Normal	[----------o----------]				(2.77)±0.61
	Extreme	[-------------o-------------]				(2.48)±0.86

The test subjects' responses to the sound levels were examined. From Table 4.22 it can be observed that the responses in the normal test condition were very close to perfect and that in the extreme test condition the test subjects indicated that it was loud. ANOVA P-value of 0.000 indicated that the participants in the extreme test room physical environmental condition perceived the sound to be significantly louder than in the normal test condition.

Table 4.22 Phase I environmental survey sound levels responses

The room sound levels were:		too loud		perfect		too quiet
		1	2	3	4	5
	Normal	[------------o------------]				(2.91)±0.81
	Extreme	[---------------o---------------]				(2.14)±0.81

The test subjects' overall comfort level responses were examined. From Table 4.23 it was observed that the responses were very close to one another between the two test conditions. P-value of 0.32 confirmed that there was no significant difference in the responses between the two test conditions. The 95% confidence interval graph for the responses is shown in Figure 4.6. Based on that analysis it was concluded that for the given task in the Phase I study the test subjects did not identify the normal test room condition to be significantly more comfortable than the extreme test condition.

Table 4.23 Phase I environmental survey responses for the comfort levels in the test room

Rate your comfort with respect to the following aspects of your study environment:		very comfortable		comfortable		very uncomfortable
		1	2	3	4	5
Rate your general level of comfort in the study room today.	Normal		[--------o--------]			(2.70)±0.89
	Extreme			[--------o--------]		(2.93)±1.09

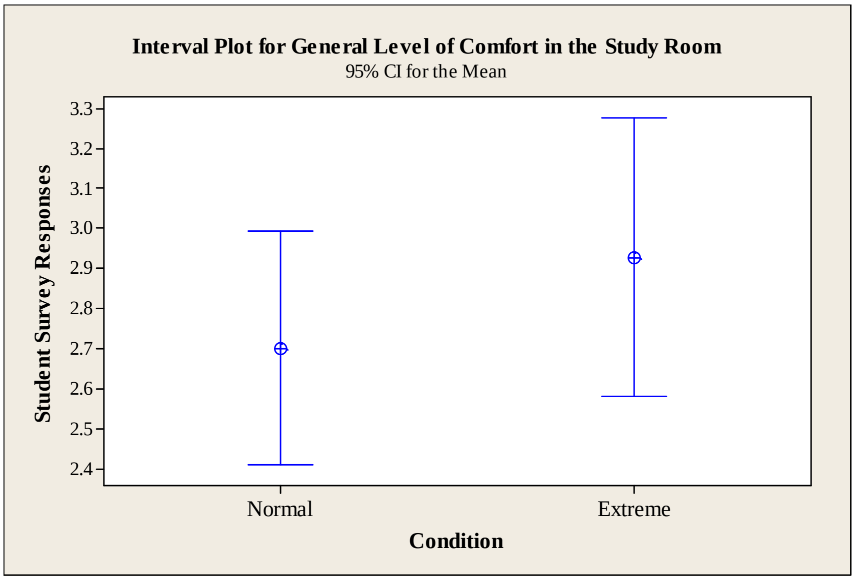


Figure 4.6 Phase I 95% CI graph for the comfort levels in the test room

Based on the environmental survey responses it was shown that the test subjects did not perceive the environmental test parameters related to temperature and lighting exactly as expected. Also, based on the test subjects' responses and their comments it was determined that for the given task their comfort level difference between the two test room physical environmental conditions was from none to very small. Therefore, further analysis was performed in which the SVT scores were compared only for the test subjects that responded to be at the intended comfort levels in their respective test condition.

4.2.2.1.4 Phase I ANOVA analysis for scores sorted by the environment responses.

Since no difference was found in SVT scores, and after it was shown that the two test room physical environmental conditions were not perceived exactly as intended by some of the test subjects, further analysis was performed. The SVT scores were sorted according to the responses on the environmental survey. Only the test subjects that perceived the extreme test room physical environmental condition as uncomfortable were considered. Those test subjects' SVT scores were compared to participants in the normal test room physical environmental condition that perceived the test environment as "perfect". Leaving out the test subjects that were not as bothered by the physical environment in the extreme test condition, and the test subjects that did not perceive the normal test condition as comfortable was aimed at comparing the participants who were at the intended comfort levels.

It is important to note that not much weight was given to the results of this analysis due to the very low number of test subjects' SVT scores that were compared. It was interesting to observe how the results would change after the test subjects were sorted according to how they perceived the test room physical environment.

The SVT scores were sorted according to how the test subjects responded to the question about the temperature in the test room shown in Table 4.20. The test subjects in the normal test condition that responded to this question with 3 (perfect) were compared to the subjects in the extreme test condition that responded with 1(too warm) and 2(warm). Twenty three test subjects from the normal test condition were compared to twenty four subjects in the extreme test condition. The SVT scores of those students were analyzed by performing ANOVA test. The results are shown in Table 4.24.

Table 4.24 Phase I ANOVA results for the SVT scores sorted by temperature responses

Source	DF	SS	MS	F	P
Factor	1	17.8	17.8	0.51	0.477
Error	42	1453.2	34.6		
Total	43	1471			

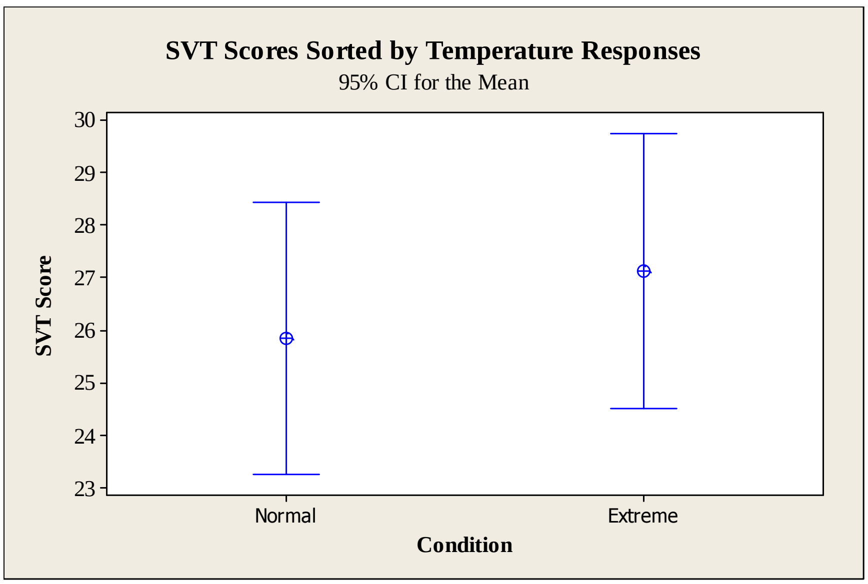


Figure 4.7 Phase I 95% CI graph for the SVT scores sorted by the temperature responses

The test subjects' SVT scores were sorted according to how they responded on the question regarding the lighting in the test room, shown in Table 4.21. The test subjects in the normal test condition that responded with 3 (perfect) were compared to the subjects in the extreme test condition that responded by 1(too bright) and 2(bright).

Thirty one participants in the normal test condition were compared to eighteen participants in the extreme condition. This big difference in the samples was expected because the majority of the test subjects in the extreme test condition responded that the lighting was not extremely bright. Not much weight was given to these results since the uneven groups and the very low number of samples. However, it was important to observe if the results would change after the test subjects' SVT scores were filtered.

Table 4.25 Phase I ANOVA results for SVT scores sorted by lighting responses

Source	DF	SS	MS	F	P
Factor	1	5.9	5.9	0.2	0.659
Error	47	1409.4	30		
Total	48	1415.3			

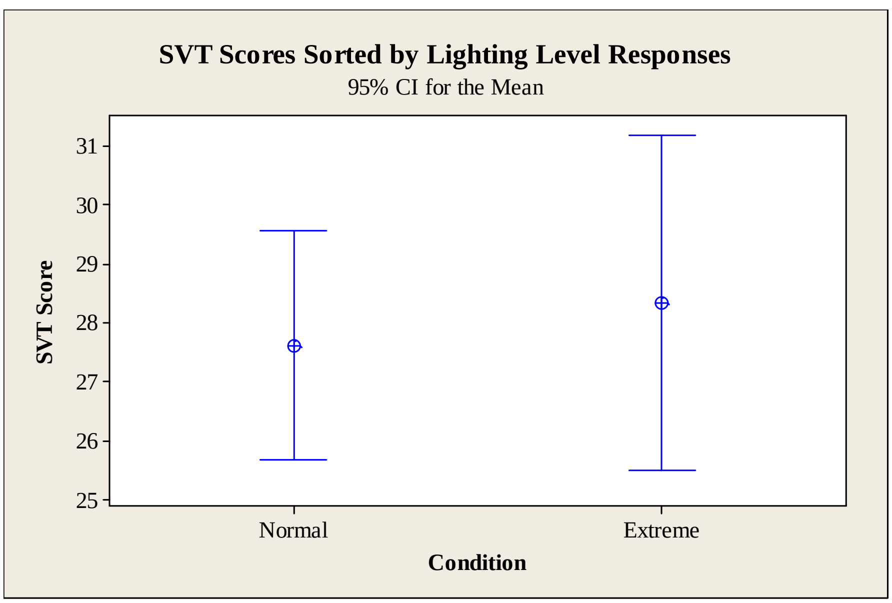


Figure 4.8 Phase I 95% CI graph for the SVT scores sorted by the lighting responses

The test subjects' SVT scores were sorted by how they responded to the question regarding the test room sound levels, shown in Table 4.22. The test subjects in the normal test condition that responded with 3 (perfect) were compared to the subjects that responded with 1 (too loud) or 2 (loud) in the extreme test condition. After filtering the SVT scores twenty three subjects in the normal test condition were compared to twenty nine in the extreme test conditions

.

Table 4.26 Phase I ANOVA results for SVT scores sorted by sound level responses

Source	DF	SS	MS	F	P
Factor	1	1.2	1.2	0.04	0.850
Error	50	1679.8	33.6		
Total	51	1681			

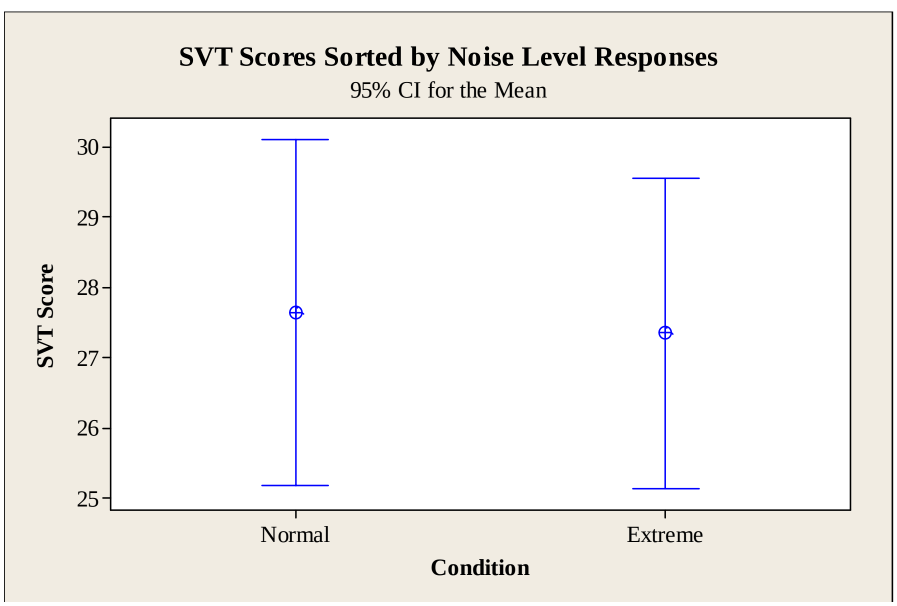


Figure 4.9 Phase I 95% CI graph for the SVT scores sorted by the sound level responses

The results from the analysis on the test subjects' scores based on their responses regarding temperature, lighting, and noise are shown above. The test subjects that responded that they were most uncomfortable were compared to the ones that were comfortable. All of the P-values are higher than the alpha value and all of the confidence interval graphs greatly overlap. Therefore, it can be concluded that even when the SVT scores are sorted by how the test subjects perceived the environment there was still no difference in the participants' SVT performance. The test subjects' scores were not sorted according to how they responded to the overall comfort level question due to the very low number of subjects in the extreme test condition that responded being uncomfortable. Since the test room physical environments were found to have no affect on the test subjects' SVT scores, other factors were examined that could have been affected by the physical environmental conditions, such as time to complete the task and mood.

4.2.2.1.5 Phase I ANOVA analysis for the reading times.

ANOVA analysis was performed to determine if there was a difference in how long the test subjects in each test room physical environmental condition spent on the reading test passage. The null hypothesis Ho was stated as: there is no significant difference in reading times between the two test conditions. The alternative hypothesis Ha was stated as: there is a difference in the reading times between the two test conditions. An alpha value of 0.05 was chosen and the ANOVA assumptions were checked and verified. The results from the analysis are shown in Table 4.27.

Table 4.27 Phase I ANOVA results for the reading times between the two test conditions

Source	DF	SS	MS	F	P
Factor	1	102.8	102.8	1.32	0.254
Error	79	6139.5	77.7		
Total	80	6242.3			

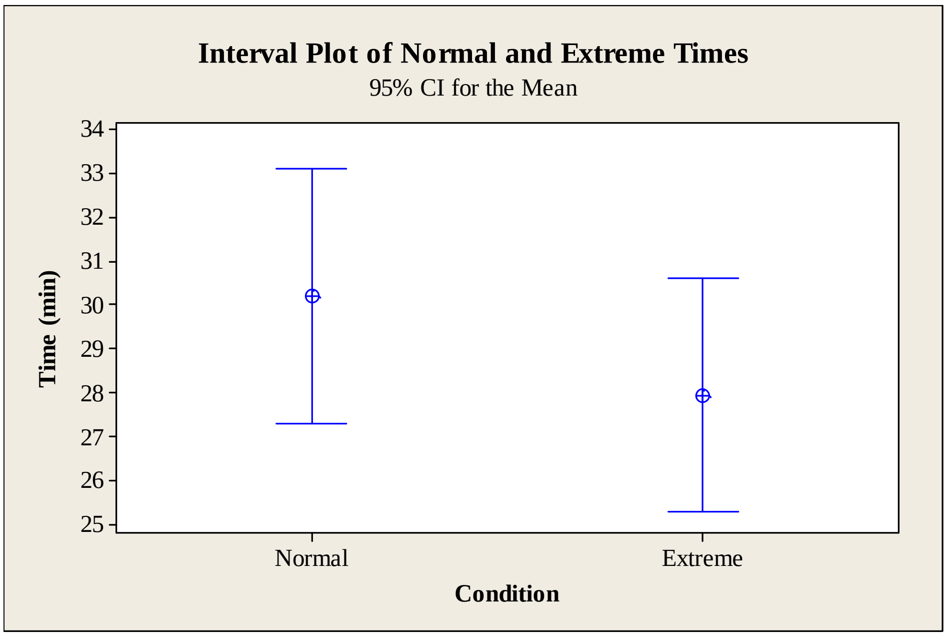


Figure 4.10 Phase I 95% CI graph for the reading times in the two test conditions

From Figure 4.10 it can be observed that the test subjects in the normal test room physical environmental condition spent on an average of two more minutes reading the passage compared to the subjects in the extreme condition. However, based on the P-value and the confidence interval graph the null hypothesis cannot be rejected; thus, the difference cannot be considered significant.

Since no difference was found between the reading times, trends of how much time the test subjects spent on each test passage segment were examined. The reading test passage had a total of 135 segments of 34 words each. The software tracked how long the test subjects spent on each segment in milliseconds. It was of interest to determine if there were different reading patterns between the two test conditions. For this purpose, the average times the test subjects spent on each segment were plotted. On Figure 4.11 the blue and red lines represent the average times the test subjects spent on each segment in the normal and extreme test room physical environmental conditions respectively.

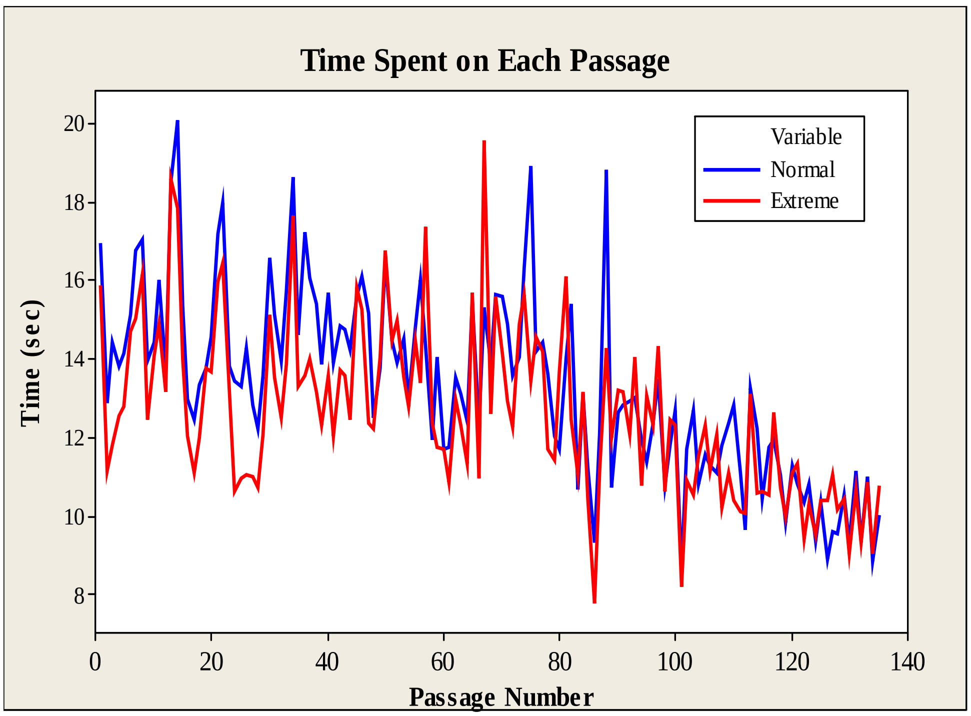


Figure 4.11 Phase I times spent on each individual reading segment

Both lines in Figure 4.11 exhibit a negative trend indicating that the test subjects spent less time on the latter test passage segments. The trends for the two test conditions are very similar to one another; therefore, it cannot be concluded that the test room physical environmental conditions caused the test subjects to exhibit different reading pattern.

4.2.2.2 Phase I Pearson Correlation Coefficients

After no difference was found in SVT scores between the two test room physical environmental conditions, the data were examined if it could provide any other information. Some of the outputs were analyzed further to determine if there was any correlation between them. For that purpose, the SVT scores, reading times, environmental survey responses, and the mood survey responses were used. Correlations between the reading times and SVT scores, overall comfort levels and SVT scores, and the overall comfort levels and the time to complete the reading were investigated for the two test conditions.

In order to determine the correlations between those outputs, Pearson correlation coefficient was used. This correlation calculates the linear relationship between two variables, and depending on the strength of the relationship a value between -1 and +1 is assigned. A value of -1 indicates a perfect negative correlation and a value of +1 indicates a perfect positive correlation. As the value approaches -0.5 or 0.5 suggests that the relationship between the variables is weaker, and a correlation value of near to 0 suggests no relationship between the variables [41].

4.2.2.2.1 Phase I Correlation between reading times and SVT scores.

The testing software tracked the time the test subjects took to read the test passage. The test subjects were able to complete the task at their own pace. Therefore, it was of interest to determine if the amount of time the subjects spent on the test reading passage correlated to how well they performed on the SVT. Figure 4.12 and Figure 4.13 present the scatter plots for those variables along with the correlation coefficient value.

The data points on Figure 4.12 and Figure 4.13 appeared to have no relationship between them, the very close to zero r-values confirmed that as well. Therefore, for the given task in the Phase I study, there was no correlation between the time it took to read the reading test passage and the SVT scores.

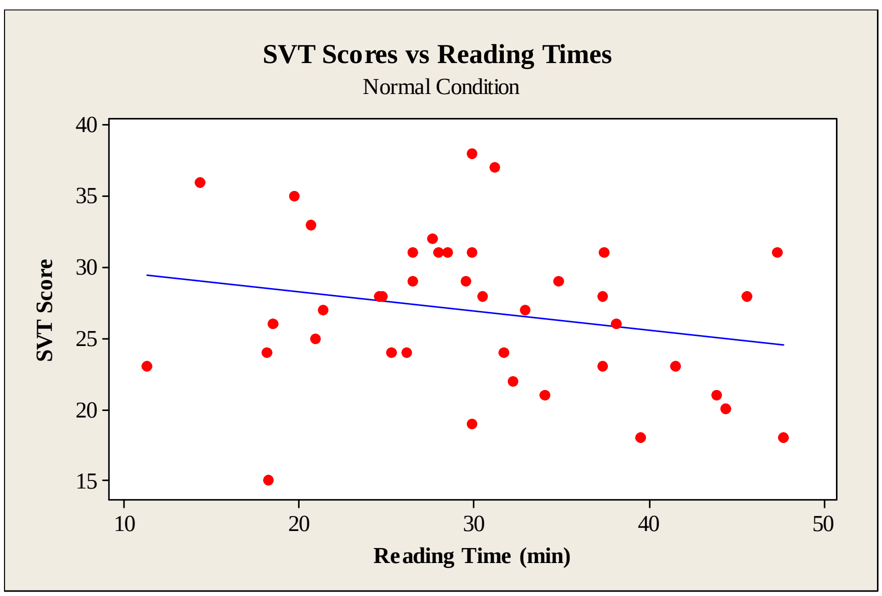


Figure 4.12 Phase I scatter plot between the reading times and the SVT scores in the normal test condition, r = -0.228

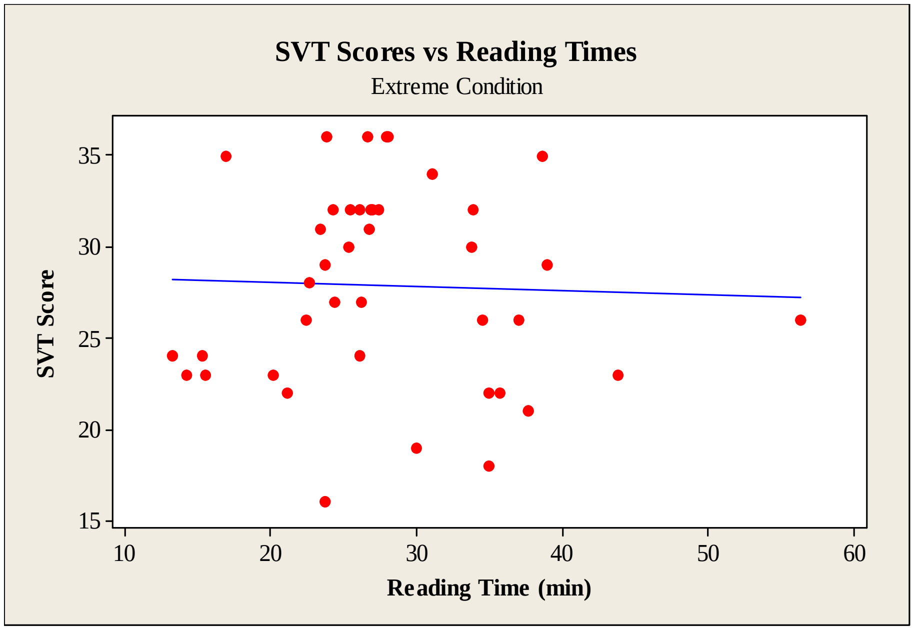


Figure 4.13 Phase I scatter plot between the reading times and the SVT scores in the extreme test condition, r = -0.037

4.2.2.2.2 Phase I Correlation between SVT Scores and the Environmental Survey

The correlations between the test subjects' responses to the environmental survey and their SVT scores were examined. The responses to the question regarding the overall comfort level in the test room were correlated with the test subjects' SVT scores. It was of interest to determine if there was correlation between the test subjects' reported comfort levels in the test room and their SVT scores. The scatter plots are shown in Figure 4.14 and Figure 4.15 for the two test conditions along with the Pearson correlation coefficients.

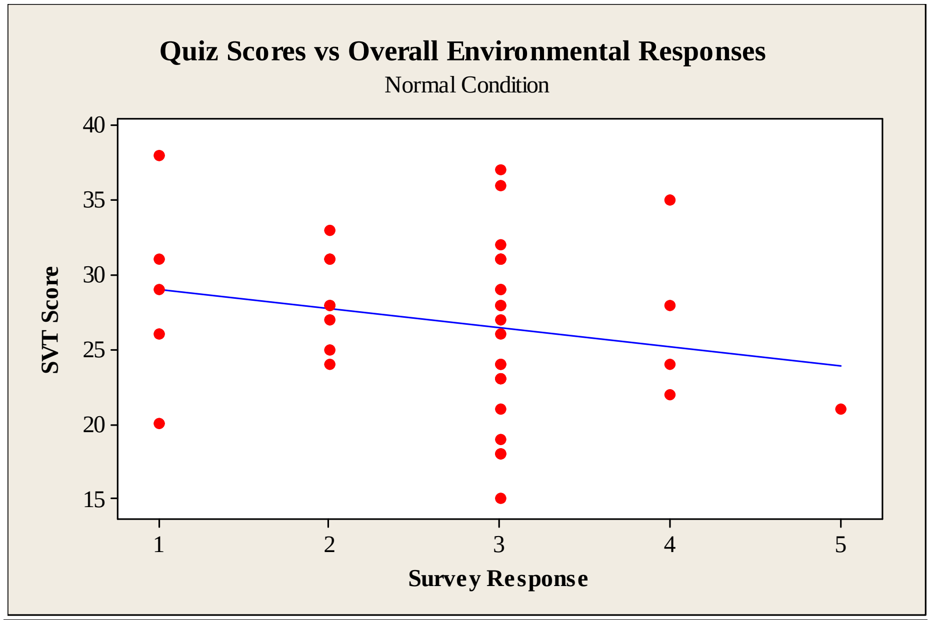


Figure 4.14 Phase I scatter plot between the SVT scores and the overall comfort levels in the normal test condition, r = -0.217

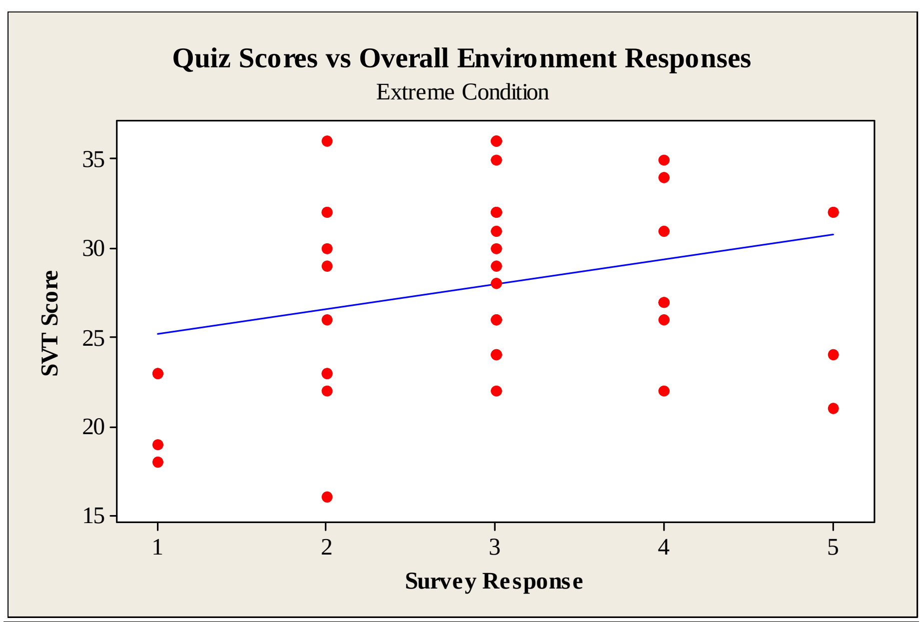


Figure 4.15 Phase I scatter plot between the SVT scores and the overall comfort levels in the extreme test, r = 0.286

The correlation coefficient values in the two test room physical environmental conditions suggest that there was no correlation between how the test subjects perceived the test room and how they scored on the SVT. The correlations between the general comfort levels and the time to complete the reading test passage indicated that there was no relationship between those variables.

4.2.2.2.3 Phase I Correlations between PANAS responses and the environmental survey

The PANAS responses, shown in Table 4.15 and Table 4.16, were analyzed for differences between the two test room physical environmental conditions as well as for correlations with other variables. It was of interest to determine if there was a relationship between how the test subjects perceived the test room physical environment and how they responded to the PANAS mood affects. Therefore, the PANAS responses were correlated to the general comfort level responses.

Two pairs of mood affects were selected to be investigated, each containing a positive and a negative affect. The first pair that was selected was the one that had the biggest difference in the average responses between the two test conditions. Those affects were “active” and “upset”. The second pair that was selected was for the affects that seems most relevant to this study. the ones that were chosen were “interested” and “irritable”. The correlations were calculated between the selected PANAS affects and the responses for the overall comfort levels in the test room, shown in Table 4.27. The responses from the other PANAS items were also examined; however, only the ones that had the biggest difference and the ones that seemed most relevant to this study are presented.

ANOVA analysis was also performed for the PANAS item responses to determine if they significantly differed between the two test room physical environmental conditions. The P-values for the four selected items are shown in Table 4.34.

Table 4.28 Phase I PANAS items that were correlated to the comfort levels

		Very slightly or not at all	A little	Moderately	Quite a bit	Extremely
		1	2	3	4	5
Interested	Normal	[----------------o----------------]				(2.93) ±1.18
	Extreme	[--------------------o--------------------]				(2.83) ±1.40
irritable	Normal	[--------------o--------------]				(2.09) ±1.09
	Extreme	[-----------------o-----------------]				(2.24) ±1.30
upset	Normal	[-------o-------]				(1.35) ±0.72
	Extreme	[-------------o-------------]				(1.67) ±0.98
active	Normal	[-----------------o-----------------]				(2.19) ±1.20
	Extreme	[----------------o----------------]				(1.79) ±1.20

Table 4.29 Phase I P-Values and correlation coefficient values between the PANAS items and the overall comfort level responses

Condition	**Correlation Coefficient**			
	PANAS affect (active)	PANAS affect (interested)	PANAS affect (upset)	PANAS affect (irritable)
Normal	0.002	-0.354	0.280	0.090
Extreme	-0.523	-0.313	0.139	0.291
P- Value	0.123	0.871	0.063	0.792

The P-values for all the PANAS items were calculated and no significant differences were found between the two test conditions. There is an indication, however, that the test subjects in the extreme test room physical environmental condition were slightly more upset than the test subjects in the normal condition. Based on the responses it can be concluded that the two test room physical environmental conditions did not significantly affect the test subjects' mood. Observing the results from Table 4.29, it can be noted that, even though the correlation levels are low, the levels in the extreme test condition were slightly higher correlated than the responses in the normal test condition. The correlation values in the normal test condition indicated that there was no relationship between how the test subjects perceived the test room and how they responded to the selected mood affects. For the extreme test condition, the negative affects were not correlated to the general comfort levels. However, there was a slight negative correlation between the test subjects' comfort level in the test room and the degree to which they were experiencing the positive affects. The correlation coefficient values were at levels which indicated only from minimal to no correlation; however, the increase in the correlations is noted from the normal to the extreme test conditions.

4.2.3 Phase I Root Cause Analysis

In the Phase I study no difference was found in the test subjects' performance on the SVT between the two test room physical environmental conditions. The cause and effect diagram is a tool used to identify possible causes that could have influenced the outcome of the study [42]. Cause and effect diagrams or "fishbone diagrams" graphically illustrates such relationships.

Constructing a cause and affect diagram can be helpful in many ways:

- Identify possible root causes, and basic reasons, for the way the results turned out,
- Determine if any interactions among the factors are affecting the results,
- By identifying such causes, corrective actions can be taken for future studies.

Ultimately, this analysis is necessary prior to making any conclusions and recommendations about the affect of the environmental test parameters on the test subjects' learning performance. The basic structure of the cause and effect diagram is shown in Figure 4.16. For this analysis, the possible causes were considered under six main categories [42].

The first step in construction the cause and effect diagram was to define an effect or a problem statement to be analyzed. An effect may be positive or negative based on the problem being discussed. For this study the problem statement was defined as: why for the given task the test subjects' SVT performance did not significantly differ between the two test room physical environmental conditions. After the problem statement was defined the horizontal line or the "spine" of the diagram was drawn pointing to the problem statement.

Next step was to identify the causes effecting the defined problem statement. The branches with the six main categories were drawn that would help identify the related causes. A commonly used main categories known as the 6Ms were used for this diagram. These were: mother nature, method, man, material, machine, and measurement.

Each main category served as a general subject matter to consider possible root causes. In order for the diagram to be helpful as many causes as possible had to be identified. The causes with specific descriptions were discussed under the relevant categories. It was possible for a root cause to apply to more than one category. That cause was then listed under all applicable categories. Increasingly more detailed levels of causes had to be listed. One way of doing this was by asking a series of questions until a possible root cause was found. The fish bone diagram with the problem statement and the six main categories is shown in Figure 4.16.

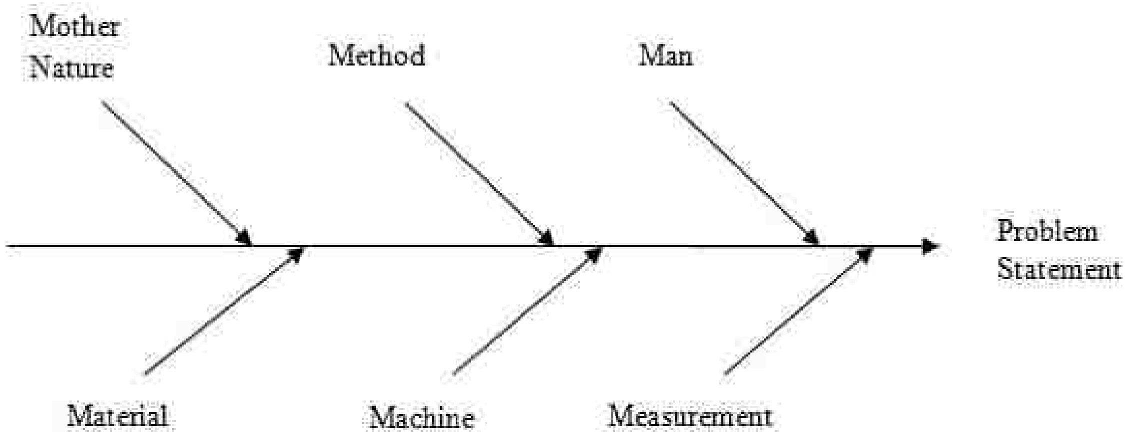


Figure 4.16 Cause and effect diagram [42]

4.2.3.1 Category "Mother Nature"

This category deals with the two test room physical environmental conditions that were created in this study. The environmental test parameter level responses are discussed under this category. The methods to produce the physical environmental conditions, such as, type of lighting or the kind of noise that was played are discussed in the material category. The idea behind the two test room physical environmental conditions was to produce one comfortable and one uncomfortable environment and to compare the test subjects' SVT performance between the two. If the test subjects' comfort levels were not as intended, that could have possibly affected the results of the study and also explain the problem statement.

In the analysis section the environmental survey responses regarding the environmental test parameters were examined. It was determined that the test subjects did not perceive the environmental test parameters exactly as intended. In the normal test room physical environmental condition, the test subjects perceived the temperature as slightly cool. In the extreme test condition, the test subjects responded that the lighting was not as bright as intended. In addition, there was no significant difference in test subjects' comfort levels between the two test room physical environmental conditions.

The selected temperature level in the normal test condition was the recommended ASHRAE temperature for optimal thermal comfort in a classroom. However, there are many factors that determine the thermal comfort, such as the person's psychological and psychical health, activity level and clothing. Besides the activity level, the research team had no control of the other factors. It is assumed that the random assignment to test room environmental conditions would even out other individual differences between the test subjects. The study took place in the third week of April in Las Vegas, during that time many students wear light or short sleeve clothing. Those test subjects are likely to feel a little bit cool in the test room. There is no information on the test subjects' type of clothing.

The noise levels appear to have produced the intended responses from the test subjects. The average responses in the normal test room physical environmental condition were mostly in the perfect range of the survey. The average responses in the extreme test condition were in the too loud and loud range of the survey. However, after further investigation of the responses in the normal test condition, there is an indication that some of the test subjects were not as comfortable as the average response value suggests. 41% of the test subjects in the normal test condition indicated that they were somewhat bothered by the constant clicking of the mice, as well as, by other noises, such as moving chairs or tapping feet. The test subjects responded differently to these noises. Some said the test room was too noisy, while others responded that the test room was too quiet. Because the test subjects responded so differently to the sound levels question when their responses were averaged the value did not show the subjects who were uncomfortable due to the background noise in the normal test condition.

According to the environmental survey, it is concluded that some of the environmental test parameter levels did not produce the intended comfort responses by the test subjects. In fact, there was no statistical difference in the general comfort level responses between the two test room physical environmental conditions. The test subjects' comments gave an indication that the subjects in the extreme test condition were slightly more uncomfortable than the subjects in the normal test condition. The insignificant difference in comfort levels between the two test room environmental conditions reduces the opportunity for detecting an effect on the test subjects' SVT performance and mood. This deviation from the indented comfort levels is considered as a root cause that can partially or fully explain the problem statement.

4.2.3.2 Category "Method"

The category method deals with the process by which the relationship between the input and output was being studied. This includes the experiment protocols and procedures the test subjects had to follow to receive full credit for their participation. The rules with which the IRB for the study was submitted were that test subjects were able to complete the task at their own pace and also no connection would be made between their names and SVT scores.

The test subjects were aware of these rules as they were listed in the experiment ad and they were also read to them at the beginning of each test session. The no time minimum to complete the task could have caused the subjects to rush through it without giving it a fair effort. Therefore, the reading times were examined and compared in the analysis section. There was no significant difference in the reading times between the two test room physical environmental conditions. The reading times were on average about thirty minutes in both test conditions. At a college level reading ability, it would take a person from thirty to thirty five minutes to read the reading test passage. Therefore, this indicates that the test subjects on average utilized most of the time to go through the reading test passage. The subjects who spent significantly shorter amounts of time (two standard deviations lower than the mean) were excluded from the analysis, as described in the Test Subjects section.

The participation given credit could have possibly reduced the motivation of the test subjects to perform at their best on the given reading task. The affect of such subjects on the results was reduced by removing them from the analysis; however, it is possible that there were others that did not give the reading task a fair effort. These test subjects possibly skewed the results and added additional variation to the SVT scores. The lack of motivational factor to give the reading task a fair effort is considered as another possible root cause that could partially explain the problem statement.

In order to have a valid study, a detailed testing protocol was developed. The procedures to conduct the study were clearly defined in order for all the test subjects to be tested exactly the same way. The protocol, as discussed in the Protocol section included everything from setting up the test room physical environmental conditions to the instructions given to the test subjects. The detailed protocol was followed closely in order to reduce variation between the different test sessions. The same test protocol was used for the Phase II study with a slight modification for the difference in presenting the information in the test passage. No issues with the test protocol were encountered in any of the testing. Besides the participation given credit no other possible root causes were found in this category.

4.2.3.3 Category "Man"

Possible root causes that fall under this category are any human errors that could have possibly occurred in this study. Under this category the student test group is also discussed. There were many possibilities where the researcher could have overlooked some details in this study. The main ones included, but are not limited to, the random assignment to test room physical environmental conditions and scheduling, setting up the test room physical environmental conditions, and running the test sessions. There are crucial steps which if done incorrectly or differently than the outlined protocol could have significantly affected the outcome of the study.

The random assigning of the test subjects to test room physical environmental conditions was done by using the random number generator in Microsoft Excel. This is a reliable and commonly used command performed and verified by knowledgeable Microsoft Excel users. There are instances in random sampling where due to "unlucky randomization" the test groups differ. In such cases, if an existing nonequivalence between the test groups is uncounted for, the output of interest could be fully or partially affected by those differences rather than the test parameters.

Typically, demographics questions, mood surveys or pretests are administered prior to the testing to obtain information about the test subjects. If any characteristics, such as age, baseline levels of mood, previous knowledge are detected to significantly differ across the test groups, they are referred to as covariates [41]. If covariates are identified, they need to be addressed in the analysis to make the test samples statistically even. If covariates are identified and accounted for that could also increase the power of the study (discussed in the "Measurement" category) [41]. The test subjects' characteristics in this study were investigated for such differences.

The demographic questions and the test anxiety responses were used to determine if the two test groups were even. In the Test Subjects section it was shown that the demographics of the subjects are fairly even between the two test groups. The test anxiety survey was discussed before the data analysis, and it was shown that there were no significant differences in the responses between the two test groups. Based on the available information, no covariates were identified between the test subjects in the two test room physical environmental conditions. Further possible effects were considered under this category.

Experienced laboratory attendants were setting up and monitoring the test room physical environmental conditions. Prior to each test session, the environmental conditions in the test room were again verified. During all of the test sessions, there was one lab attendant in the test room, and one lab attendant in the control room verifying that the environmental parameters were at their specified levels. After reviewing the experimental process, no significant human error was detected. The experimental protocol was closely followed and verified by other research team members.

The test subject pool, which was used for this study, consisted of undergraduate UNLV students. The intellectual make up of the student test group can be considered reasonably homogenous. The intellectual capabilities of the students were sufficient to be admitted to a university. Those students are typically capable of adequately adapting, coping and filtering the substandard test room physical environmental conditions. A possible root cause was identified, such that for the given task the college students that took part in the study were capable of filtering out the negative effects of the extreme test room physical environment.

4.2.3.4 Category “Material”

This category deals with the materials with which the laboratory test room was equipped to resemble a classroom. These included the furniture such as tables and chairs that were used, shown in the Furniture and Electronic Equipment in the Test Room section. Typical classroom furniture, such as the chairs and desks were used. The same furniture and layout were used in all of the testing sessions. Only a few test subjects, 7 in the normal test room physical environmental condition and 5 in the extreme condition, commented that they were somewhat uncomfortable with the chairs. The others indicated that they were either satisfactory or comfortable. There is no significant indication that the students were uncomfortable with furniture with which the room was equipped.

Other possible root causes that fall in this category is the type of noise and lighting which was used to create the two test room physical environmental conditions. A recording of a room ventilator fan was used as the noise source and one type of fluorescent lighting was used as the lighting source in this project. The ventilator fan noise had slight tonal characteristics and a broad sound spectrum. This type of noise is often present in classrooms with faulty HVAC equipment. The type of fluorescent lighting that was used in this study is typical for normal classroom environments. There is no indication that there were any root causes in the “material” category.

4.2.3.5 Category “Machine”

This category deals with the electronic equipment that was used in this study, such as the computers, the testing software and the systems and instruments producing and controlling the desired test room physical environmental conditions. Ensuring that everything works properly and smoothly was one of the main tasks that was performed in the design of experiment. A few dry runs were conducted where everything was tested for full occupancy of the test room.

For this study brand new Sony Vaio laptop computers were used, described in the Furniture and Electronic Equipment in the Test Room section. The test subjects were able to perform the task without any problems from the laptop computers. There were no negative comments from the test subjects about the equipment.

The computers were connected to a local server via a wireless router. The professionally developed testing software, that included the reading task and the surveys, was uploaded onto the local server. The testing software and the responses export function were tested numerous times to verify that they are working properly. No issues were ever detected either with the software or with the export function prior to the testing or during the actual experiments.

The equipment used in this study was tested many times prior to the testing of the subjects. The state of the art instrumentation and systems that created the two physical environmental conditions in the test room were checked and verified for accuracy. During the experiments everything worked properly and without any problems. The two physical environmental conditions were maintained at the specified levels. The test subjects did not have problems using the computers or navigating through the testing software. Therefore, no root cause was detected under this category.

4.2.3.6 Category “Measurement”

This category deals with the test instruments that were used to measure student learning performance, comfort levels and mood. These instruments detected no differences between the two test room physical environmental conditions. This indicates that the given test instruments may not have been very sensitive enough to the physical environmental parameters being tested. In completing the learning performance test instrument (test reading passage and the SVT) the test subjects were capable of filtering out the negative effects of the extreme test room physical environmental condition. Therefore, the low sensitivity of that instrument to detect an effect of the physical environmental conditions on student learning performance is considered as a possible root cause that could explain the problem statement.

The statistical power was examined to determine the ability of the learning performance test instrument to identify significant effects [41]. Statistical power evaluates, if a test is repeated many times, how often the correct interpretation of the effect can be concluded. The power is probability and its values are typically expressed in numbers between 0 and 1. In power analysis, four major components are used. These include power value, sample size, effect size, and alpha level [41]. This analysis can be used in different ways since any three of those components completely determine the forth one. Power analysis can be performed prior (priori) to an experiment to determine the sample size or after (post hoc) the data collection to determine the power in the study [41]. In this study, post hoc power analysis was performed.

The post hoc analysis is typically used in studies which did not find any significant effect to determine if there was a problem with the study or if no significant effect exists. The statistical power in the Phase I pilot study was calculated to be 0.2 or 20%. This value indicates that the performed study is highly underpowered, meaning that the given task has a low probability of finding statistically significant effect. Typically the power of a study is increased by increasing the sample size, increasing the alpha value, decreasing the standard deviation or adjusting for covariates.

Due to the subject pools that were used for this study, the number of volunteers was limited to about 80-100 per semester. Some sort of compensation will be necessary to attract additional participants. Increasing the sample size should be considered if those resources are available. Increasing the alpha value also increases the probability that any effect that is detected could be due to chance. The used value of 0.05 or 5% is typical for many studies, and there is no justification for increasing it. In the "man" category, it is shown that no covariates exist between the two test room physical environmental conditions that could be accounted for to increase the power. A motivational factor would give an incentive for all of the test subjects to give the task a fair effort and could possibly result in decreased variation among SVT scores.

4.2.3.7 Results of the Root Cause Analysis

The guidelines for creating a useful cause and effect diagram were followed in order to identify possible root causes. A problem statement was defined to determine the factors that could have influenced the results. The study protocols and instruments were examined in detail in order to explain the problem statement. After completing the analysis few main causes were identified that explain the problem statement. The possible root causes were:

- There were no significant differences in the reported test subjects comfort levels between the two classroom environmental conditions,
- The reasonably high intellectual university student test group was capable of filtering out the negative effects of the extreme test room physical environmental condition,
- The reading test instrument had a low sensitivity,
- The experiment had a low statistical power, and
- The test subjects had no motivation to give the reading task a fair effort.

The main root cause that was identified, based on the test subjects' responses, was that there was no significant difference in their comfort levels between the two test room physical environmental conditions. The fact that, in performing the reading test instrument, the test subjects did not identify the extreme test room physical environmental condition as more uncomfortable, could explain why there was no difference in student performance and mood.

The above identified root cause led to the conclusion that the reading test instrument was not sensitive enough to the test room environmental parameter levels being tested. By focusing on the computer screens, the test subject were less susceptible to the effects of the physical environmental conditions. The university test subject group that was used in this study can possibly be considered as better equipped in filtering the effects of the environment than students in public schools.

The low statistical power and the lack of motivational factor are also possible root causes that were identified. Based on the available information, it is difficult to determine the degree to which the test subjects gave the task a fair effort. Observing the SVT scores and their high standard variation suggest that there were test subjects that could have primarily guessed on the task. This fact along with the low sensitivity reading test instrument would explain the low statistical power.

Many modifications to the pilot study can be made in order to make it more likely to detect an effect of the test room physical environmental conditions on student learning performance and mood. These changes include, but are not limited to: make the extreme test condition levels more extreme, modify the reading test instrument, add motivational factor, test a more intellectually diverse test subject group, increase exposure time, or increase sample size.

For the Phase II study, it was decided to investigate the effects of the test room physical environment on student performance related to the oral presentation of the test passage. It was of interest to determine how the results from Phase I were going to change given a teaching modality that is in line with what the students (K-12) experience in a real classroom. In order to build upon the information already obtained from the Phase I tests, it was decided to explore how the outputs would change if nothing else but the teaching modality was modified. The environmental parameter levels (with an exception of slight modification to the test room background noise levels), the test protocol and test instruments were kept the same.

4.3 Phase II Findings

The Phase II study was a replication of the Phase I study with a main difference in the method of presenting the test passage. The test subjects of the Phase II study viewed an oral presentation of the test passage as opposed to reading it on a computer screen. The environmental parameter levels were kept the same with the exception of the decreased the noise level in the extreme test room physical environmental condition in order to make the speech fully intelligible. The environmental parameter levels are shown above in the Parameter Selection and Levels section in Chapter 3. It should be noted also that the Phase II study was conducted in November while the Phase I study was conducted in April.

The oral presentation was a video recording of a research team member reading the test passage. The quality of the video and audio of the recording were excellent. For the purpose of uniform speech levels across the test room, a surround sound system was used. The length of the oral presentation was 32 minutes. This is not significantly different than the average reading times from the Phase I tests. Besides the mode of presenting, the test passage the test instruments were the same; therefore, the test subjects in the Phase I and II studies spent an equal amount of time in the test room.

4.3.1 Phase II Experimental Results

The results from the Phase II tests are shown in this section. The outputs, as in the Phase I tests, included the SVT scores and the responses to the anxiety, environmental and PANAS surveys. For the purpose of presenting the results, statistical tools such as box plots and five number summaries are used, along with the mean and standard deviation. The outputs are analyzed in Phase II Analysis and Discussion section.

4.3.1.1 Phase II SVT Scores

The SVT scores shown below are graphically presented for the test subjects in each test session in the normal and extreme test room physical environmental conditions. The SVT scores are shown by the number of correct answers for a total of 40 questions. Due to the number of test subject, there were three test sessions in each test room physical environmental condition in the Phase II study. The test times and dates and the number of subjects are shown in the Test Subjects section.

The SVT scores, as in the Phase I tests, were examined individually from each test session prior to combining them under the respective test room physical environmental condition. The three test sessions in each test condition were plotted together in Figure 4.17. Minitab software was used to create the descriptive statistics and the box plots.

The SVT results from the normal and extreme test room physical environmental conditions are shown in Figure 4.18 and Table 4.30.

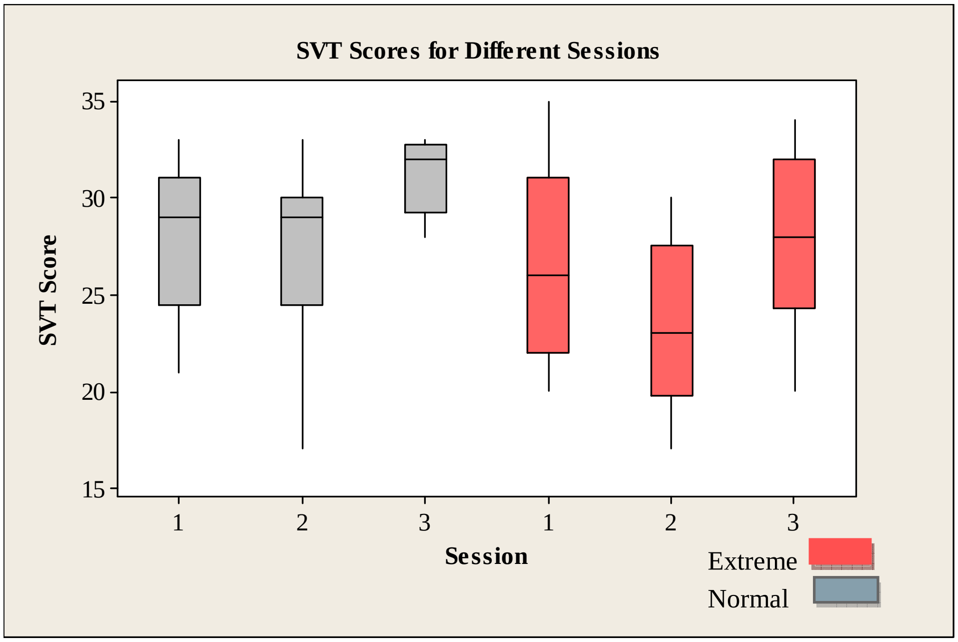


Figure 4.17 Phase II box plot for the SVT scores in the different test sessions in the normal and extreme test conditions

In Table 4.30 are shown the combined results for the normal and extreme test room physical environmental conditions. The table displays statistics of the SVT results such as the mean, standard deviation and the five number summary. The results are also graphically presented by the box plot in Figure 4.18.

Table 4.30 Phase II total SVT results

Condition	N	Mean	Std Deviation	Minimum	Q1	Median	Q3	Maximum
Normal	34	28.59	3.82	17.00	26.50	29.00	32.00	33.00
Extreme	35	26.11	4.76	17.00	22.00	26.00	30.00	35.00

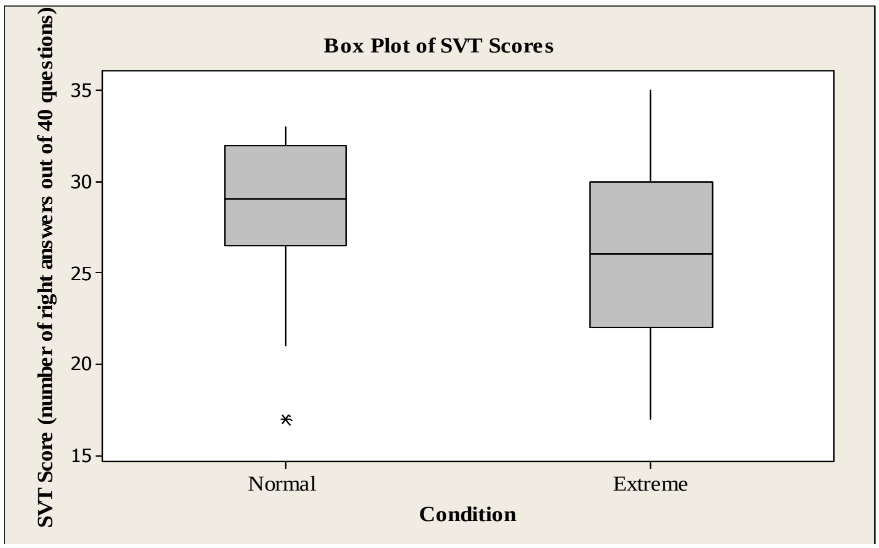


Figure 4.18 Phase II box plot for the SVT scores in normal and extreme test conditions

4.3.1.2 Phase II Survey Responses

The same surveys were administered in Phase I and II tests. The average responses from the Phase II study are shown below. The responses are shown along with the survey responses from Phase I for the purpose of easier comparison between the two test phases. Normal 1st test and Extreme 1st test correspond to the responses from the Phase I tests, conducted in April 2010. Normal 2nd test and Extreme 2nd test correspond to the responses from the Phase II tests conducted in November 2010. On the tables below the “o” indicates the location of the mean and the range of the brackets “[ ]” represents the distance of one standard deviation away from the mean.

4.3.1.2.1 Phase II anxiety survey responses.

The Phase II anxiety survey results are show in Table 4.31 and Table 4.32.

Table 4.31 Phase I and II anxiety survey questions 1-10

	Test Attitude Inventory	Test Condition	Almost Never 1	Sometimes 2	Often 3	Almost Always 4
1	I feel confident and relaxed when taking tests	Normal 1st test	[------o------]			(2.49) ±1.03
		Extreme 1st test	[------o------]			(2.33) ±0.82
		Normal 2nd test	[------o------]			(2.79) ±0.84
		Extreme 2nd test	[------o------]			(2.40) ±0.77
2	While taking examinations I have an uneasy, upset feeling	Normal 1st test	[------o------]			(2.07) ±0.96
		Extreme 1st test	[------o------]			(2.14) ±0.93
		Normal 2nd test	[------o------]			(1.71) ±0.63
		Extreme 2nd test	[------o------]			(1.89) ±0.76
3	Thinking about my grade in a course interferes with my work on tests	Normal 1st test	[------o------]			(2.30) ±0.99
		Extreme 1st test	[------o------]			(2.24) ±0.93
		Normal 2nd test	[------o------]			(1.85) ±0.89
		Extreme 2nd test	[------o------]			(2.23) ±0.88
4	I freeze up on important exams	Normal 1st test	[------o------]			(2.14) ±1.01
		Extreme 1st test	[------o------]			(1.79) ±0.75
		Normal 2nd test	[------o------]			(1.62) ±0.74
		Extreme 2nd test	[------o------]			(1.91) ±0.95
5	During exams I find myself thinkg about whether I'll ever get through school	Normal 1st test	[------o------]			(1.77) ±1.00
		Extreme 1st test	[------o------]			(1.83) ±0.88
		Normal 2nd test	[------o------]			(1.26) ±0.51
		Extreme 2nd test	[------o------]			(1.91) ±0.95
6	The harder I work at taking a test, the more confused I get	Normal 1st test	[------o------]			(1.79) ±0.80
		Extreme 1st test	[------o------]			(1.98) ±0.92
		Normal 2nd test	[------o------]			(1.47) ±0.66
		Extreme 2nd test	[------o------]			(1.97) ±0.86
7	Thoughts of doing poorly interfere with my concentration on tests	Normal 1st test	[------o------]			(1.91) ±0.81
		Extreme 1st test	[------o------]			(1.86) ±0.87
		Normal 2nd test	[------o------]			(1.71) ±0.76
		Extreme 2nd test	[------o------]			(2.06) ±1.06
8	I feel very jittery when taking an important test	Normal 1st test	[------o------]			(2.19) ±1.03
		Extreme 1st test	[------o------]			(2.14) ±1.00
		Normal 2nd test	[------o------]			(1.79) ±0.81
		Extreme 2nd test	[------o------]			(2.14) ±0.73
9	Even when I'm well prepared for a test, I feel very nervouse about it	Normal 1st test	[------o------]			(2.28) ±1.05
		Extreme 1st test	[------o------]			(2.43) ±1.13
		Normal 2nd test	[------o------]			(1.79) ±0.84
		Extreme 2nd test	[------o------]			(2.31) ±0.93
10	I start feeling very uneasy just before getting a test paper back	Normal 1st test	[------o------]			(2.28) ±0.88
		Extreme 1st test	[------o------]			(2.36) ±1.03
		Normal 2nd test	[------o------]			(2.03) ±0.94
		Extreme 2nd test	[------o------]			(2.43) ±0.95

Table 4.32 Phase I and II anxiety survey questions 11-20

	Test Attitude Inventory	Test Condition	Almost Never	Sometimes	Often	Almost Always
			1	2	3	4
11						
	During tests I feel very tense	Normal 1st test	[------o------]			(1.95) ±0.95
		Extreme 1st test	[------o------]			(2.17) ±1.06
		Normal 2nd test	[-----o-----]			(1.74) ±0.67
		Extreme 2nd test	[------o------]			(2.17) ±0.86
12			1	2	3	4
	I wish examinations did not bother me so much	Normal 1st test	[--------o--------]			(2.47) ±1.28
		Extreme 1st test	(2.76) ±1.23	[--------o--------]		
		Normal 2nd test	[-------o-------]			(2.00) ±1.04
		Extreme 2nd test	[--------o--------]			(2.49) ±1.20
13			1	2	3	4
	During important tests I am so tense that my stomack gets upset	Normal 1st test	[-----o-----]			(1.56) ±0.85
		Extreme 1st test	[------o------]			(1.60) ±0.80
		Normal 2nd test	[----o----]			(1.18) ±0.39
		Extreme 2nd test	[-----o-----]			(1.23) ±0.43
14			1	2	3	4
	I seem to defeat myself while working on important tests	Normal 1st test	[------o------]			(1.65) ±0.81
		Extreme 1st test	[------o------]			(1.60) ±0.83
		Normal 2nd test	[-----o-----]			(1.44) ±0.66
		Extreme 2nd test	[------o------]			(1.69) ±0.90
15			1	2	3	4
	I feel very panicky when I take an important test	Normal 1st test	[-------o-------]			(1.91) ±1.04
		Extreme 1st test	[-------o-------]			(1.83) ±1.06
		Normal 2nd test	[-----o-----]			(1.38) ±0.60
		Extreme 2nd test	[------o------]			(1.63) ±0.88
16			1	2	3	4
	I worry a great deal before taking an important examination	Normal 1st test	[-------o-------]			(2.28) ±0.98
		Extreme 1st test	[--------o--------]			(2.40) ±1.01
		Normal 2nd test	[-------o-------]			(2.12) ±1.00
		Extreme 2nd test	[--------o--------]			(2.17) ±1.01
17			1	2	3	4
	During tests I find myself thinking about the consequences of failing	Normal 1st test	[-------o-------]			(2.09) ±0.97
		Extreme 1st test	[--------o--------]			(2.02) ±1.02
		Normal 2nd test	[-----o-----]			(1.56) ±0.70
		Extreme 2nd test	[-------o-------]			(2.23) ±1.03
18			1	2	3	4
	I feel my heart beating very fast during important tests	Normal 1st test	[------o------]			(1.79) ±0.86
		Extreme 1st test	[------o------]			(1.71) ±0.89
		Normal 2nd test	[-----o-----]			(1.44) ±0.66
		Extreme 2nd test	[-----o-----]			(1.43) ±0.61
19			1	2	3	4
	After an exam is over I try to stop worrying about it, but I can't	Normal 1st test	[------o------]			(1.81) ±0.88
		Extreme 1st test	[------o------]			(1.67) ±1.00
		Normal 2nd test	[-----o-----]			(1.44) ±0.56
		Extreme 2nd test	[------o------]			(1.60) ±0.88
20			1	2	3	4
	During examinations I get so nervouse that I forget facts I really know	Normal 1st test	[-------o-------]			(2.12) ±1.00
		Extreme 1st test	[------o------]			(1.86) ±0.87
		Normal 2nd test	[------o------]			(1.68) ±0.73
		Extreme 2nd test	[-------o-------]			(2.00) ±1.00

4.3.1.2.2 Phase II environmental survey responses.

The average survey responses from the three part environmental survey are shown below. The tables also include the responses from the Phase I study. In the third part of the environmental survey, the questions about each environmental parameter are shown separately.

Table 4.33 Phase I and II first part of the environmental survey

The room moisture level was:		**too humid**		**perfect**		**too dry**
		1	2	3	4	5
	Normal 1st test	[-----o-----]				(3.05)±0.43
	Extreme 1st test	[--------------o--------------]				(2.79)±0.87
	Normal 2nd test	[-------o-------]				(3.09)±0.51
	Extreme 2nd test	[----------------o----------------]				(2.74)±0.98
The room temperature was:		**too warm**		**perfect**		**too cool**
		1	2	3	4	5
	Normal 1st test	[-----------o-----------]				(3.63)±0.76
	Extreme 1st test	[-------------o-------------]				(2.26)±0.86
	Normal 2nd test	[-----------o----------]				(3.38)±0.74
	Extreme 2nd test	[-------------o-------------]				(1.80)±0.83
The room air felt:		**too stuffy**		**perfect**		**too drafty**
		1	2	3	4	5
	Normal 1st test	[---------o---------]				(3.21)±0.67
	Extreme 1st test	[-----------o-----------]				(2.17)±0.76
	Normal 2nd test	[---------------o---------------]				(3.30)±0.87
	Extreme 2nd test	[------------------o------------------]				(2.29)±1.15
The room lighting was:		**too bright**		**perfect**		**too low**
		1	2	3	4	5
	Normal 1st test	[----------o----------]				(2.77)±0.61
	Extreme 1st test	[-------------o-------------]				(2.48)±0.86
	Normal 2nd test	[-----------o-----------]				(2.59)±0.70
	Extreme 2nd test	[--------------o--------------]				(2.06)±0.94
Glare on my computer screen was:		**unnoticable**		**moderately noticable**		**very noticable**
		1	2	3	4	5
	Normal 1st test	[------------o------------]				(1.60)±0.90
	Extreme 1st test	[----------------o----------------]				(2.17)±1.08
	Normal 2nd test	[-----------------o-----------------]				(1.94)±1.15
	Extreme 2nd test	[----------------o----------------]				(1.83)±1.12
The room sound levels were:		**too loud**		**perfect**		**too quiet**
		1	2	3	4	5
	Normal 1st test	[------------o------------]				(2.91)±0.81
	Extreme 1st test	[--------------o--------------]				(2.14)±0.81
	Normal 2nd test	[------o------]				(3.12)±0.41
	Extreme 2nd test	[-----------------o-----------------]				(2.49)±1.07

Table 4.34 Phase I and II second part of the environmental survey

Rate your comfort with respect to the following aspects of your study environment:		**very comfortable**		**comfortable**		**very uncomfortable**
		1	2	3	4	5
Desk	Normal 1st test			[------------o------------]		(2.91)±0.89
	Extreme 1st test			[--------------o--------------]		(2.90)±1.10
	Normal 2nd test			[-------------o-------------]		(2.76)±0.99
	Extreme 2nd test			[--------------o--------------]		(2.97)±0.86
Chair	Normal 1st test			[---------------o---------------]		(3.00)±1.02
	Extreme 1st test			[-----------------o-----------------]		(2.88)±1.27
	Normal 2nd test			[-----------------o-----------------]		(3.00)±1.18
	Extreme 2nd test			[---------------o---------------]		(3.03)±0.98
Computer Keyboard	Normal 1st test			[-------------o-------------]		(2.65)±0.87
	Extreme 1st test			[------------o------------]		(2.57)±0.83
	Normal 2nd test			[-------------o-------------]		(2.68)±0.84
	Extreme 2nd test			[---------------o---------------]		(2.74)±1.07
Computer Monitor	Normal 1st test			[-------------o-------------]		(2.60)±1.00
	Extreme 1st test			[------------o------------]		(2.64)±0.91
	Normal 2nd test			[------------o------------]		(2.56)±0.79
	Extreme 2nd test			[---------------o---------------]		(2.71)±0.99
Rate your general level of comfort in the study room today.	Normal 1st test			[-------------o-------------]		(2.70)±0.89
	Extreme 1st test			[-------------o-------------]		(2.93)±1.09
	Normal 2nd test			[---------------o---------------]		(2.62)±0.99
	Extreme 2nd test			[------------o------------]		(3.31)±0.83
In your own words, please explain why you were comfortable or uncomfortable in the study room today.						

Table 4.35 Phase I and II third part of the environmental survey regarding the moisture

Rate your level of agreenent/disagreement with the following statements		**strongly agree**	**somewhat agree**	**neither agree nor dissagree**	**somewhat disagree**	**strongly disagree**
		1	2	3	4	5
The room moisture negatively affected my performance on the reading and test assignments.	Normal 1st test	(3.86)±1.17			[------------------o------------------]	
	Extreme 1st test	(3.79)±1.16			[-----------------o-----------------]	
	Normal 2nd test	(4.24)±1.10			[-----------------o-----------------]	
	Extreme 2nd test	(3.83)±1.27			[-----------------o-----------------]	
I had difficulty focusing my attention on the reading and test assignments because of the room moisture.	Normal 1st test	(4.09)±1.06			[--------------o--------------]	
	Extreme 1st test	(4.00)±1.10			[----------------o----------------]	
	Normal 2nd test	(4.26)±1.14			[-----------------o-----------------]	
	Extreme 2nd test	(3.91)±1.31			[-----------------o-----------------]	

Table 4.36 Phase I and II third part of the environmental survey regarding temperature

Rate your level of agreenent/disagreement with the following statements		**strongly agree**	**somewhat agree**	**neither agree nor dissagree**	**somewhat disagree**	**strongly disagree**
		1	2	3	4	5
The room temperature negatively affected my performance on the reading and test assignments.	Normal 1st test	(3.65)±1.40				
	Extreme 1st test	(3.55)±1.47				
	Normal 2nd test	(4.06)±1.28				
	Extreme 2nd test	(3.34)±1.49				
I had difficulty focusing my attention on the reading and test assignments because of the room temperature.	Normal 1st test	(3.72)±1.32				
	Extreme 1st test	(3.64)±1.43				
	Normal 2nd test	(4.06)±1.28				
	Extreme 2nd test	(3.14)±1.44				
The room air (stuffy/drafty) negatively affected my performance on the reading and test assignments.	Normal 1st test	(3.86)±1.13				
	Extreme 1st test	(3.55)±1.47				
	Normal 2nd test	(4.06)±1.28				
	Extreme 2nd test	(3.48)±1.34				
I had difficulty focusing my attention on the reading and test assignments because of the room air (stuffy/drafty).	Normal 1st test	(3.91)±1.13				
	Extreme 1st test	(3.45)±1.43				
	Normal 2nd test	(4.12)±1.23				
	Extreme 2nd test	(3.63)±1.26				

Table 4.37 Phase I and II third part of the environmental survey regarding the noise levels

Rate your level of agreenent/disagreement with the following statements		**strongly agree**	**somewhat agree**	**neither agree nor dissagree**	**somewhat disagree**	**strongly disagree**
		1	2	3	4	5
The room sound levels negatively affected my performance on the reading and test assignments.	Normal 1st test	(3.44)±1.28				
	Extreme 1st test	(3.26)±1.40				
	Normal 2nd test	(4.24)±1.28				
	Extreme 2nd test	(3.46)±1.44				
I had difficulty focusing my attention on the reading and test assignments because of the room sound levels.	Normal 1st test	(3.51)±1.22				
	Extreme 1st test	(3.26)±1.45				
	Normal 2nd test	(4.29)±1.22				
	Extreme 2nd test	(3.54)±1.38				

Table 4.38 Phase I and II third part of the environmental survey regarding the lighting

Rate your level of agreenent/disagreement with the following statements		**strongly agree**	**somewhat agree**	**neither agree nor dissagree**	**somewhat disagree**	**strongly disagree**
		1	2	3	4	5
The room lighting negatively affected my performance on the reading and test assignments.	Normal 1st test	(3.88)±1.03	[--------------o--------------]			
	Extreme 1st test	(3.62)±1.41	[--------------------o--------------------]			
	Normal 2nd test	(3.94)±1.41	[--------------------o--------------------]			
	Extreme 2nd test	(3.69)±1.39	[--------------------o--------------------]			
I had difficulty focusing my attention on the reading and test assignments because of the room lighting.	Normal 1st test	(4.02)±1.06	[----------------o----------------]			
	Extreme 1st test	(3.60)±1.43	[--------------------o--------------------]			
	Normal 2nd test	(3.97)±1.38	[--------------------o--------------------]			
	Extreme 2nd test	(3.69)±1.41	[--------------------o--------------------]			
Glare on my computer screen negatively affected my performance on the reading and test assignments.	Normal 1st test	(4.07)±1.03	[--------------o--------------]			
	Extreme 1st test	(3.81)±1.27	[------------------o------------------]			
	Normal 2nd test	(4.12)±1.20	[----------------o----------------]			
	Extreme 2nd test	(4.20)±0.96	[--------------o--------------]			
I had difficulty focusing my attention on the reading and test assignments because of the glare on my computer screen.	Normal 1st test	(4.07)±1.06	[--------------o--------------]			
	Extreme 1st test	(3.86)±1.30	[-----------------o-----------------]			
	Normal 2nd test	(4.29)±1.06	[----------------o----------------]			
	Extreme 2nd test	(4.17)±1.04	[---------------o---------------]			

4.3.1.2.3 Phase II PANAS responses.

The average responses from the PANAS survey are shown in Table 4.39 and Table 4.40. The responses are presented for the Phase I and II tests. Normal 1st test and Extreme 1st test are the responses from the Phase I tests, and Normal 2nd and Extreme 2nd are the responses from the Phase II tests.

Table 4.39 Phase I and II affects 1-10 of the PANAS

		Very slightly or not at all	A little	Moderately	Quite a bit	Extremely
		1	2	3	4	5
Interested	Normal 1st test	[----------------o----------------]				(2.93) ±1.18
	Extreme 1st test	[-------------------o-------------------]				(2.83) ±1.40
	Normal 2nd test	[--------------o--------------]				(2.15) ±1.05
	Extreme 2nd test	[-------------o-------------]				(1.86) ±1.06
distressed	Normal 1st test	[------------o------------]				(1.88) ±0.93
	Extreme 1st test	[-------------o-------------]				(1.95) ±1.03
	Normal 2nd test	[-----------o-----------]				(1.53) ±0.83
	Extreme 2nd test	[--------------o--------------]				(1.89) ±1.16
excited	Normal 1st test	[--------------o--------------]				(1.93) ±1.12
	Extreme 1st test	[----------------o----------------]				(2.00) ±1.21
	Normal 2nd test	[---------o---------]				(1.35) ±0.88
	Extreme 2nd test	[------------o------------]				(1.43) ±0.70
upset	Normal 1st test	[-------o-------]				(1.35) ±0.72
	Extreme 1st test	[-------------o-------------]				(1.67) ±0.98
	Normal 2nd test	[-------o-------]				(1.44) ±0.82
	Extreme 2nd test	[----------o----------]				(1.57) ±0.81
strong	Normal 1st test	[----------o----------]				(1.88) ±0.96
	Extreme 1st test	[-------------o-------------]				(1.98) ±1.14
	Normal 2nd test	[------------o------------]				(1.94) ±1.10
	Extreme 2nd test	[--------------o--------------]				(2.06) ±1.21
guilty	Normal 1st test	[------o------]				(1.16) ±0.53
	Extreme 1st test	[---o---]				(1.10) ±0.30
	Normal 2nd test	[---------o---------]				(1.41) ±0.93
	Extreme 2nd test	[-----o-----]				(1.26) ±0.61
scared	Normal 1st test	[-----o-----]				(1.14) ±0.41
	Extreme 1st test	[--------o--------]				(1.31) ±0.64
	Normal 2nd test	[-----o-----]				(1.20) ±0.54
	Extreme 2nd test	[-----o------]				(1.17) ±0.57
hostile	Normal 1st test	[-------o-------]				(1.23) ±0.57
	Extreme 1st test	[-------------o-------------]				(1.52) ±0.94
	Normal 2nd test	[----o----]				(1.15) ±0.50
	Extreme 2nd test	[----o----]				(1.17) ±0.45
enthusiastic	Normal 1st test	[----------o----------]				(1.93) ±0.96
	Extreme 1st test	[----------------o----------------]				(2.17) ±1.25
	Normal 2nd test	[-------------o-------------]				(1.79) ±1.04
	Extreme 2nd test	[---------------o---------------]				(1.94) ±1.11
proud	Normal 1st test	[----------------o----------------]				(1.86) ±1.19
	Extreme 1st test	[---------------o---------------]				(1.98) ±1.16
	Normal 2nd test	[----------------o----------------]				(1.85) ±1.10
	Extreme 2nd test	[--------------------o--------------------]				(2.14) ±1.40

Table 4.40 Phase I and II affects 11-20 of the PANAS

		Very slightly or not at all	A little	Moderately	Quite a bit	Extremely
		1	2	3	4	5
irritable	Normal 1st test	[-------------o-------------]				(2.09) ±1.09
	Extreme 1st test	[----------------o----------------]				(2.24) ±1.30
	Normal 2nd test	[-----------o-----------]				(1.56) ±0.93
	Extreme 2nd test	[--------------o--------------]				(2.14) ±1.12
alert	Normal 1st test	[---------------o---------------]				(2.49) ±1.20
	Extreme 1st test	[---------------o---------------]				(2.10) ±1.12
	Normal 2nd test	[--------------o--------------]				(2.38) ±1.07
	Extreme 2nd test	[--------------o--------------]				(2.37) ±1.14
ashamed	Normal 1st test	[-----o-----]				(1.09) ±0.37
	Extreme 1st test	[----o----]				(1.07) ±0.34
	Normal 2nd test	[-----o-----]				(1.12) ±0.48
	Extreme 2nd test	[-------o------]				(1.23) ±0.64
inspired	Normal 1st test	[-------------o-------------]				(2.14) ±1.08
	Extreme 1st test	[-----------------o-----------------]				(2.00) ±1.27
	Normal 2nd test	[------------o------------]				(1.82) ±1.09
	Extreme 2nd test	[---------------o---------------]				(2.03) ±1.20
nervouse	Normal 1st test	[-------o-------]				(1.33) ±0.57
	Extreme 1st test	[---------o---------]				(1.48) ±0.83
	Normal 2nd test	[---------o---------]				(1.38) ±0.74
	Extreme 2nd test	[---------o---------]				(1.37) ±0.77
determined	Normal 1st test	[-----------------o-----------------]				(2.53) ±1.33
	Extreme 1st test	[---------------o---------------]				(2.38) ±1.41
	Normal 2nd test	[------------------o------------------]				(2.15) ±1.31
	Extreme 2nd test	[------------------o------------------]				(2.49) ±1.42
attentive	Normal 1st test	[-------------------o-------------------]				(2.72) ±1.22
	Extreme 1st test	[-----------------o-----------------]				(2.48) ±1.17
	Normal 2nd test	[-----------------o-----------------]				(2.62) ±1.18
	Extreme 2nd test	[---------------o---------------]				(2.40) ±1.12
jittery	Normal 1st test	[-----------o-----------]				(1.56) ±0.85
	Extreme 1st test	[---------------o---------------]				(1.74) ±1.17
	Normal 2nd test	[--------------o--------------]				(1.56) ±1.02
	Extreme 2nd test	[---------------o---------------]				(1.74) ±0.92
active	Normal 1st test	[---------------o---------------]				(2.19) ±1.20
	Extreme 1st test	[---------------o---------------]				(1.79) ±1.20
	Normal 2nd test	[------------------o------------------]				(1.92) ±1.23
	Extreme 2nd test	[------------------o------------------]				(2.14) ±1.26
afraid	Normal 1st test	[-----o-----]				(1.12) ±0.32
	Extreme 1st test	[---------o---------]				(1.17) ±0.58
	Normal 2nd test	[------o------]				(1.15) ±0.44
	Extreme 2nd test	[-------o-------]				(1.17) ±0.45

4.3.2 Phase II Analysis and Discussion of the Results

The results from the Phase II tests were analyzed by using the same statistical methods as in the Phase I tests. ANOVA analysis was used to determine if there are any differences in SVT scores and survey responses between the two test room physical environmental conditions. Correlation analysis was used to identify relationships between different variables. There was no time data as in the Phase I study since the test subjects had to view the oral presentation, rather than go through the reading test passage at their own pace. Therefore, no time analysis was performed in the Phase II study.

Prior to statistically comparing the two test room physical environmental conditions, the available information on the test subjects was observed to determine if the two samples can be considered even. The demographics of the subjects, shown in the Test Subjects section, indicated that there were no significant differences between the two test conditions. The test anxiety survey responses, shown in Table 4.31 and Table 4.32, indicated that the test subjects in the two test room physical environmental conditions experienced similar levels of anxiety during the tests. Based on the test subjects' information, it was concluded that the two test conditions were fairly even.

The demographics of the test subjects between the Phase I and Phase II were also compared. With the exception that Phase I had slightly higher number of test subjects there were no significant differences in either the demographics or the anxiety questions. Therefore, based on the available information the test subject groups from the Phase I and Phase II tests can also be considered even.

4.3.2.1 Phase II Analysis of Variance

The ANOVA analysis was first used to determine if there were any differences between the individual test sessions at each test room physical environmental condition. The results from that analysis would indicate whether the SVT scores from the test sessions in the same test condition can be assumed to come from the same population. ANOVA was then performed to determine if there was a difference in the SVT performance of the test subjects between the two test room physical environmental conditions.

4.2.2.1.1 Phase II ANOVA analysis between each testing session.

The SVT scores between the three test sessions in each physical environmental condition were analyzed for differences. One way ANOVA was performed with a significance level of 0.05. The null hypothesis Ho was stated as: the SVT scores between the different test sessions for the same test room physical environmental condition are not significantly different. The alternative hypothesis Ha was stated as: the SVT scores in at least one of the test sessions are different. Prior to performing the analysis, the ANOVA assumptions was checked and verified. The results from the analysis in the normal test room physical environmental condition are shown in Table 4.41 and Figure 4.19..

Table 4.41 Phase II ANOVA results for normal test condition sessions 1, 2, 3

Source	DF	SS	MS	F	P
Factor	2	69.2	34.6	2.6	0.091
Error	31	413	13.3		
Total	33	482.2			

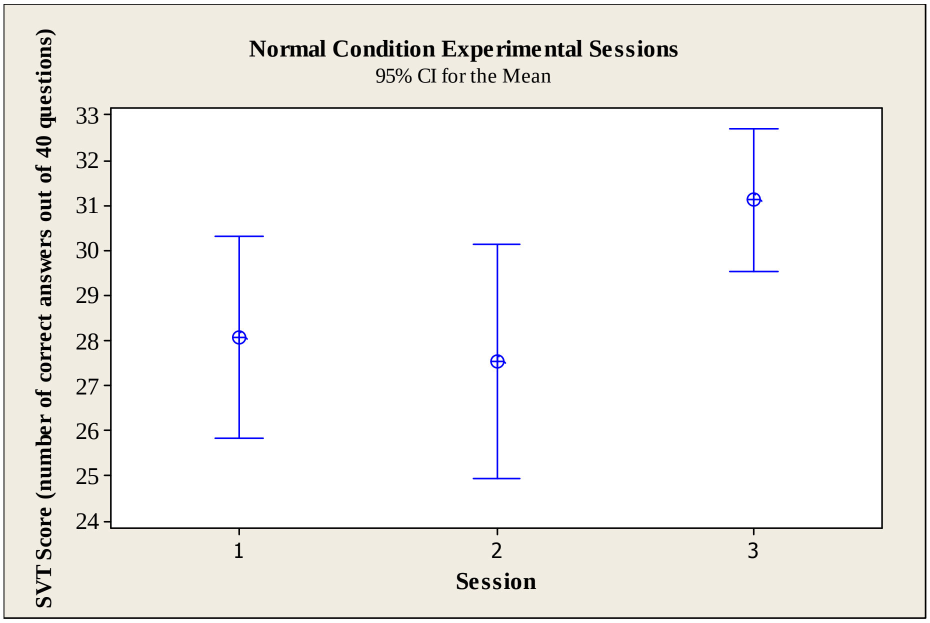


Figure 4.19 Phase II 95% CI plot for the SVT scores in the normal test condition

The same analysis was performed for the SVT scores in the extreme test room physical environmental condition. The ANOVA hypothesis and alpha significance values remain the same. The ANOVA assumptions were also verified prior to performing the analysis. The results are shown in Table 4.42 and Figure 4.20.

Table 4.42 Phase II ANOVA results for extreme test condition sessions 1, 2, 3

Source	DF	SS	MS	F	P
Factor	2	107.1	53.6	2.59	0.091
Error	32	662.4	20.7		
Total	34	769.5			

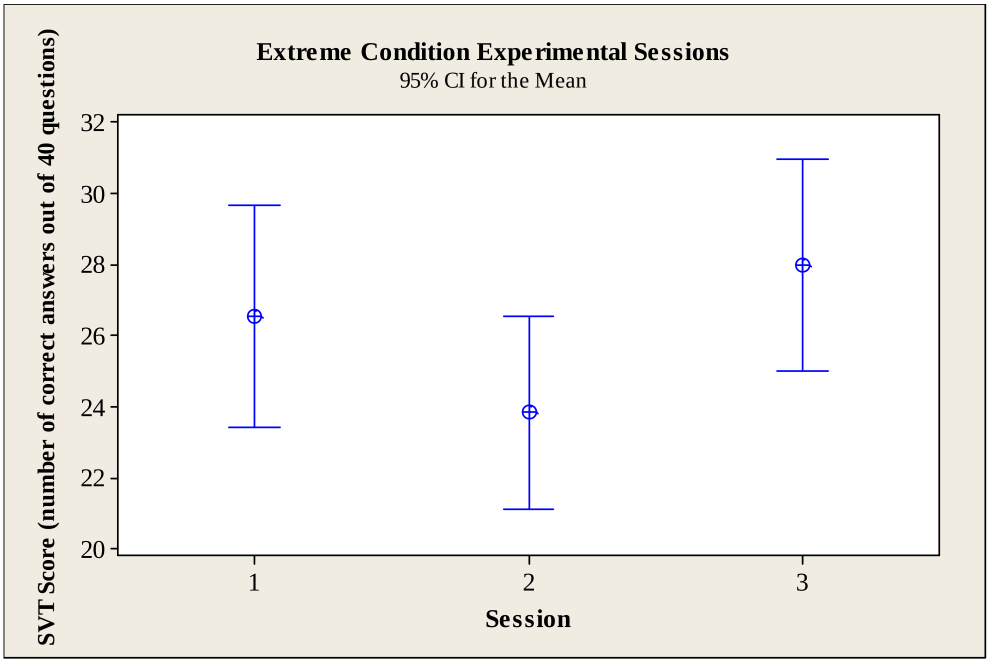


Figure 4.20 Phase II 95% CI plot for the SVT scores in the extreme test condition

Based on the P-values and the confidence interval plots it was concluded that the mean SVT scores between the different test sessions in both the normal and the extreme test room physical environmental conditions somewhat varied. The reasons for this variation are mostly unknown; however, some of it can be attributed to the time of day the test session was administered. Generally the morning sessions averaged slightly higher SVT scores than the afternoon test sessions for both test room environmental conditions. This was anticipated; therefore, both test room environmental conditions had test sessions in the morning and in the afternoon in order to make that within sample variation even between the two test groups.

In fact the P-values in both conditions came out to be exactly even. Even though the P-values indicates that there is some variation between test sessions SVT scores, they are not at levels at which significant differences can be concluded. The P-values of 0.091

are higher than the alpha significance value; therefore, the null hypothesis cannot be rejected. Consequently, the SVT scores can be considered that they are from the same population and they can be combined for each test room physical environmental condition for further analysis.

4.3.2.1.2 Phase II ANOVA analysis for the SVT scores between the two test room physical environmental conditions.

After the SVT scores from the individual test sessions were shown that they can be considered from the same population, they were combined for the normal and extreme test room physical environmental conditions. ANOVA was performed with a null hypothesis Ho stated as: the SVT scores from one test room physical environmental condition are not significantly different than the SVT scores from the other test room physical environmental condition. The alternative hypothesis Ha was stated as: the SVT scores from one of the two test room conditions are different. Alpha significance level of 0.05 was used. Prior to performing the analysis the ANOVA assumptions were checked and verified. The results from the analysis are shown in Table 4.43 and Figure 4.21.

Table 4.43 Phase II ANOVA results for the SVT scores between the two test conditions

Source	DF	SS	MS	F	P
Factor	1	105.6	105.6	5.65	0.020
Error	67	1251.8	18.7		
Total	68	1357.3			

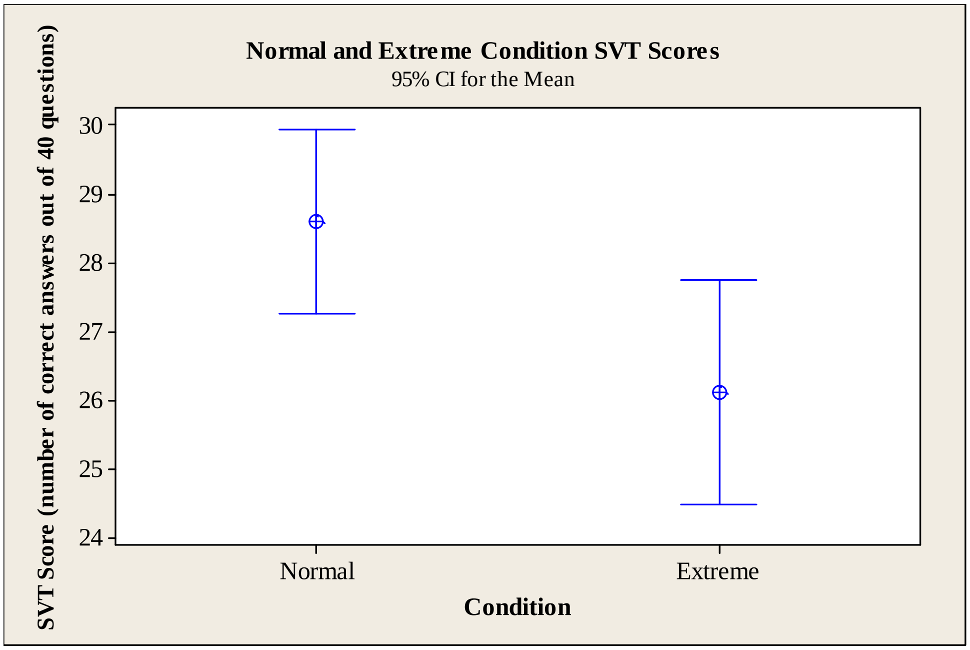


Figure 4.21 Phase II 95% CI graph for the SVT scores in the two test conditions

The 95% confidence interval graph shows a slight overlap of the mean SVT scores between the two test room physical environmental conditions. However, if the confidence interval is decreased to 90%, the plots of SVT scores do not overlap anymore. The 90% confidence interval graph is shown in Figure 4.22. The P-value of 0.02 is less than the alpha significance value; thus, the null hypothesis can be rejected in favor of the alternative hypothesis. The ANOVA analysis confirms that there is a small but significant statistical difference in the SVT scores between the two test room physical environmental conditions. The test subjects in the normal test classroom condition averaged higher SVT scores than the subjects in the extreme condition.

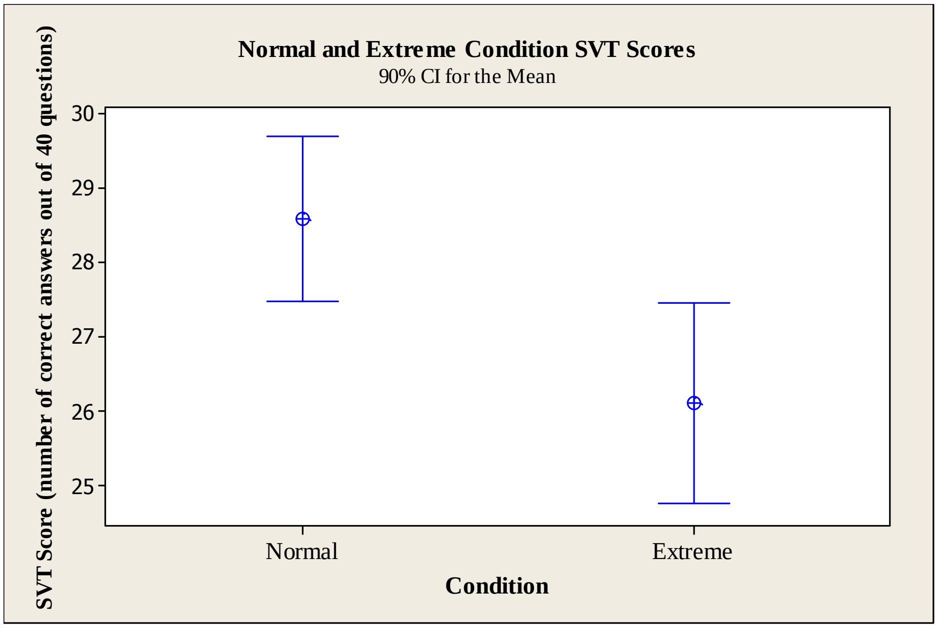


Figure 4.22 Phase II 90% CI graph for the SVT scores in the two test conditions

4.3.2.1.3 Phase II ANOVA analysis for the environmental survey responses.

As in the Phase I study, the responses to the environmental survey were analyzed to determine how the test subjects perceived the two test room physical environmental conditions. In the Phase I tests no significant difference was found in the test subjects' overall comfort level responses between the two test room conditions. There was also no significant effect of the physical environment on student SVT performance. It is of interest to determine how the test subjects perceived the test room physical environment in the Phase II tests since a significant difference in SVT performance between the two test conditions was identified.

The responses to the questions regarding the temperature, noise, lighting and general comfort level in the test room were examined. In Table 4.44 are shown the average test subjects' responses about the temperature in the test room in Phase II. The responses from the Phase I tests are also shown for comparison, labeled as Normal 1st test and Extreme 1st test.

From Table 4.44 it can be observed that the responses from the Phase II tests for both test room physical environmental conditions are closer to the expected levels than they were in the Phase I tests. The responses in the normal test room physical environmental condition in Phase II were almost entirely in the perfect range. The responses in the extreme test condition were in the too warm- warm range of the survey. With a P-value of 0.00 there was a significant difference for the temperature responses between the normal and extreme test room physical environmental conditions in Phase II. The interval plot in Figure 4.23 portrays the magnitude of that difference. In the Phase I and II Discussion of the Results section, the differences for the respective test room environmental conditions between Phase I and II studies are discussed.

Table 4.44 Phase I and II average responses about the temperature in the test room

		too warm		perfect		too cool
		1	2	3	4	5
The room temperature was:	Normal 1st test			[-----------o-----------]		(3.63)±0.76
	Extreme 1st test		[-------------o-------------]			(2.26)±0.86
	Normal 2nd test			[-----------o----------]		(3.38)±0.74
	Extreme 2nd test		[-------------o-------------]			(1.80)±0.83

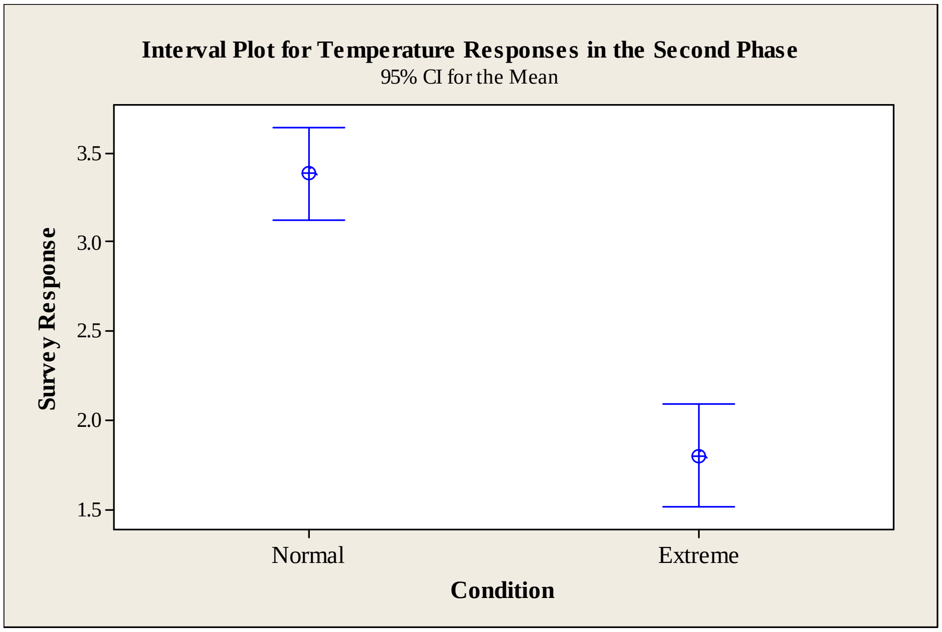


Figure 4.23 Phase II 95% CI plot for the temperature response in the two test conditions

The lighting responses in Phase II, shown in Table 4.45, were closer to the intended levels. In the normal test room environmental condition they were in the bright-perfect range. The extreme test condition responses were in the bright-too bright range. In the Phase I study there was no significant difference found for the responses between the two test conditions. An ANOVA P-value of 0.01 indicated that the responses from Phase II were significantly different between the two test room physical environmental conditions.

Table 4.45 Phase I and II average responses about the test room lighting

		too bright		perfect		too low
		1	2	3	4	5
The room lighting was:	Normal 1st test	[----------o----------]				(2.77)±0.61
	Extreme 1st test	[-------------o-------------]				(2.48)±0.86
	Normal 2nd test	[-----------o-----------]				(2.59)±0.70
	Extreme 2nd test	[--------------o--------------]				(2.06)±0.94

The average responses for sound levels in the normal test room physical environmental condition in Phase II were well within the perfect range. In the extreme test condition they were in the loud-perfect range. The sound levels in the extreme test condition were decreased from 65 dBA to 60 dBA from Phase I to Phase II in order for the oral presentation to be intelligible. Typically the human ear threshold for detecting a noise level change is 3 dBA. The difference in responses between Phase I and II in the extreme test condition was not statistically significant; however, there was an indicative of a trend that the test subjects perceived the 5 dBA sound level difference. Regardless, with a P-value of 0.002 there was a significant difference in the responses between the normal and extreme test room physical environmental conditions in the Phase II tests.

Table 4.46 Phase I and II average responses about the test room sound levels

		too loud		perfect		too quiet
		1	2	3	4	5
The room sound levels were:	Normal 1st test		[------------o-----------]			(2.91)±0.81
	Extreme 1st test	[--------------o--------------]				(2.14)±0.81
	Normal 2nd test			[------o------]		(3.12)±0.41
	Extreme 2nd test	[-----------------o-----------------]				(2.49)±1.07

The responses for the general comfort levels are shown in Table 4.47. It was observed that the responses in the normal test room condition in Phase II were in the comfortable- more comfortable range, and the responses in the extreme test condition were in the comfortable-slightly uncomfortable range. With a P-value of 0.002 the difference in the test subjects' responses between the two test room physical environmental conditions was statistically significant. That difference can be more easily observed in the 95% confidence interval graph shown in Figure 4.24.

Table 4.47 Phase I and II average responses about general comfort levels in the test room

Rate your comfort with respect to the following aspects of your study environment:		**very comfortable**		**comfortable**		**very uncomfortable**
		1	2	3	4	5
Rate your general level of comfort in the study room today.	Normal 1st test			[-------------o-------------]		(2.70)±0.89
	Extreme 1st test			[--------------o--------------]		(2.93)±1.09
	Normal 2nd test			[---------------o---------------]		(2.62)±0.99
	Extreme 2nd test			[------------o------------]		(3.31)±0.83

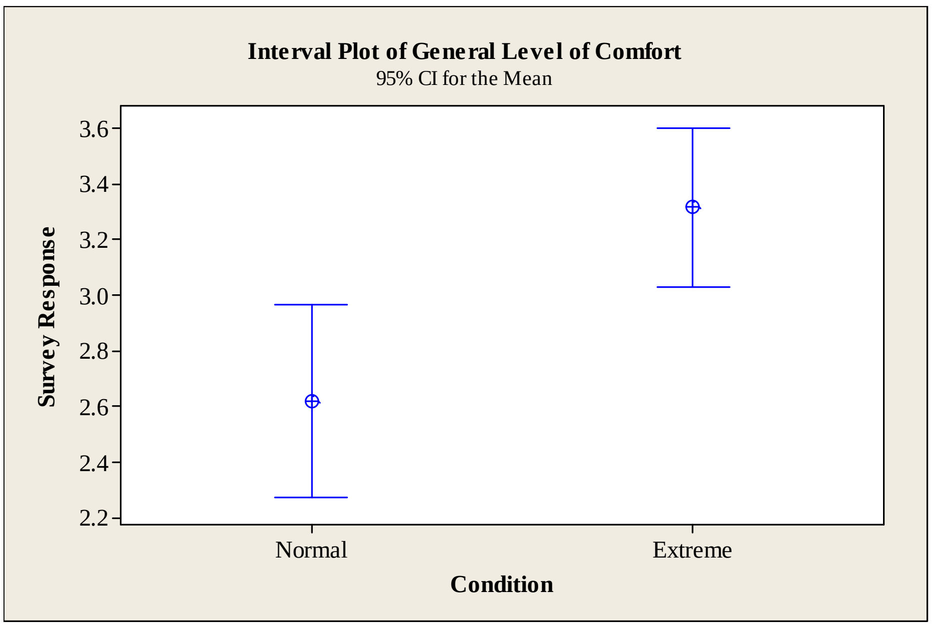


Figure 4.24 Phase II 95% CI graph for the general level of comfort in the test room

The environmental survey responses in the Phase II tests were closer to the expected levels. The test subjects' responses to every environmental parameter in the normal test room physical environmental condition were mostly in the perfect range. The responses for every environmental parameter in the extreme test condition were more in the extreme range. In the Phase I tests no significant difference was found between the responses for the lighting as well as the general comfort level. In the Phase II tests there was significant difference in all environmental parameter level responses and the general comfort level between the two test room physical environmental conditions. Therefore, the analysis in Phase I that compared the SVT scores according to how the test subjects responded on the environmental survey was not performed for Phase II. The statistical differences in the environmental survey responses between Phase I and II are discussed in the Phase I and II Discussion of Results section.

The third part of the environmental survey was examined. This part dealt with the questions regarding how the test subjects perceived the physical environmental conditions to have affected their task performance and attention on the task. The responses are shown in Table 4.36, Table 4.37 and Table 4.38. First the responses were compared between the normal and extreme test room physical environmental conditions for Phase I and II. Then the responses were also compared in the respective test conditions between the Phase I and II.

Table 4.36 shows the average responses from the third part of the environmental survey regarding the affect of the temperature parameter. Normal 1st and Extreme 1st are the responses from the Phase I tests, and Normal 2nd and Extreme 2nd are the responses from the Phase II tests. In the table it was observed that the responses from the Phase I tests for both the task performance and attention questions were very similar between the two test room physical environmental conditions. In fact there is no statistical difference in the responses between the two test conditions (P-value 0.901 about the affect on task performance, P-value 0.979 about the affect on attention to the task). In Phase II the test subjects in the extreme test condition responded that the temperature levels had a significantly greater negative impact on their task performance and attention to the task than in the normal test condition (P- value 0.036 about the affect on performance, P-value 0.007 about the affect on attention).

The temperature responses were also examined in the respective test room environmental conditions between Phase I and II to identify where the differences in responses occurred. For the temperature parameter it can be observed that the degree of shift in the responses was very similar for the respective test conditions between Phase I and II. The test subjects of the normal test condition of Phase II on average had greater level of disagreement (not significant) than the subjects of the normal test condition of Phase I. The test subjects in the extreme test condition of Phase II had lower level of disagreement (not significant) than the subjects of the extreme test condition of Phase I.

Table 4.37 shows the average responses from the third part of the environmental survey regarding the affect of the sound parameter. The responses in the Phase I tests did not significantly differ between the two test room physical environmental conditions (P value 0.546 about the affect on performance, P-value 0.395 about the affect on attention). While, in the Phase II tests the tests there were significant differences to those questions between the two environmental test conditions (P-value 0.021 about the affect on performance, P-value 0.019 about the affect on attention).

Comparing the responses in the respective test conditions between Phase I and II a few observations can be made. The differences between the Phase I and II mostly came from the test subjects in the normal test condition. The subjects in the normal test conditions of Phase II indicated that they more strongly disagree with the following statements than the subjects of the normal test condition in the Phase I tests. The responses in the extreme test conditions between Phase I and II were fairly similar.

Furthermore, there is an indicative of a trend that the test subjects of the extreme test condition of Phase II detected the 5 dBA decrease in sound levels. On average they disagreed more about the negative effect than the test subjects in the extreme test condition of Phase I. This difference was not significant; however, this trend is observed for a second time, once in the first and also in the third part of the environmental survey.

Table 4.38 displays the responses about the affect of the lighting parameter on student task performance and attention to the task. In Phase I the test subjects' responses did not differ statistically between the two test room conditions (P-value 0.438 about the affect on performance, P-value 0.195 about the affect on attention). In Phase II the test subjects identified in the first part of the environmental survey that the lighting in the extreme test condition was significantly brighter than in the normal test condition. However, on the question regarding the affect the lighting parameter on their performance and attention the test subjects' responses did not differ between the two test room conditions (P-value 0.451 about the affect on performance, P-value 0.400 about the affect on attention). The responses between the respective test room physical environmental conditions remained were similar between Phases I and II.

4.3.2.2 Phase II Pearson Correlation Coefficients

Correlations between some of the variables were examined to determine if there is relationship between them. For this purpose, the SVT scores, environmental survey responses and mood (PANAS) survey responses were used. In order to determine the correlations between these outputs, Pearson correlation coefficient was used. In contrast to the Phase I tests, no time data was available in the Phase II tests due to the equal duration of the oral presentation; therefore, no correlation analysis with time data was performed.

4.3.2.2.1 Phase II correlation between SVT Scores and the environmental survey responses.

The correlations between the test subjects' responses of the environmental survey and their SVT scores were examined for the two test room physical environmental conditions. The responses to the question regarding the overall comfort level in the study room were used. The scatter plots for the two conditions along with the Pearson correlation coefficient factor are shown in Figure 4.25 and Figure 4.26.

The correlation coefficient values in both test room conditions indicated that there was no relationship between the SVT scores and the level of comfort of the test subjects. The correlations between the responses regarding the physical environmental parameters and the SVT scores were examined and also no relationship between those variables was found. Correlations between the overall comfort level responses and the mood affects items from the PANAS survey were also investigated and there was no relationship identified between the variables.

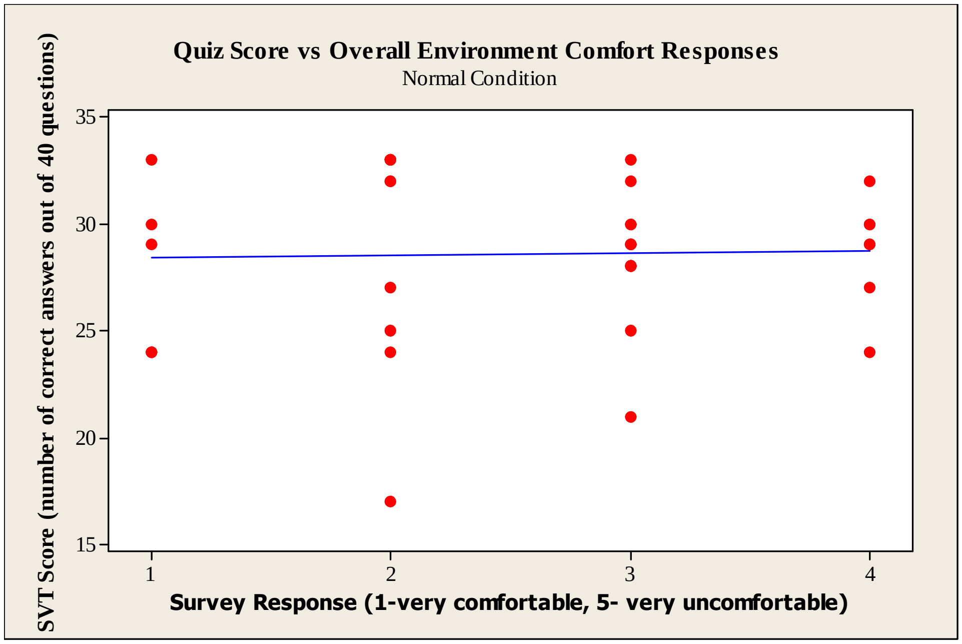


Figure 4.25 Phase II scatter plot between the SVT scores and overall comfort in the normal test condition, r = 0.029

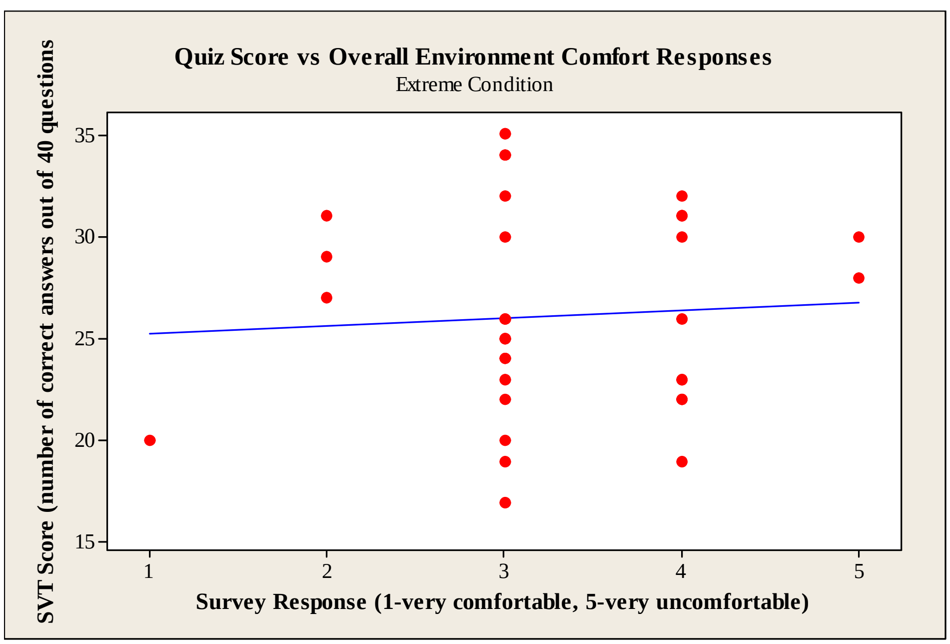


Figure 4.26 Phase II scatter plot between the SVT scores and overall comfort in the extreme test condition, r = 0.065

4.3.2.2.2 Phase II correlation between PANAS responses and the environmental survey.

The same four PANAS items are presented as in the Phase I study. Those are the items that either appeared to have a greater difference in the average responses between the two test conditions or were considered relevant to the study. The average responses are shown on the Table 4.48 for the Phase I and Phase II tests. Table 4.49 gives the correlations of those items the general comfort level responses as well as the P values between the two test room physical environmental conditions in Phase II.

The first thing that can be observed in Table 4.48 is the fact that the average responses for the "interested" affect decreased in both test room conditions from Phase I to Phase II. This decrease was significant for both test room conditions. P-value of 0.004 was calculated between the normal test conditions of Phase I and II, and a P-value of 0.001 was calculated between the extreme test conditions of Phase I and II. This is an indication that the test subjects in both conditions in the Phase II tests were significantly less interested in the task than the test subjects in the Phase I tests.

The correlation values are very close to zero. Therefore, they indicate no linear relationship between the test subjects' comfort level and how they responded to the PANAS items. The correlations of the other PANAS items were also examined and similar results were obtained. The PANAS responses were also analyzed for differences between the two test room conditions. There was no significant difference in the responses with the exception of the "irritable" affect. Even though the responses indicated very slight levels, the test subjects in the extreme test room condition responded that they were significantly more irritable (P-value 0.02) than the subjects in the normal condition.

Table 4.48 Phase II correlations between the PANAS items and comfort level responses

		Very slightly or not at all	A little	Moderately	Quite a bit	Extremely
		1	2	3	4	5
Interested	Normal 1st test		[--------o--------]			(2.93) ±1.18
	Extreme 1st test		[---------o---------]			(2.83) ±1.40
	Normal 2nd test		[-------o-------]			(2.15) ±1.05
	Extreme 2nd test	[-------o-------]				(1.86) ±1.06
upset	Normal 1st test	[----o----]				(1.35) ±0.72
	Extreme 1st test	[-------o-------]				(1.67) ±0.98
	Normal 2nd test	[----o----]				(1.44) ±0.82
	Extreme 2nd test	[------o------]				(1.57) ±0.81
irritable	Normal 1st test	[-------o-------]				(2.09) ±1.09
	Extreme 1st test	[---------o---------]				(2.24) ±1.30
	Normal 2nd test	[------o------]				(1.56) ±0.93
	Extreme 2nd test	[--------o--------]				(2.14) ±1.12
active	Normal 1st test	[---------o---------]				(2.19) ±1.20
	Extreme 1st test	[--------o--------]				(1.79) ±1.20
	Normal 2nd test	[---------o---------]				(1.92) ±1.23
	Extreme 2nd test	[---------o---------]				(2.14) ±1.26

Table 4.49 Phase II P-values and correlation coefficients for selected PANAS items

Condition	**Correlation Coefficient**			
	PANAS affect (active)	PANAS affect (interested)	PANAS affect (upset)	PANAS affect (irritable)
Normal	-0.202	-0.472	-0.047	0.075
Extreme	0.040	-0.048	0.074	0.267
P- Value	0.446	0.258	0.511	0.021

4.3.3 Phase II Root Cause Analysis

A root cause, similar to the one that was completed in Phase I, was also performed for the Phase II study. Even though a statistically significant effect of the test room physical environment was detected on student SVT performance, comfort levels, and mood, the effect size was fairly small. Therefore, the problem statement for Phase II was defined as: why, for the given task, the test room physical environmental conditions did not have a larger effect on student SVT performance, comfort levels and mood. The same structure of constructing the fish bone diagram as in Phase I was followed. The possible root causes were considered under the same six categories; however, the length of the discussion is significantly shorter since many of the possible root causes are the same as in Phase I. Causes that are only particular for Phase II were discussed in this section.

4.3.3.1 Category "Mother Nature"

This category dealt with the test room physical environmental conditions. In the Phase II study, the test subjects perceived the parameter levels to be closer to the expected levels. The responses in the normal test room environmental condition regarding the temperature, lighting and sound were mostly in the perfect range. The responses in the extreme test condition were more in the extreme range. There were significant differences in the responses for all three parameters, as well as, the comfort levels between the two test room physical environmental conditions. Even though these differences were statistically significant, besides the temperature parameter the test subjects did not perceive the other parameters to be as extreme. However, that was expected since the extreme test physical environmental parameter levels were selected to be slightly outside of the comfort zone. Therefore, no possible root cause was identified in this category.

4.3.3.2 Category "Method"

The testing protocols were very similar between Phases I and II. The only difference dealt with the modification from reading to an oral presentation of the test passage. Therefore, the possible root causes that were discussed under the root cause analysis for Phase I apply for Phase II as well. As in Phase I, the testing protocol was followed very closely in order for all of the test subjects to complete the experiment in the same manner. As in the Phase I tests, the only possible root cause that was identified was the lack of motivation factor. In this phase no test subjects fit the criteria for being excluded from the analysis. There is a possibility that there are test subjects that did not fit the criteria but still did not give the oral presentation task a fair effort. Depending on the number of such subjects, the results could be skewed slightly or significantly. Therefore, the lack of a motivational factor is considered a possible root cause.

4.3.3.3 Category "Man"

All of the discussion under this category from Phase I can be applied to Phase II. The demographics and the test anxiety levels of the test subjects were examined prior to the analysis. No differences (covariates) were detected between the two test room environmental conditions. A possible root cause that was identified in the Phase I tests regarding the test subjects group can be applied to Phase II. The effect size that was detected is considered to be influenced by the type of subjects who completed the study. The intellectual capabilities of the test subjects were sufficient to be admitted to a university. Those students can be considered more capable of suppressing the negative effects of the environment on their performance, comfort levels and mood than K-12 students. This homogeneous intellectual make-up of the test subject group can be considered a possible root cause that can explain the effect size that was detected in the Phase II study.

4.3.3.4 Category “Material”

This category deals with the furniture that was used in the test room, such as tables and chairs. This category also deals with the type of noise and lighting that were used to create the two test room physical environmental conditions. The furniture and the type of noise and lighting were the same for Phase I and II. Therefore, the possible root causes that were discussed in Phase I apply to Phase II. From the discussion in Phase I, no possible root causes were in this category in Phase II.

4.3.3.5 Category “Machine”

This category deals with the electronic equipment that was used in Phase II. This included the laptop computers with the test software, and the instruments and systems in the test room that created and controlled the physical environmental conditions. In addition to the already discussed possible root causes in Phase I, Phase II utilized additional electronic equipment such as the television and the DVD player with the surround sound system. The image on the television was clearly seen from everywhere in the test room. The surround sound system made possible for the speech levels of the oral presentation to be of fairly uniform levels across the test room. The media system along with the other electronic equipment was tested for full occupancy prior to the Phase II study. No issues prior or during the experiment were ever encountered with the electronic equipment. Therefore, no possible root cause was identified in this category.

4.3.3.6 Category "Measurement"

This category deals with the test instruments that were used to measure student learning performance, comfort levels and mood. In the Phase I tests, the sensitivity of the learning performance measurement instrument (reading test passage and the SVT) was considered as a possible root cause. The same measurement instrument was used in Phases I and II. Therefore, even though there were differences detected in the test subjects' SVT performance in the Phase II study, the sensitivity of the learning performance measurement instrument can be considered as a possible root cause for the effect size which was identified.

In the Phase II study, the different teaching modality also resulted in the increase in the statistical power of the study. The low statistical power was one of the root causes identified in the Phase I tests. The Phase II tests had higher statistical power, 77.2% as compared to 20% in the Phase I tests. In Phase II every test subject had to listen to the oral presentation, while in Phase I there is a possibility that some subjects could have clicked through the test passage without trying to retain the information for the SVT. This change in the teaching modality possibly resulted in less variance in the SVT performance between the test subjects that gave the task a fair effort and the ones who did not. This observation along with the higher sensitivity resulted in the learning performance measurement instrument to have a higher probability of detecting the correct effect. Therefore, no possible root cause was identified in this category.

4.3.3.7 Phase II Results of the Root Cause Analysis

The root cause analysis was conducted to determine the factors that could have influenced the effect size that was identified in Phase II. The possible root causes were considered under the six categories that were discussed in the root cause analysis of Phase I. After completing the analysis in Phase II, two possible root causes that can explain the problem statement were identified:

- The reasonably high intellectual university student test group was capable of filtering out the negative effects of the extreme condition,
- The reading test instrument had low sensitivity,
- The test subjects had no motivation to give the oral presentation a fair effort.

The same root causes were identified in Phase I along with three others. The other two, such as no reported difference in the comfort levels between the two test room physical environmental conditions, and low statistical power do not apply to Phase II. The reasonably high intellectual university student test group, however, can be considered to be fairly capable of filtering out the negative effects of the extreme condition. This could explain the small effect size which was identified in the SVT performance between the two test room physical environmental conditions.

As in Phase I no motivational factor was present for the test subjects of Phase II to give the oral presentation task a fair effort. The number of such test subjects and the degree to which they gave the task a fair effort is unknown. Subjects that did not take the task seriously could have skewed the results one way or the other. Therefore, this was identified as a possible root cause could have affected the effect size that was detected.

4.4 Phase I and II Discussion of the Results

The task that involved viewing an oral presentation showed to be more sensitive to the test room physical environmental conditions than the task of reading on the laptop computer. Significant differences in Phase II were identified in the test subjects' SVT performance between the two test room physical environmental conditions. In addition, in Phase II the responses to the physical environmental parameters were closer to the intended levels than they were in the Phase I tests. Also in contrast to Phase I, the test subjects in the normal test room physical environmental condition of Phase II reported that they were more comfortable and less irritable than the subjects in extreme condition. There were also significant differences in the subjects' responses to how the physical environmental conditions affected their task performance and attention to the task. The SVT scores and environmental survey responses were examined in more detail to determine in what manner they changed between the Phase I and II tests.

The increase in the SVT scores in the normal test room condition (average of 1.7 correct answers) from Phase I to Phase II is almost the same as the decrease of the SVT scores in the extreme test condition (average of 1.8 correct answers). This increase and decrease in the SVT scores is not significant between the respective test room conditions of Phase I and II (normal test condition P-value 0.121, and extreme test condition P-value 0.139). However, this shift in the test subjects' SVT performance resulted in small but statistically significant difference between the normal and extreme test room physical environmental conditions of Phase II. To investigate this shift in SVT performance from Phase I to Phase II the environmental survey responses were examined. The responses were studied to determine if there was a significant change in test subjects' environment perception and comfort levels between the Phase I and II tests.

The first parameter that was examined was temperature. The test subjects in the normal test condition of the Phase II tests responded that they were slightly warmer on average than the subjects in the normal condition of Phase I but that difference was insignificant (P-value of 0.133). The test subjects in the extreme test condition of Phase II responded that the test room was significantly hotter than in the extreme condition of the Phase I tests (P-value of 0.019). The fact that Phase I and II were conducted at different time of year could have possibly influenced this shift in responses. With significant difference in the outside temperatures in April and November in Las Vegas, it can be safely assumed that the level of clothing of the test subjects was different between Phase I and II. This could have contributed to the fact that on average the test subjects in Phase II were feeling warmer than the test subjects in Phase I. However, it was observed that the degree of change between the two test room physical environmental conditions was not the same. The fact that the difference in responses in the extreme condition is greater than the normal condition indicates that there are other factors that influence this than just the difference in outside temperatures between Phase I and II.

The lighting level responses were also examined. In both test room environmental conditions in Phase II on average the test subjects responded that the lighting level was brighter than in Phase I. There was no significant difference in the lighting levels responses between the normal test conditions from Phase I to II (P-value 0.300). The extreme test condition responses were borderline significantly different for the lighting (P-value 0.054). For lighting as well as for temperature, the changes in the responses between the extreme test conditions were greater than the changes in the responses between the normal conditions from the Phase I to II tests.

The noise level responses were also examined. The responses for the normal and extreme test room conditions did not differ significantly between the Phase I and II tests. However, the reduction in the sound levels in the extreme test condition from Phase I to II could possibly have affected this result.

The overall comfort responses in the study room were examined for differences between the Phase I and II tests. The responses between the normal test conditions did not change (P-value 0.710). The shift in responses between the extreme test conditions was not significant (P-value 0.093), but the degree of change is again higher than the change between the normal conditions.

From this discussion there is indication that test subjects' perception of the physical environmental parameters and comfort levels were differently affected based on the test room environmental condition they were in from Phase I to II. The difference in test subjects' responses between the extreme test conditions was greater than the difference in responses between the normal test conditions from the Phase I to Phase II tests. The test subjects in the extreme test condition in the Phase II tests responded that the temperature was hotter, the lighting was brighter and there is an indication that they were overall more uncomfortable than in the extreme condition of the Phase I tests. No such trends on any of these parameters were detected for the test subjects in the normal test condition. The test subjects' perceptions of the physical environmental parameters and comfort levels in the normal test room conditions were the same for the Phase I and II tests.

The observed trend is hypothesized to be as a result of the different teaching modalities used in the Phase I and II studies. The test subjects who viewed the oral presentation of the test passage in the Phase II study were possibly less engaged in the task than the subjects in the Phase I study who read the test passage. The test subjects that completed the reading were more effectively able to filter out the negative effects of the extreme test room environmental condition. Instead of having to focus on the computer screen, and as they were sitting back and viewing the oral presentation, the test subjects in the Phase II study were more prone to observe and be affected by the test room physical environmental conditions. This would explain why the perception of the environmental test parameters and comfort levels were more affected for the test subjects in the extreme test conditions in the Phase II study.

In the pilot study it was found that for the different teaching modalities, the same test room physical environmental conditions have different effect on test subjects' SVT performance, perception of the physical environmental conditions, comfort levels and mood. In addition, the physical environmental conditions responses in the normal test condition did not differ significantly between the reading and the oral presentation of the test passage. In the extreme condition, the subjects' perceptions of the environmental conditions and comfort were more negatively affected. This can lead to the hypothesis that, for tasks that require lower levels of concentration, substandard room environmental conditions may be harder to filter out, creating lower levels of comfort and more negatively affecting student learning performance and mood.

CHAPTER 5

SUMMARY CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary of Results

The analysis of data from the Phase I tests where the test subjects read a test passage in the normal and extreme test room environments demonstrated no significant difference of the test subjects' SVT scores between the two conditions. The root cause analysis identified several possible factors that could have contributed to this result. The possible root causes were:

- There were no significant differences in the reported test subjects comfort levels between the two classroom environmental conditions,
- The reasonably high intellectual university student test group was capable of filtering out the negative effects of the extreme condition,
- The reading test instrument had a low sensitivity,
- The experiment had a low statistical power, and
- Test subjects had no motivation to give the reading task a fair effort.

After replicating the study for a different teaching modality, the Phase II results were different. The Phase II tests detected difference in test subjects' SVT scores between the two test room physical environmental conditions. The identified difference in which the test subjects in the normal test environmental condition performed better than the test subjects in the extreme condition was small; nonetheless, it was statistically significant. A root cause analysis was performed to identify the possible root causes that could have influenced the effect size that was detected. The SVT scores for the Phase I and II tests are summarized in Table 5.1 and Figure 5.1. The possible root causes for Phase II were:

- The reasonably high intellectual university student test group was capable of filtering out the negative effects of the extreme condition,
- The reading test instrument had low sensitivity,
- The test subjects had no motivation to give the oral presentation a fair effort.

Table 5.1 Phase I and II Summary of the SVT results and analysis

Pilot Test Phase	Environmental Test Condition	Number of Test Subjects	Mean SVT Score (number of correct answers out of 40 questions)	Standard Deviation	ANOVA P- Value	Conclusion
Phase I	Normal	40	26.9	5.4	0.407	Fail to reject Ho
	Extreme	41	27.9	5.4		
Phase II	Normal	34	28.6	3.8	0.02	Reject Ho
	Extreme	35	26.1	4.8		

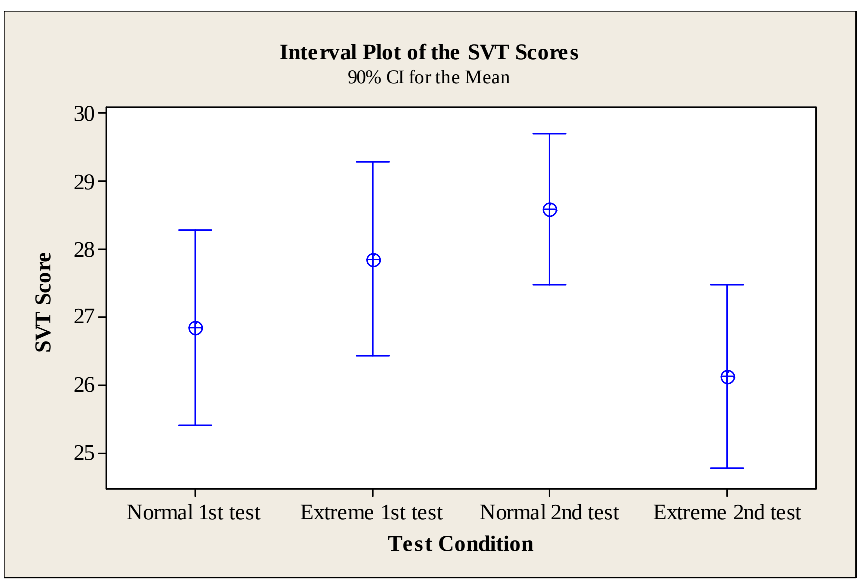


Figure 5.1 Interval Plot of the SVT Score from Phase I and II

In addition to the SVT scores for the Phase I and II tests, the other outputs of these experiments were the test subject survey responses. The anxiety survey and the demographic questions were used to determine if, after the random assignment of test subjects, the two test groups both in Phase I and II could be considered to be similar. The average anxiety level responses, shown in Table 4.31 and Table 4.32, closely overlap between the two test subject groups in each of the Phase I and II tests. The responses to the demographic questions shown in Table 4.2 and Table 4.4 were also very similar between the two test subject groups in each of the Phase I and II tests. Therefore, based on these results, it was concluded that the two test subject groups for each of the Phase I and II tests had nearly the same characteristics, and no covariates were detected.

The environmental survey responses from the Phase I test room physical environmental conditions indicated that the test subjects did not perceive the test room environmental parameter levels exactly as expected. Some test subjects responded that the temperature in the normal test room environment was a little cool and some indicated that the lighting in the extreme classroom environment was not as bright as intended. There was no significant difference in the lighting responses and the perceived test subjects comfort levels between the two test room physical environmental conditions in Phase I. There was also no significant difference in the test subjects' responses on the questions regarding to how they perceived the physical environmental conditions to have affected their performance and attention.

The test subjects of Phase II responded differently to the same test room physical environmental conditions as in Phase I. The test subjects in Phase II perceived the physical environmental parameters more as expected. The responses about the environmental parameters in the normal test condition were close to the perfect region and in the extreme condition were in the more extreme region. There was significant difference in responses for the levels in temperature, lighting and noise. The test subjects in the normal test room physical environment also responded that they were significantly more comfortable than the subjects in the extreme condition in Phase II. The test subjects in the extreme test room physical environment also indicated that their task performance and attention to the task were more negatively affected due to the temperature and sound levels than the subjects in the normal test room physical environment.

The responses from the PANAS survey indicated there was no significant difference in mood between the test subjects of the two test room physical environmental conditions in Phase I. The test subjects in the extreme test room condition of Phase II responded that they were more irritable than the subjects in the normal test room physical environment. The correlation analysis did not find any relationships between the PANAS items and the environmental responses.

After Phase I and II provided different results, the differences in the corresponding conditions between the two phases were analyzed. It was determined that the test subject in the extreme test condition in Phase II responded that temperature was significantly hotter (P-value 0.019) and the lighting was borderline significantly brighter (P-value 0.054) than test subjects in the extreme condition in Phase I. Overall it was shown that there was a trend that the test subjects in the extreme test condition of Phase II responded to be more uncomfortable than the test subject in the extreme condition in Phase I, while no such trend was detected for the normal test conditions. This finding lead to the hypothesis that, for tasks that require lower level of concentration, substandard physical learning environmental conditions can be more pronounced, create lower comfort levels, and have a greater negative effect on student learning performance.

5.2 Recommendations for Further Studies

The main goal of this pilot study was to determine weather or not engineering and student performance measuring instruments and testing protocols can be used to identify relationships between the test room physical environmental conditions and student learning performance. That would allow the research team to determine how to better conduct more detailed and sophisiticated studies in the following phases of the I-SPIDER research. Based on the results of the pilot study, recommendations for future studies are made.

1. There was no measureable difference in the Phase I SVT scores for the normal and extreme classroom environments when the test passage was read by the test subjects. There was a small but still statistically significant difference in the Phase II SVT scores for classroom the environments when the test passage was orally presented to the test subjects by means of a video presentation. Therefore, there is little justification to undertake a full factorial laboratory study for investigating the effects of classroom temperature, lighting and sound on student learning performance.
2. Instead of performing a full factorial laboratory study a slight variation to the already conducted study could be made. From this pilot study it is not know the degree to which each parameter influenced the difference in the test subjects' performance, comfort levels and mood in the Phase II tests. Based on the environmental survey responses the test subjects responded that they were mostly bothered by the

temperature, then noise and the least was by lighting. A useful way to somewhat isolate the effect of each parameter would be to repeat the Phase II test in the extreme condition three times and each time to set one of the parameters of interest to its normal condition level. Since baseline data is already available such variation to the Phase II tests would give an indication of the degree of influence of each parameter has on the outputs.

3. A useful follow-up study will be to replicate the laboratory pilot study in actual K-12 classroom settings for both the reading and oral presentation of an appropriate age-level test passage. The goal of the study will be to determine how well the results of the laboratory pilot study will extend into actual K-12 classroom environments. The intellectual make-up of the university student test groups in the laboratory study was reasonably homogeneous. The intellectual capabilities of the students were sufficient to be admitted to a university. It is anticipated that the intellectual variance among public school students will be much greater. It is desirable to determine the potential effects of this anticipated increased intellectual variance within K-12 student test groups on measured student learning performance.
4. Another variation to the conducted laboratory pilot would be to investigate the effects of different tasks that require different concentration levels on student performance, comfort levels, and mood. Based on the Phase I and Phase II tests it was detected that for the different tasks, the same conditions can be perceived differently, especially in the substandard condition. It was noted in this study that the test subjects perceived the extreme conditions a lot more differently than the test subjects in the normal condition from the Phase I to II tests.

5. Another variation to the laboratory pilot study and the K-12 classroom study proposed in (3) is to add a motivational element to the studies. There were indications in the survey responses during the laboratory pilot study that some of the test subjects did not take their participation in the study seriously. These test subjects were not considered in the statistical analyses. However there is possibility that there could have been other test subjects that did not fit the criteria for the removal from the analyses but still could have primarily guessed at answers or did not give the SVT test a fair effort. Introducing a motivation element could increase the participation effort of these test subjects. This could possibly decrease the SVT test score variations, increase the power of the study, and overall would be a more realistic test scenario.
6. The proposed study in actual K-12 classroom settings can be undertaken by selecting classrooms in which it will be possible to vary the temperature, sound and lighting levels to replicate those levels that were used in the laboratory pilot study. An age-appropriate test passage will be either selected or developed for the SVT tests. Normal and extreme temperature, sound and lighting levels similar to those used in the laboratory study will be used. The test passage will be read by and presented to the student test groups in two series of tests. Four student tests groups, two for each tests series, would be randomly selected. The time required for an individual K-12 student to participate in this study would typically be less than one hour. This study could be conducted with three K-12 school grade levels: 4th grade, 7th grad and 10th or 11th grade.
7. A parallel K-12 classroom study can be conducted by initially selecting classrooms with known deficiencies associated with temperature, ventilation, sound and lighting

that are slated for renovation. Classrooms will be selected within the following grade groups: 4th grade, 7th grade and 10th or 11th grade. Temperature, ventilation, sound and lighting levels will be measured in the classrooms over a period of several days before and after the classroom deficiencies have been corrected by the classroom renovations. In addition, student test records will be reviewed for periods before and after the classroom renovations have been completed to identify the effects of the classroom renovations on student learning performance.

8. The studies proposed in (3) and (6) would be initially conducted in Nevada Clark County School District schools. The studies can then be expanded to other school districts within different urban/suburban school districts in different climate zones throughout the US.
9. The laboratory pilot study room was slightly reverberant. The effects of this were noticeable during the Phase II tests when the test passage was orally presented to the test subjects. Laboratory and K-12 classroom studies can be conducted that investigates the effects of classroom acoustical characteristics associated with sound reverberation on speech intelligibility and it related effects on learning performance.
10. The extreme sound source in the Phase I and II tests was a room ventilator fan with a slight tonal characteristic and a broad sound spectrum. Only the effect of source sound level on learning performance was investigated. The effects of other sound sources with different sound spectra and with time varying and tonal characteristics on learning performance should be investigated.
11. In the normal test condition in Phase I it was also noted that a number of test subjects responded that they were bothered by the constant clicking of the mice and other

sounds such as moving chairs or tapping feet. A useful variation to the study would be to test different background noise levels and identify which level would successfully mask those noises and provide higher comfort levels.

12. Test subjects in the Phase II laboratory pilot study tests tended to be more responsive to the differences in lighting levels between the normal and extreme classroom environments. One type of fluorescent lights was used for the tests. Other effects of other types of lights with different light spectral contents on learning performance should be explored.

5.3 Conclusion

The performed pilot study was very beneficial and gave very useful information that determined the direction of the whole I-SPIDER research effort. The research team now has an understanding of how the test subjects are going to perform and respond to the physical environmental conditions related to a reading task and oral presentation. The results from the pilot indicated that there is no justification in conducting the initially planned full or partial factorial laboratory study. Instead a slight variation to the pilot study can be performed that will give an indication of the individual environmental parameter effects on student learning performance output. In addition, a field study will be performed which will verify the extent to which the results from the laboratory study apply to a real K-12 classroom for a different test subject group. Recommendations were made for the following phase of the study, as well as, for future studies.

Identifying the effects of the classroom environment on student performance is a complex task. Documenting these effects in detail by considering all of the related variables is an impossible assignment for a single study. Based on the findings of this pilot study and the follow up field studies, solid understanding will be developed about the effects of temperature, noise and lighting on student learning performance, comfort levels and mood. Eventually through valid research, the scientific evidence will benefit students by providing information and guidelines for a better classroom physical environment.

APPENDIX A

IRB APPROVAL

UNIVERSITY OF NEVADA LAS VEGAS

Biomedical IRB – Expedited Review
Approval Notice

NOTICE TO ALL RESEARCHERS:

Please be aware that a protocol violation (e.g., failure to submit a modification for <u>any</u> change) of an IRB approved protocol may result in mandatory remedial education, additional audits, re-consenting subjects, researcher probation suspension of any research protocol at issue, suspension of additional existing research protocols, invalidation of all research conducted under the research protocol at issue, and further appropriate consequences as determined by the IRB and the Institutional Officer.

DATE:	February 23, 2010
TO:	**Dr. Douglas Reynolds**, Mechanical Engineering
FROM:	Office for the Protection of Research Subjects
RE:	Notification of IRB Action by Dr. Charles Rasmussen, Co-Chair Protocol Title: **International Study Program for Indoor Environmental Research (I-Spider)** Protocol #: 1001-3339M

This memorandum is notification that the project referenced above has been reviewed by the UNLV Biomedical Institutional Review Board (IRB) as indicated in regulatory statutes 45 CFR 46. The protocol has been reviewed and approved.

The protocol is approved for a period of one year from the date of IRB approval. The expiration date of this protocol is February 18, 2011. Work on the project may begin as soon as you receive written notification from the Office for the Protection of Research Subjects (OPRS).

PLEASE NOTE:

Attached to this approval notice is the **official Informed Consent/Assent (IC/IA) Form** for this study. The IC/IA contains an official approval stamp. Only copies of this official IC/IA form may be used when obtaining consent. Please keep the original for your records.

Should there be *any* change to the protocol, it will be necessary to submit a **Modification Form** through OPRS. No changes may be made to the existing protocol until modifications have been approved by the IRB.

Should the use of human subjects described in this protocol continue beyond February 18, 2011 it would be necessary to submit a **Continuing Review Request Form** *60 days* before the expiration date.

If you have questions or require any assistance, please contact the Office for the Protection of Research Subjects at OPRSHumanSubjects@unlv.edu or call 895-2794.

APPENDIX B

SUBJECT POOL AD

Subject Pool Ad to appear in the Experiment Management System of the Department of Educational Psychology. Students will see this study description when they log into the "Available Studies" section of the system. This ad will also be presented in some of the undergraduate Engineering classes.

Study Name International Study Program for Indoor Environmental Research (I-SPIDER)

Description

Undergraduate Educational Psychology students- Complete two hours of your research requirement with one study!
Undergraduate Engineering Students- Receive extra credit for participating in a study!

This is a combined study between the Colleges of Engineering and Educational Psychology which is focused on better understanding reading and comprehension in a controlled classroom environment. This study will provide researchers and instructors with information on how learning is affected by the environment.

This is a one part study which will take approximately two hours to complete. The study will take place in on-campus lab within the college of Engineering. The experimental area, which is a normal classroom environment, is equipped with comfortable chairs and laptop computers. A researcher will give you instructions, guide you through the paper and pencil consent process, and will be also available to answer any questions. The study will be performed on the laptop computer and will consist of completing a reading task, answering surveys about your test-taking experiences and general self-perception, and taking a short reading test. You can withdraw from the study at anytime; however, no credit will be given unless the whole study is completed. Your name will only be required for the purpose of assigning you credit for participation, no connection will be made to the actual data collected.

The study will take place March and different testing schedules will be offered. For Educational Psychology students you will be able to sign up through the electronic Experimental Management System. For Engineering students more information will be provided during your courses. In both cases you will need to contact the research team member via email (shown below) to sign up for a testing time.

Lab Study VAST lab located within the College of Engineering,

Location TBE B-building

Eligibility Requirements undergraduate students at UNLV

Duration 2 hours

Credits 2 Credits for Educational Psychology students
Extra Credit for Engineering students

Researcher Stoil Pamoukov
Email: stoil11@yahoo.com

Principal Investigator Douglas Reynolds, PhD

Participant Sign-Up Deadline 48 hours before the study is to occur

Participant Cancellation Deadline 0 hours before the study is to occur

Study Status Visible to participants (approved)
Inactive study (does not appear on list of available studies)

IRB Approval Code

APPENDIX C

INFORMED CONSENT FORM

TITLE OF STUDY: International Study Program for InDoor Environmental Research

INVESTIGATOR(S): Douglas D. Reynolds, Ph.D., Gwen C. Marchand, Ph.D., Brian J. Landsberger, Ph.D., Stoil Pamoukov

CONTACT PHONE NUMBER: 702-895-3807

Purpose of the Study

You are invited to participate in a research study. The purpose of this study is to determine the how attention and reading comprehension works in a controlled classroom environment. This study will provide researchers and instructors with information on how much and in what manner environment affects learning.

Participants

You are being asked to participate in the study because you are an undergraduate student at UNLV.

Procedures

There are two parts to this study. If you volunteer to participate in this study, you will be asked to come to an on-campus lab where you will: (1) complete a reading task (2) answer some questions about your test-taking experiences and general self-perceptions (3) take a short reading test.

Benefits of Participation

There may not be direct benefits to you for participating in this study. However, you may find that you are interested in the reading material provided for the study. Also, your participation will help educators better understand how classroom environments influence learning.

Risks of Participation

There are risks involved in all research studies. This study may include only minimal risks. You may feel uncomfortable while completing the study tasks due to the noise, temperature, or lighting conditions inside the lab room. You may also feel fatigued or bored when completing the study tasks.

Cost /Compensation

There will not be a financial cost to you to participate in this study. In its entirety, this study will take between 2 hours of your time. You will not be compensated for your time. However, you may also receive partial course-credit or extra credit for participating in the study.

Contact Information

If you have any questions or concerns about the study, you may contact Dr. Douglas Reynolds at **702-895-3807.** For questions regarding the rights of research subjects, any complaints or comments regarding the manner in which the study is being conducted you may contact **the UNLV Office for the Protection of Research Subjects at 702-895-2794.**

Voluntary Participation

Your participation in this study is voluntary. You may refuse to participate in this study or in any part of this study. You may withdraw at any time without prejudice to your relations with the university or with your teacher or school. You are encouraged to ask questions about this study at the beginning or any time during the research study.

Confidentiality

All information gathered in this study will be kept completely confidential. No reference will be made in written or oral materials that could link you to this study. All records will be stored in a locked facility at UNLV for three years after completion of the study. After the storage time the information gathered will be destroyed. Administrative and teaching staff at your school will not have access to any information gathered during the course of this study at any time.

Participant Consent:

I have read the above information and agree to participate in this study. A copy of this form has been given to me.

_______________________________________ ____________________

Signature of Participant Date

____

Participant Name (Please Print)

Participant Note: Please do not sign this document if the Approval Stamp is missing or is expired.

APPENDIX D

TEST INSTRUCTIONS

D.1 Phase I Test Instructions

Hello welcome to our classroom,

Thank you for participating in the Ispider study. My name is Stoil and I am the research assistant for this project. In this study we are concerned with how people learn from text material. The whole experiment will be conducted on the laptop computers in front of you. The study will consist of completing a reading task, answering surveys about your test-taking experiences and general self-perception, and taking a short reading test.

The testing software will guide you from one section of the study to the next. You will need to complete all of the questions before moving on to the next section.

The reading is presented in groups of approximately 34 words. To advance the text from one segment to the next segment, click on **next passage**. This will replace the segment that was on the screen with the next one. You cannot go back to a segment once you have moved forward. You will continue to repeat this procedure until you finish the text. After reading the text you will be given a comprehensive quiz, so study the text carefully. Once you have completed the quiz, your score will appear on the screen.

No food or drinks are allowed in the lab except water. You cannot use headphones. Please turn off your cell phones. You are also not allowed to perform any task on the laptop computer other than completing the test that is already up and running on the screens.

Please refrain from using the restroom but if you need to, you can leave at any time but please do so without distracting others. You can also withdraw from the study at anytime. If you do withdraw before completing the study, credit will be given in proportion to the time you have committed to completing the study. Once you complete the test, you need to sign out before you leave.

If you have any questions please ask them now.

At this point you can start the test, by entering the ID number given to you on the first screen.

D.2 Phase II Test Instructions

Hello welcome to our classroom,

Thank you for participating in the Ispider study. My name is Stoil and I am the research assistant for this project. This study will consist of viewing a video lecture, answering a few surveys and taking a short reading test on the lecture. This should take you a approximately one hour.

In the first part in this study you will be presented with the video lecture on the TV. The presentation is 30 min long. Once that is finished the rest of the study will be completed on the laptop computers in front of you. You will need the ID number that I gave you to start the testing software so please don't throw it away. Please do not start using the laptops before the completion of the video lecture and instructions from me.

The testing software that is up and running is pretty much self explanatory and will guide you from one section of the study to the next. The testing software consists of demographic questions, quiz and two surveys. You will need to complete all of the questions before moving on to the next section. Once you have completed the software your quiz score will appear on the screen. Remember, the quiz is based on the video so please pay close attention to the lecture.

No food or drinks are allowed in the lab except water. You cannot use headphones. Please turn off your cell phones. Also, please do not perform any task on the laptop computer other than completing the test that is already up and running on the screen.

Try to complete this task without interruption. If you need to use the restroom, you can leave at any time but please hurry back without taking any additional break, like going for a smoke or making a call. You can also withdraw from the study at anytime. If you do withdraw before completing the study, credit will be given in proportion to the time you have committed to completing the study. Once you complete the test, you need to sign out before you leave.

If you have any questions please ask them now.

At this point I will start the video lecture, do not start on the using the laptops until the lecture is complete and hear instructions from me to do so.

APPENDIX E

TEST PASSAGES

E.1 Practice Reading Passage

"The Matriculating Brain"
by Michael H. Chase (edited for experimental purposes)

The human brain, for all our intimacy with it, has surrendered less to scientific research than have the distant moon, stars, and ocean floor, or such intimate processes as genetic coding, immune reactions

or muscle contraction. This complex organ, with its more than 10 billion neurons, has had the incredibly difficult task of understanding itself. Perhaps the task has been so difficult because even thinking about thinking

is like picking oneself up by the bootstraps – one process negates the other. The brain interacts with every system in a person's body. Experiments to determine how the brain controls body movements (motor responses)

date back hundreds of years. Recently, we have begun to understand how the brain controls our internal organs (visceral processes). We had assumed that, unlike body movements, the brain regulated the internal organs automatically ——

that the muscles of the heart, for instance, were beyond conscious control. Our assumption turned out to be wrong. Within the last six years we have discovered that one can condition the processes of

his internal organs, and we now know that the brain can actually learn to control its own activity. This discovery fundamentally altered our perception of how the brain can be trained to control

the function of other organs, and has suggested a new approach to brain research: operant conditioning of the brain. With this methodology, which applies the same behavioral principles that B. F. Skinner developed,

we can teach the brain to alter its patterns of electrical activity. We can even teach it to fire one neuron and not to fire an adjacent neuron, or to alternate their firing

in a complex pattern. The scientific and clinical implications of this new research are staggering. For the first time we will be able to determine the limits of brain function in a rather direct manner.

It may, for example, give physicians the facts they needed to develop new treatments for illnesses, like Parkinson's disease, that involve abnormal neural control of body movements.

E.2 Experimental Reading Passage

The Sea Around Us

by Rachel Carson

(edited for experimental purposes)

Between the sunlit surface waters of the open sea and the hidden valleys of the ocean floor lies the least known area on earth with its unsolved problems beckoning man. This area covers a

considerable part of the earth. The whole ocean extends over a major portion of the surface of the globe. If we subtract the shallow areas along the shore and the scattered banks and shoals,

where at least the pale ghost of sunlight reaches the bottom, there still remains about 1/2 the earth that is covered by miles deep, lightless water that has been dark since the world began.

Only a very few men have had the experience of descending, alive, beyond the range of visible light. William Beebe and Otis Barton are members of this select group. They reached this exclusive domain

with a dive in the water of the open ocean in a device called a bathysphere. The bathysphere allowed them to reach depths that man alone could not approach. Wearing a diving helmet, man can walk on the ocean floor about 10 fathoms down. He can descend to an extreme limit of about 500 feet in a complete diving suit so heavily armored that movement is difficult. Improvements in the

technology of ocean going craft had allowed Barton and Beebe to descend to a much greater depth than was possible before. Later working alone. Barton, using a new deep ocean vehicle known as a benthosphere

reached even greater depths. Both of these new diving vehicles, the bathysphere and the benthosphere, were spherical in shape and therefore withstood the pressure of the deep well. By the summer of 1949, a depth of 4500 feet

had been reached. In achieving this plateau man with his machines had taken the first step in exploring the least-known area remaining on the earth's surface. Barton's descent was a landmark in deep

ocean diving. Auguste Piccard, a Swiss physicist, who had already attained fame because of his daring hot-air balloon ascents was one of the major pioneers in deep ocean exploring. He proposed a new

vehicle (a bathyscaphe or Depth Boat) which, instead of being suspended from a cable like the bathysphere would move freely independent of control from the surface. Work on the new vehicle was begun in

1948. Like its recent predecessors the new diving boat was spherical in shape, again because spheres withstood the grinding pressure of the deep ocean well. Money for this project was provided by the

Fonds National de la Rechereche Scientifique, which is the Belgian Scientific Research Fund. Three of the new diving boats were built and names FNRS-2, FNRS-3, and Trieste. These bathyscaphes (depth boats) were constructed so that the needed ballast was provided by iron pellets held to the boat by electromagnets. The divers rode in a pressure resisting ball suspended from a metal envelope containing high-octane gasoline, which is

an extremely light, almost incompressible fluid. When the divers wanted to return to the surface, the pellets were released by stopping the current. In one such vehicle the Professor and his son made

a record breaking descent into the ocean in 1953. They reached a depth of 10,395 feet in an inland sea. This was more than double the previous record. Later the boat was purchased

from the Piccards by the United States Office of Naval Research. The boat was taken to Guam where a descent into the Mariana Trench (the deepest hole in the ocean) was planned. Here, using

the newly invented bathyscaphe, an attempt would be made to descend to the 'floor' of the ocean. The time seemed right for man to reach this greatest of his goals. On January 23, 1960,

the descent was made. When the bottom of the trench was reached, man was 35,000 feet or nearly 7 miles beneath the ocean surface, in a place which light had not reached since time began.

August Piccard's son Jacques and Don Walsh had thus become the first men ever to reach the floor of the ocean at it's greatest depth. Although, only the very fortunate few can ever visit

the ocean's floor. The precise instruments of the oceanographer, such as the newly developed thermistor chain which records water temperature at many varied depths .as it is towed behind a vessel, and the devices which record light penetration, pressure, salinity, and the temperature, have given us the materials with which to reconstruct in imagination these eerie, forbidding regions. Unlike the surface waters, which are sensitive to every gust of wind, which know day and night, respond to the pull of the sun and the moon, and change as the seasons change, the deep waters are a place where change comes slowly if at all.

But, gradually, as man pushes the limits of his technology to the brink, the secrets of the unchanging, largely unknown, deep ocean will be revealed for all who are interested to see. Down beyond

the reach of the sun's rays, there is no alternation of light and darkness. There is rather an endless night, as old as the sea itself. For most of the creatures groping their way

endlessly through its black waters, it must be a place of hunger, where food is scarce and hard to find, a shelterless place where there is no sanctuary from ever-present enemies, where one

can only move on and on, from birth to death, through the darkness, confined as in a prison to his own particular layer of the sea. They used to say that nothing could live

in the deep sea. It was a belief that must have been easy to accept, for without proof to the contrary how could anyone conceive of life in such a place. Until relatively recently

there has been no such contrary evidence. In 1818, a sample of mud was collected at a depth of 1,000 fathoms in which there were worms thus proving that there was animal life

prospering in the bed of the ocean notwithstanding the darkness, stillness, silence, and immense pressure produced by the more than a mile of superincumbent water. Sir John Ross is credited with this discovery during

his exploration of the arctic seas. But many oceanographers and ichthyologists remained unconvinced. They asserted that more and varied evidence was required before any definite conclusions could be reached. In the year 1872,
the first ship ever equipped for ocean exploring set out to trace a course around the globe. Net-haul after net-haul of strange fantastic creatures came up and were spilled onto the decks.

Poring over the weird beings brought up for the initial time into the light of day, beings no man had seen before, the Challenger's scientists realized that life existed even on the deepest floor

of the abyss. Many years later echo sounding was developed. The echo-sounder or Fathometer is used in conjunction with a chronoscope, an instrument which measures the time space between the sound impulse and

it's echo. Knowing the speed of the sound (about 1,500 ft/sec) and the time it traveled, it is simple to calculate the distance that the sound traveled. Operators of the new instruments soon discovered

that the sound waves, directed downward from the ship like a beam of light, were reflected back from any solid object they met. Answering echoes were returned from intermediate depths, presumably from school of fish,

whales, or submarines; then a second echo was received from the bottom. The facts were well established when Oscar Sund on the research ship Johan Hjort was able to correlate certain images or traces

concerning schools of cod on echograms. Then the war brought the whole subject of locating schools of fish with echo sounders under strict security regulations, and little more was heard about it for

the next few years. In 1946, however, a significant bulletin was issued. It reported that several scientists working with sounding equipment in the deep ocean had discovered a widespread reflecting layer of some sort
which gave back a soft diffuse answering echo to the sound waves unlike the clear, hard answering echoes returned from solid objects. The composition and nature of this layer were not only unknown,

but unimagined as well. Speculations about this mysterious layer ranged far and wide through the scientific world for the next several years. It was not a static or immovable phenomenon, yet it seldom varied

greatly from its original location. It was seemingly suspended between the ocean's bottom and it's surface. The layer was a truly baffling phenomenon. Gradually, however, the scientific data began rolling in. First discovered in 1942,

this reflecting layer was found over an area 300 miles wide. Seemingly suspended between the surface and the floor, it lay from 1,000 to 1,500 feet below the surface. This discovery had been made

by three scientists, Eyring, Christensen, and Raitt aboard the U.S.S. Jasper. Later, Martin W. Johnson, marine biologist of the Scripps Institution of Oceanography, found the first clue to the nature of the layer.

Using instruments of the nature of the fathometer, he found that the echoes moved upward and downward in a rhythmic fashion, being found near the surface at night and in deep water during the day.

This discovery disposed of speculations that the reflections came from something inanimate, perhaps a mere physical discontinuity in the water, and showed that the layer was composed of living creatures capable of controlled movement.

It became clear that the phenomenon was not something peculiar to the west coast alone. It occurs almost universally in all deep ocean basins - at night rising to the surface, an again, before sunrise,
sinking into the depths. Although the nature of the layer was slowly being revealed it was to remain a mystery to scientists and their colleagues for the next several years. In 1947, the reflecting layer

was detected during most of the- day, at depths varying from 50 to 450 fathoms. This 'phantom-bottom' was recorded each day, indicating that it exists continuously in the ocean. Recordings made aboard

the U.S.S. Nereus showed that the- scattering layer existed over all deep waters between Pearl Harbor and the Arctic. It didn't occur, however, in the shallow Bering and Chuckchee seas. Whatever composes the layer,

it's seemingly repelled by sunlight. In other words, it is negatively phototropic. The creatures of the layer seem almost to be held prisoner at the end of Lhe Sun's rays during the hours of sunlight,

waiting only for the welcome return of darkness to hurry upward into the surface waters. But what is the power that repels; and what the attraction that draws them surfaceward once the inhibiting force

is removed? Is it the comparative safety from enemies that makes them seek darkness? Is it more abundant food near the surface that lures them pack under cover of night? Despite attempts to sample

or photograph it, no one is sure what the layer is, although the discovery may be made any day. These observations have led to three principle theories, each of which has its own ardent supporters.

According to these theories, the phantom-bottom might consist of either small shrimp, fishes, or squid, which might make vertical migrations of 100s of feet in response to the presence or absence of sunlight.

These regular vertical migrations, which were detected by the U.S.S. Henderson's echo-sounding devices throughout the Pacific ocean, provide one of the most convincing arguments that the layer consistes of shrimp. In support of the

planktonic shrimp theory is the fact that many tiny plankton creatures make regular vertical migrations rising surfaceward during the night and sinking below the zone of light penetration early in the day. The scattering

layer exhibits exactly the same type and pattern of migration behavior as these creatures. In fact, the name of these tiny shrimp is derived from an ancient word meaning "wandering." In addition to the

migration pattern that is compatible with the movement of the 'phantom-bottom,' it is well known that these creatures live in sufficiently large and dense populations which might account for the strong reflection of

the sound waves of the echo-sounding instruments. Furthermore, these shrimp live in all of the areas in which the reflecting layer was detected and studied during these expeditions. Those who say that fish

are the reflectors of the sound waves usually account for the vertical migrations of the layer by suggesting that the fish are feeding on the shrimp and therefore must follow their food. They believe

that the air bladder of a fish is, because of it's construction the most likely of all the structures concerned to return a strong echo. A large number of fish would account for

the echoes which were recorded. There is one outstanding difficulty in the way of accepting this theory: we have no evidence that concentrations of fish are universally present in the oceans. In fact almost everything else we know suggests that the really dense populations of fish live over the continental shelves. It is doubtful that fish would be present in large enough numbers to account for the 300

mile wide area discovered in 1942. Dense populations of fish found in the open ocean are usually restricted to certain predetermined zones. The recent work of Robert S. Dietz gives convincing evidence that the layer

is composed of small fish. More evidence indicates that the layer consists not only of small fish in search of food, but also of crustaceans. These small fish and crustaceans tend to seek out

areas where food is particularly abundant. The most startling theory seems to have the fewest supporters. It proposes that the layer consists of concentrations of pelagic or free-swimming squid hovering below the illuminated

zone of the sea and awaiting the arrival of the darkness in which to resume their raids into the surface waters rich with food. Squid are unusually mobile, predatory members of a group of

invertebrates called mollusks which includes such creatures as clams, oysters, snails and slugs. Hundreds of proponents of the squid theory agree that they are abundant enough and of wide enough distribution to give the echoes.

They have been picked up almost everywhere from the equator to the poles. Squid form the exclusive diet of the bottlenosed whale and are eaten extensively by most other tooth whales, by seals, and

by many sea birds. These facts argue that they must be prodigiously abundant. The squid are the primary staple of many creatures and yet they are numerous enough to be seen in many different

parts of the world. Even the Architeuthis, or giant squid, is not safe from undersea predators. It seems that squid provide much of the diet of many varieties of whales. That immense square-headed formidably toothed whale known as the cachalot or sperm whale discovered long ago what men have known for only a short time—that many fathoms below the almost uninhabited surface waters of these regions

there is an abundant animal life. A cable repair ship. All American, was investigating an apparent break in the submarine cable between Balboa in the Canal Zone and Esmeralda, Ecuador. The cable was brought

to the surface off the coast of Columbia. The ichthyologists (zoologists who study fish) on the ship found entangled in the cable, a dead male sperm whale. The submarine cable was twisted around the

lower jaw and was wrapped around one flipper, the body, and the fins. The cable was raised from a depth of 540' fathoms - 3,240 feet. In 1957, scientists concerned with the study of the ocean

and its animals began to find further evidence concerning the echo zone. Bruce C. Heezen of the Lament Geological Observatory published a compilation of instances of whales entangled in submarine cables. Some of the

accidents occurred of the Pacific coast of Central and South America. Heezen suggests that as a whale skims along the ocean bottom in search of food, its lower jaw may become entangled in a

slack loop of cable lying on the bottom. The struggles of the whale to free itself could easily result in it’s complete entanglement in the cable. Ichthyologists suggest that some types of seals also

appear to have discovered the hidden food reserves of the deep ocean. How either whales or seals endure the tremendous pressure changes involved in dives to great depths is not definitely known. This is puzzling since they are warm blooded mammals like ourselves. The rapid accumulation of nitrogen bubbles in the blood with sudden release of pressure, called Caisson Disease, kills human divers if they are brought up rapidly

from great depths. Yet according to whalers, certain whales, when harpooned, can dive straight down to a depth of 1/2 mile, as measured by the amount of line carried out. From these depths, where

it sustains a pressure of 1,000 Ibs on every inch of its body, it returns almost immediately to the surface. This sudden and dramatic change in pressure does not affect the whale. The most

plausible explanation is that, unlike the diver, who has air pumped to him while he is under water in the pneumatic caisson or diving bell, the whale has in its body only the limited

supply of air it carries down, and does not have enough nitrogen in its blood to do serious harm. The plain truth is, however, that we really do not know why there is this difference

between human divers and whales. Immense pressure, then, is one of the governing conditions of life in the deep sea. For creatures at home

in the deep sea, however, the. saving fact is that the pressure inside their tissues is the same as the pressure from without. As long as this balance is preserved, the creatures are no

more inconvenienced by a pressure of 2,000 pounds or so that we are by the ordinary atmospheric pressure of 14.7 pounds per square inch (p.s.i.). In a curious way, the colors of marine animals tend to be related to the zone in which they live. Fishes of the surface waters, like the mackerel and herring, often are blue or green as are the thin colored wings of swimming snails.

A more elaborate camouflage is adopted by some of the surface creatures which live in the floating sargassum weed. The fish, Pterophryne, is camouflaged to closely resemble the sargassum weed in that it resembles

almost all parts of the weed including the numerous encrusted worm tubes. Flying fish deposit their eggs in the weeds in clumps or bunches which closely resemble the weeds' beeries. Down below these drifting

weeds, where the water becomes ever more deeply and brilliantly blue, many creatures are crystal clear. Their glassy, ghostly forms blend with their surroundings and make it easier for them to elude the ever-present

and ever-hungry enemy. Such creatures of this layer are the transparent hoards of the arrowworms or glassworms, the comb jellies, and the larvae of many fishes. The unrelieved darkness of deep waters has

produced wierd and incredible modifications of the abyssal fauna. Only a few men, such as Jacques Piccard and Don Walsh have seen it with their own eyes-Light fades rapidly below the surface.

The red rays are gone after the first 200 or 300 feet. Then the greens fade, and at 1,000 feet only a deep brilliant blue is left. Violet rays will penetrate to 2,000 feet.

Beyond this is only the blackness of the deep sea. Where only the violet rays of the spectrum are left, silver fishes are common, and many others are red, drab brown, or black.

The petropods are dark violet. Arrowworms, whose relatives in the upper layers of the brilliant blue waters **are** colorless, are here a deep red. Jellyfish, which above would be transparent, at this depth are

a deep brown. The men who have witnessed the darkness of these waters, such as Barton and Beebe, have reported that the sea has its stars, and here and there an eerie and transient

equivalent of moonlight appears. Below 1,000 feet where only the violet rays of the spectrum penetrate, 1/2 of all the fishes that live, in dimly lit or darkened waters, and by many of the

lower forms as well, the mysterious phenomenon of luminescence is displayed. Bioluminescence in most cases is a light emitting chemical reaction in which a complex compound called luciferin is oxidized in the presence of

its catalyzing enzyme luciferase. Many fish carry luminous torches that can be turned on and off at will, presumably helping them to find or

pursue their prey. Other creatures use luminescence to defend themselves from their enemies* For example, the deep sea squid ejects a spurt of fluid that becomes a luminous cloud. This is the counterpart of

the 'ink' of his shallow-water relative. Immense pressure and darkness, then seem to be examples of the governing conditions of life in the deep sea. These unremitting conditions in the deep water have

produced modifications of life which are necessary for survival in this environment. Down beyond the reach of even the longest and strongest of the- sun's rays, the eyes of fishes become enlarged, as though to make the most of any chance illumination of whatever sort, or they may become telescopic, large of lens, and protruding. In deep-sea fishes, hunting always in dark waters, the eyes tend to

lose the cones or color perceiving cells of the retina, and to increase the 'rods,' which perceive dim light. The last traces of plant life are left behind in the thin upper layer of water,

for no plant can live below about 600 feet even in very clear water, and few plants are able to find sunlight for their food manufacturing activities when such plants are found be-low the

first 300 feet called the photic zone. Only a small percentage of the entire ocean bottom is within the photic zone. Since no animal can make its own food, the creatures of the deeper

waters live a strange, almost parasitic existence of utter dependence on the upper layers. These hungry meat eaters prey fiercely and relentlessly upon each other, yet the whole community is ultimately dependent upon the

slow rain of descending food particles from above. The components of this never ending rain are the dead and dying plants and animals from the surface, or from one of the intermediate layers.

For each of the horizontal zones or communities of the sea that lie, in tier after tier, between the surface and the sea bottom, the food supply is different and in general, poorer than

for the layer above. There is a hint of the fierce and uncompromising competition for food in the immense mouths and in the elastic and distensible bodies that make it possible for the fish to swallow other fish several times their own size, enjoying swift repletion after a long fast. We have learned recently that the conception of the sea as a silent place is wholly false. Wide experience

with underwater microphones and other listening devices for the detection of submarines has proved that, around the shore lines of much of the world, there is an extraordinary uproar produced by fishes, shrimps, porpoises,

and probably other forms not yet identified. There had been little investigation of sound in the deep, offshore areas, until the crew of the Atlantis, the research ship of the Wood's Hole Oceanographic Institution

lowered a microphone into deep water off Bermuda, where they recorded strange mewing sounds, shrieks, and ghostly moans, the sources of which have not been traced. Some 25 years ago in the Spring of 1942,

the microphone network set up during the war, was temporarily made useless when the speakers at the surface began to give forth, every evening, a sound described as being like a 'pneumatic drill tearing up

pavement.' The extraneous noises that came over the microphones completely masked the sounds of the passage of ships. It was discovered that the sounds were the voices of fish known as croakers (marabunta rectatus),

which in the Spring move into the coastal areas from their offshore Winter grounds. As soon as the noise had been identified and analyzed, it was possible to screen it out with an electric filter,

so that once more the sounds of the ships came through the speakers. Mammals as well as fishes and crustaceans contribute to the undersea chorus. Biologists listening through a microphone in an estuary of the St. Lawrence River heard 'high pitched resonant whistles and squeals, as well as mewing and occasional chirps.' The remarkable medley of sounds was heard only while schools of the white porpoise were seen

passing up or down the river, and so was assumed to be produced by them. Old whalers often heard these sounds and therefore referred to the white porpoises as sea-canaries. For years people

have speculated as to the function served by sound production on the part of marine species. It has been known for at least 20 years that the bat finds its way about in lightless

caves and on dark nights by means of an apparatus that detects the presence and location of objects by emitting a stream of high-frequency sound waves which are reflected back from the objects.

Among the early tape recording of underwater sound obtained by the Woods Hole Oceanographic Institution was a recording of some mysterious calls that emanated from waters so deep as surely to be lightless.

They were distinguished by the fact that each call was followed by a faint echo of itself, (probably something equivalent to the bat's sounding device, or the physiological equivalent of sonar) so that

for want of a better name, the unknown author of these eerie sounds was christened the "echo fish." Actual evidence of anything similar to the bat's echo location or echo ranging has come

only recently (about 10 years ago) in the form of ingenious experiments performed on porpoises caught and then experimented on in captivity by W. N. Kellogg of Florida State University. Although they are popularly called porpoises in America and elsewhere, and thought to be a different species than the dolphin, these creatures are in fact bottle-nosed dolphins. The professor finds that the porpoise emits streams

of underwater sound pulses by which they are able to swim accurately through a field of obstructions without collision. They could do this in darkness or in water too turbid for vision.

Far from being the original home of life, the deep **sea** has probably been inhabited for a relatively short time. While life was developing and flourishing in the surface waters, there were immense

regions of the earth that still forbade invasion by living things. Included in these were the continents and the waters of the deep sea. As we have seen, the immense difficulties of surviving

on land were initially overcome by colonists from the sea about 300 million years ago. The deep sea, with its unending darkness, its crushing pressures, its glacial cold, presented even more formidable difficulties.

Probably the successful invasion of this region – at least by higher forms of life - occurred somewhat later. This is all conjecture of course, but it is amazing to consider that the ocean

floor is as alien an environment for most species of fish as the land masses themselves are. As our knowledge increases we continue to note the delicate balance by which things exist in nature.

APPENDIX F

SENTENCE VERIFICATION TEQNIQUE

1. Between the sunlit surface waters of the open sea and the hidden valleys of the ocean floor lies the least known area on earth with its unsolved problems beckoning man.
2. Very few men have had the experience of diving further than the range of visible light.
3. The exclusive domain of the deep sea was reached with a dive in the water of the open ocean in a device called a bathysphere.
4. Before spherically shaped diving boats were introduced, man was able to reach far into the deep by simply wearing a complete diving suit.
5. The funding for development of the diving boat was provided by numerous scientists and individual researchers who were amazed by the scope of the project and excited about any new discoveries.
6. Due to the lack of precise instruments, during the first years of deep sea exploration, the description of the ocean floor was mostly formed by the few men who had made the descent.
7. Like the surface waters, the deep waters are sensitive to every gust of wind, know day and night, respond to the pull of the sun and the moon, and change as the seasons change.
8. Deep down below the surface of the ocean, there is no light and darkness alternation.
9. For most creates groping their way endlessly through its black waters, the deep sea must be a place of peace, where food is abundant and easy to find, a place where there is sanctuary from ever-present enemies, where one can move on and on, from birth through death, through the darkness, confined as if in a womb to his own particular layer of sea.
10. The initial evidence showing that life exists beyond the reach of the sun’s rays was provided by finding worms from a sample of mud collected at depth of 1000 fathoms.
11. The echo-sounder or Fathometer is used in conjunction with a chronoscope, an instrument which measures the time space between the sound impulse and it's echo.
12. Scientists found that although it was simple to gather data from the ocean with new instruments, in order to calculate depth powerful computers were required to analyze the data.
13. Operators of the new instruments soon discovered that sound waves, directed downward from the ship like a beam of light, were reflected back only from the ocean floor regardless of any obstacles.

14. Several scientists working with sounding equipment in the deep ocean had discovered a widespread reflecting layer of some sort which gave back a soft diffuse answering echo to the sound waves unlike the clear, hard answering echoes returned from solid objects.
15. First discovered in 1942, the reflecting layer was found only near the west coast of the United States.
16. One of the explanations for the movement of the reflecting layer is that the fish move up to lay their eggs in the warmer waters near the surface.
17. In support of the planktonic shrimp theory is the fact that many tiny plankton creatures make regular vertical migrations rising surfaceward early in the day and sinking below during the night.
18. Those who believe that the layer is composed of fish argue their theory with the fact that the air bladder of a fish is the most likely structure to return a the strong echo.
19. There is one outstanding difficulty in the way of accepting the fish theory: we have no evidence that concentrations of fish are universally present in the oceans.
20. Minor evidence indicates that the layer consists not only of small fish in search of food, but also of aquatic plant life.
21. The opponents of the squid theory argue that the squid is not capable of making such great vertical migrations as displayed by the layer.
22. Squid form the exclusive diet of the bottlenosed whale and are eaten extensively by most other tooth whales, by seals, and by many sea birds.
23. Scientists suggest that as a whale skims along the surface in search of food, its lower jaw may become entangled in a slack loop cable from a ship or a submarine.
24. How either whales or seals endure the tremendous pressure changes involved in dives to great depths is not definitely known.
25. Human divers are at risk of death if they are brought up too rapidly from great depths due to the rapid accumulation of nitrogen bubbles in the body, combined with a sudden release of pressure.
26. The saving fact for deep sea creatures is the pressure balance between the inside of their tissues and the outside; as long as that is preserved they are no more inconvenienced by the immense sea pressures than we are by the atmospheric pressure.
27. Down below the drifting weeds, where the water becomes ever more deeply and brilliantly blue, many creatures are crystal clear.
28. Deep below the surface where only violet rays of the light spectrum are present, silver, red, drab brown, or black fishes are found.
29. It is still unexplained why the phenomenon of luminescence is displayed only by creatures living in the Atlantic Ocean.

30. Many fishes have luminous torches that help the fishes to find and pursue their prey, however the inability of the torches to be turned off also makes the fishes easier target for enemies.
31. Down beyond the reach of even the longest and strongest of the sun's rays, the eyes of the fishes become enlarged, as though to make the most of any chance illumination of whatever sort, or they become telescopic, large of lens, and protruding.
32. For each of the horizontal zones or communities of the sea that lie, in tier after tier, between the surface and the sea bottom, the food supply is similar and in general, richer than for the layer above.
33. Due to the small size of the majority of the food particles the fishes in the deeper levels do not have well developed teeth and tend to have small mouths.
34. Scientists have abandoned the notion notion the sea is a quiet place.
35. There has been extensive investigation of sound in the deep, offshore areas, including by the crew of the Atlantis, the research ship of the Wood's Hole Oceanographic Institution that lowered a microphone into deep water off Russia, where they recorded strange mewing sounds, shrieks, and ghostly moans, the sources of which were traced to a new type of squid.
36. Fish known as croakers make a sound described as a "pneumatic drill tearing up pavement", which entirely masks the underwater sounds from passing ships.
37. For years people have speculated as to the function served by sound production on the part of marine species.
38. "Echo fish" use their sounding device or sonar during their seasonal migrations as a sort of homing device.
39. As the original home of life, the deep sea has probably been inhabited for a relatively long period of time.
40. It is amazing to consider that the ocean floor is as alien an environment for most species of fish as the land masses themselves are.

APPENDIX G

SURVEYS

Table G.1 Demographic questionnaire

What is your age?						
What is your gender?	male	female				
What is your ethnicity?	Caucasian	African-American	Hispanic	Asian or Pacific Islander	American Indian or Alaskan Native	Other
I am a:	Freshman	Sophomore	Junior	Senior		
What is your program of study or major at UNLV?						
I wear eye glasses	All of the time	Most of the time	Some of the time	Occasionally	Never	
I wear contact lenses	All of the time	Most of the time	Some of the time	Occasionally	Never	

Table G.2 Positive and negative affect scale

	Very slightly or not at all	A little	Moderately	Quite a bit	Extremely
Interested	1	2	3	4	5
distressed	1	2	3	4	5
excited	1	2	3	4	5
upset	1	2	3	4	5
strong	1	2	3	4	5
guilty	1	2	3	4	5
scared	1	2	3	4	5
hostile	1	2	3	4	5
enthusiastic	1	2	3	4	5
proud	1	2	3	4	5
irritable	1	2	3	4	5
alert	1	2	3	4	5
ashamed	1	2	3	4	5
inspired	1	2	3	4	5
nervouse	1	2	3	4	5
determined	1	2	3	4	5
attentive	1	2	3	4	5
jittery	1	2	3	4	5
active	1	2	3	4	5
afraid	1	2	3	4	5

Table G.3 Test anxiety survey

	Test Attitude Inventory	Almost Never	Sometimes	Often	Almost Always
1	I feel confident and relaxed when taking tests	1	2	3	4
2	While taking examinations I have an uneasy, upset feeling	1	2	3	4
3	Thinking about my grade in a course interferes with my work on tests	1	2	3	4
4	I freeze up on important exams	1	2	3	4
5	During exams I find myself thinkg about whether I'll ever get through school	1	2	3	4
6	The harder I work at taking a test, the more confused I get	1	2	3	4
7	Thoughts of doing poorly interfere with my concentration on tests	1	2	3	4
8	I feel very jittery when taking an important test	1	2	3	4
9	Even when I'm well prepared for a test, I feel very nervouse about it	1	2	3	4
10	I start feeling very uneasy just before getting a test paper back	1	2	3	4
11	During tests I feel very tense	1	2	3	4
12	I wish examinations did not bother me so much	1	2	3	4
13	During important tests I am so tense that my stomack gets upset	1	2	3	4
14	I seem to defeat myself while working on important tests	1	2	3	4
15	I feel very panicky when I take an important test	1	2	3	4
16	I worry a great deal before taking an important examination	1	2	3	4
17	During tests I find myself thinking about the consequences of failing	1	2	3	4
18	I feel my heart beating very fast during important tests	1	2	3	4
19	After an exam is over I try to stop worrying about it, but I can't	1	2	3	4
20	During examinations I get so nervouse that I forget facts I really know	1	2	3	4

Table G.4 First part of the environmental survey

The room moisture level was:	**too humid**		**perfect**		**too dry**
	1	2	3	4	5
The room temperature was:	**too warm**		**perfect**		**too cool**
	1	2	3	4	5
The room air felt:	**too stuffy**		**perfect**		**too drafty**
	1	2	3	4	5
The room lighting was:	**too bright**		**perfect**		**too low**
	1	2	3	4	5
Glare on my computer screen was:	**unnoticable**		**moderately noticable**		**very noticable**
	1	2	3	4	5
The room sound levels were:	**too loud**		**perfect**		**too quiet**
	1	2	3	4	5

Table G.5 Second part of the environmental survey

Rate your comfort with respect to the following aspects of your study	**very comfortable**		**comfortable**		**very uncomfortable**
desk	1	2	3	4	5
chair	1	2	3	4	5
computer keyboard	1	2	3	4	5
computer monitor	1	2	3	4	5
Rate your general level of comfort in the study room today.	1	2	3	4	5
In your own words, please explain why you were comfortable or uncomfortable in the study room today.					

Table G.6 Third part of the environmental survey

Rate your level of agreenent/disagreement with the	strongly agree	somewhat agree	neither agree nor dissagree	somewhat disagree	strongly disagree
The room moisture negatively affected my performance on the reading and test assignments.	1	2	3	4	5
I had difficulty focusing my attention on the reading and test assignments because of the room moisture.	1	2	3	4	5
The room temperature negatively affected my performance on the reading and test assignments.	1	2	3	4	5
I had difficulty focusing my attention on the reading and test assignments because of the room temperature.	1	2	3	4	5
The room air (stuffy/drafty) negatively affected my performance on the reading and test assignments.	1	2	3	4	5
I had difficulty focusing my attention on the reading and test assignments because of the room air (stuffy/drafty).	1	2	3	4	5
The room lighting negatively affected my performance on the reading and test assignments.	1	2	3	4	5
I had difficulty focusing my attention on the reading and test assignments because of the room lighting.	1	2	3	4	5
Glare on my computer screen negatively affected my performance on the reading and test assignments.	1	2	3	4	5
I had difficulty focusing my attention on the reading and test assignments because of the glare on my computer screen.	1	2	3	4	5
The room sound levels negatively affected my performance on the reading and test assignments.	1	2	3	4	5
I had difficulty focusing my attention on the reading and test assignments because of the room sound levels.	1	2	3	4	5

APPENDIX H

TEST SUBJECTS' COMMENTS

H.1 Phase I Normal Test Condition Comments

1. I feel comfortable because the room was queit and the notion of disturbance was alomost zero
2. The chair had soft padding.
3. Nothing was bothering me. No students getting up wandering around. No whispers.
4. I was comfortable in this study room because there were not too many people in the study, and we were all spaced out at a comfortable distance.
5. except for being just a little cold, I thought it was a great environment to study in.
6. I was uncomfortable because of the noises of mouse clicks distracted me and made my worried I was going to slow
7. The chair was comfortable but the screen size made it a difficult to sit comfortably while reading.
8. At first I was a little nervous but after getting started on the test and taking my attention off of other things I noticed myself calm down, thus making me more comfortable.
9. I was comfortable in the room becuase i had enough space around me and on my desk and there was no one sitting next to me to bother me as well as not that many noises. The temperature or the room was perfect and setting of the lab was perfect.

10. I was comfortable having a soft chair, and a large amount of space with my own table. Room was a little chilly. Overall I was cofortable having a mouse and being able to do the quiz on a computer.
11. room smells like gasoline..headache
12. the tempature was very nice and the air was good. and the over all atsmoshpere was good. But is was a liltle to quite in here.
13. I felt very comfortable because the seat was very comfy and the reading was not at all stress-ful.
14. It was most definately loud from the little noises people would make from time to time
15. Because I was using a mouse, my elbow lined up with the arm of my chair, and because there was no cushion it got sore.
16. I felt a bit uncomfortable as this seem to be time consuming so sitting in the is chair for a while is not that comfortable.
17. Someone kept slamming their bag down or making not just a little noise but quite loud. It was distracting and irratating. It wasn't an on going thing but it happened more than once. That and the room itself is rather cold and bare. I feel like I am in detention.
18. I were ccnfortable because it was an easy task.
19. This wasn't the most comfortable room but it has a good amount of space between people.
20. i could feel the metal in the chair as i sat and the dest is very slippery so when i tried to rest my head on my hand my arm would slip.

21. For the most part the room was comfortable, but I qould have appreciate a more verstile and accomadating chair, perhaps dim lighting, and having an arm rest so I wouldn't have to extend my arm for long periods of time. It was still relatively calm and comfortable though.
22. The only reason I can think of being uncomforatble during the survey and passages is because i felt tired and exhausted during this experiment.
23. There was nothing really uncomfortable or very comfortable. I have lower back issues so sometimes certain chairs can give me problems, but nothing too serious.
24. chairs were fine! computers were easy and we were spaced nice;therefore the person siting next to you was not right on top of you.
25. it seemed like a normal room and ireally wasnt uncmfortable or very comfortable it was pretty much like any classroom or office space.
26. I experienced nothing out of the ordinary
27. I was cold I usually bring a sweater but I left mine in the car today. That is the main reason I was uncomfortable in the study room today.
28. the only thing that was uncomfortable to me were the chairs but they werent to bad at all
29. i was comfortable because i was able to have moving room know was right next to me were i can't have arm move meant, i was able to move my feet with out kicking anyone or anyone chair
30. because
31. I didn't find any uncomfortable feelings during the test except for the temperature.

32. I was comfortable because the temperature in the room was perfect for me. I was a little uncomfortable because there were constant clicks from the other mouses that were being used.
33. This is a good learning environment, where there is little to distract me. What does distract me is justified by making the room conformable for the group as a whole.
34. THe room was very quiet so the sounds from the clicking of the mouses were very noticable, but this didn't affect my comfort level too much. The only other discomfort I felt was from holding the mouse for a long period of time. Other than those two discomforts the room was an ideal environment for taking an examination.
35. I WASNT UNCOMFORTABLE WITH THE TOOLS PROVIDED, MAINLY i WORRIED THAT I DIDNT RETAIN THE FACTS FOR THE QUIZ, AND I WOULD SCORE POORLY.
36. I was uncomfortable because I am too cold, and I do not like bright lights.
37. the chair has no lumbar support.
38. I think my shoes kept getting stuck to the ground.
39. The chair felt soft, the computer screen didn't really bother, or the lighting. The air temperature was great.

H.2 Phase I Extreme Test Condition Comments

1. the simpleness of the ensembler brought relief on what was to be expected, and the materials just seemed correct for the performance of this test. Overall I felt equipment was just right for this experiment.
2. Because the room was small there weren't a lot of people.
3. so comfortable I fell asleep
4. The room was quiet and peaceful which allowed me to read the passages attentively.
5. I was pretty comfortable in this study room but it seems a little weird being in a room with white walls and a fancy intense door but other than that the computer and mouse were easy to work with and the chairs were pretty comfortable as well.
6. I was comfortable since I had space and was able to complete the study with no disruptions next to me. I did not like however the continuous sound which went on. The room seemed very weird as well
7. Over all the room was pretty comfortable, except the warmth of the room.
8. The arm of the chair hurt my arm as it rested on it and the lighting was a little too bright and almost gave me a headache.
9. i am comfortable because it is a big room and people are able to spread out moderately. we all have our own space and no one gets in our way.
10. I was comfortable because the air and the seating arragements were comfortable
11. Mostly I was comfortable because I did not feel rushed for time. I wish the air vent wasn't making as much noise and that it was a little cooler, but I've definitley taken exams in worse settings so for the most part it did not bother me.

12. it was like any other room
13. My Chair had a small nail sticking my leg, which i got stuck by a few times during the study. The room temp was fine, but the lighting was bad. I just dont care for bright lights.
14. The loud noise is distracting, and sometimes when I find myself unintentionally focusing on it, I space out. The lighting is a bit bright, and I noticed I chose a really bright monitor compared to other students. I can feel my contacts dru out a bit as I take this long test.
15. Even though the sounds of the air conditioner were a bit annoying, I was able to ignore them for the most part during the test. The room was well lit and not distracting if the monitor was placed at the right angle. I moved a little bit in my chair to get comfortable, but in retrospect I do that often anyways, so the chair played no real role. Overall, I didn't feel like I was in a bad environment. A few distractions, but nothing stopped me from focusing on the reading.
16. Everything was ok, but the room was a little too hot and the desk was at a weird height. my fingers started to fall asleep as I was clicking through the reading task.
17. anxious to get done. I dont let the atmosphere bother with me when it comes to education (learning)
18. The chair was what did it for me. It was really comfortable. If i'm going to be sitting for a long period of time i'd like it to be in one of these chairs. The glair of the monitor was too distracting. I found myself trying to block it too often.
19. I was comfortable because it was not much different than any other class. However, staring at the computer screen did discomfort my eyes toward the end.

20. I knew some of the people taking part in the study room. We discussed school related subjects before the test, and joked about them as well, making it comfortable to be in a strange place.
21. The sound of the A/C was a little loud and distracting, but everything else was fine.
22. this room is strange.
23. Well being tall i often have to lean over to work and it puts strain on my back and neck.
24. IT WASNT TOO CROWDED. PEOPLE ARENT SEATED TOO CLOSE TO ONE ANOTHER.
25. Everything was satisfactory.
26. I was relaxing in the chair and felt like falling asleep most of the time.
27. The chair is comfortable because it fits me welll, however, the tape on the floor bothers me.
28. I was comfortable because I was sleepy and just about anything feels comfortable when I am sleepy.
29. Temperature was good, and chair was comfortable. Once I was able to use the magnifier in Windows, everuything worked out for the better.
30. chair hurt my back and the room was eerily quiet
31. static noise, and sometimes too warm
32. The monitor is a bit small and I found myself leaning closer and closer to it. I noticed the room as feeling quite warm as soon as I sat down and anticipate the occasional air movements which relieved that feeling. It is also bright in here, but

I found that helpful considering it is early and I could not bring in more coffee to the lab.

33. In the study room I am overall uncomfortable due to the temperature. I feel the room is overly warm and find myself getting irratable and bored with the material. The chair and desk were fine, better than most other crammed auditorium-like classes. This didn't overcome the temperature though.
34. I think it mostly has to do with the actual appearance of the room because it doesn't feel like a normal classroom and looks unfinished.
35. the room is too bright, the chiars were not comfortable, and the room was warmer than what i would consider ideal.
36. The desk was too high, or the chair was too low. It made it uncomfortable to hold my hand on the mouse. The chairs were also really hard. The floor was uneven which made it a little difficult for me to concentrate because I kept wiggling my feet.The room was also really warm which made me extremely tired and also made it almost impossible to concentrate fully on the reading. It also didn't help that I'm sick.
37. I was uncomfortable because the room was too warm and I was not comfortable using the mouse.
38. The sound in the room was almost completely blocking my thoughts out.
39. There is a static noise that has been going on since before I entered. I figured it was part of the test. It gave me a headache and it made it very difficult to concentrate on the reading. When answering the questions sometimes I would have to read the question several times to get through the annoyance of the static.

40. I was uncomfortable because the whole time that I was reading I was worried about how well I would do on the test and all in all it made me space out and forget what I read.

H.3 Phase II Normal Test Condition Comments

1. There wasn't really any distractions. The seating/tables weren't uncomfortable at all.
2. The room felt like most general class rooms and I find myself confortable in most class rooms
3. everything was normal in taking part of this study, nothing prohibited me in accomplishing my task
4. The instructor was easy-going. The class size is small.
5. THe temperature in the room was perfect, giving me comfort however the chair was hard and uncomfortable making it difficult to sit still.
6. i didn't like the voice of the speaker. the sound of her voice did not coincide with the image on the screen.
7. it wasnt to hot or dry just at the right temberature, the chair was really confortable so i wasnt figiting in my seat. table a little uncofortable but didnt affect much, the lighting of the room equalized the computer's lighting so your dont get that drouzy feeling that you would get in a darker room. there was a nice draft of what felt like fresh air, that helped a lot becuase i heat up real qiuck and that bothers and distracts me. overall the room was relatively confortable for a lab workplace.

8. The computer lab was set up much like any other lab. The desk and chair were very generic so it was much like sitting at any computer.
9. Nothing bothered me, everything was confortable. The seats were cushioned and the tv was at the right height.
10. The desk wwas at a good height and the laptop was at an ok distance, the chair was just an uncomfortable structure for me becuase if was a little firm for its appearance.
11. IT was cold and the lady speaking was off. I wasn't even looking a her; therefore, I was concentrating on how cold and drafty the room was. Plus I got tired of looking at the same color walls while trying to listen to the girl speak.
12. I felt a little uncomfortable because i do not like sitting still for long periods of time where i must be quiet and make a little noise as possible.
13. I don't like metal chairs and the fact that they're red. I don't like how there's no keypad on the laptop.
14. The desk and chair were at the right height for me. The size of the computer monitor and keyboard does not bother me at all.
15. The room is quite except the whistling of the air, the light is not to bright, the chair is nice the table is roomy and the computer is nice!!!
16. The workout this morning was intense and made me tired for the day. I prefer to have a computer monitor at eye level instead of looking down at one. I've grown up in a humid environment so any dry environment is noticeable.
17. There were no distractions to gain my attention, other than it was a little chilly. The chair was comfortable and I didn't have to move around much to get cozy.

18. it was a little chilly, but the chairs were very uncomfortable and made it hard to focus on the lecture.
19. Well, at the beginning of the study, I was extremely alert and focused. The room conditions seemed fair, so I could not complain. The presentation even began well and I was considerably interestred. However, after perhaps 20 minutes, my concentration began to falter, and I started dipping into sleep. I was perhaps too comfortable. I forced myself back awake and returned to alertness.
20. I had room around me instead of being crowded by other students.
21. I was comfortable in the study room today. The only thing that was slightly uncomfortable was the small keyboard and that I forgot my glasses so the words look small on the screen.
22. I was comfortable because the chairs were cushioned and the temperature was nice.
23. The room was very white and reminded me of a hospital. It was sort of scarry looking with button like things on the walls and a lot of wires and such around the room.
24. Just the chair was a little too upright.
25. The only uncomfort I really exprienced was a little sensitivity to the fluerescent lighting. However, this sensitivity isn't an uncommon experience for me, and I have noticed it in the past; I often wear sunglasses. I was also fairly tired so this probabaly effected this sensitivity slightly more. Other than the lighting, I was sufficiently comfortable.
26. there was nothing that made me feel uncomfortable so I remained comfortable.

27. Everything was appropriate for taking a test. It was easy to use and the chair was soft enough.
28. I was comfortable because i was in a soft chair and had a coat on. I think it would have been a little brisk with out my coat.
29. The room was neither too hot nor too cold. It was also not too loud nor was the lighting too bright or dim to be comfortable. The only distraction during the video lecture was that it seemed that the lady in the video moved her lips out of sinc with the recorded voice. This lack of sinc made it hard to look at her while she was talking. I found myself trying to read her lips rather than just listening to her lecture.
30. it wasn't anything special but it wasn't horrible so it was comfortable
31. The environment of the testing location was acceptable. The equipment (e.g. chair & desk) were significantly lower than I might have liked, so I had to lean down to view the screen and crane my neck forward.
32. For a classroom, the chair had good padding. Also the audio on the television was great. It was just loud enough, and was of good quality.

H.4 Phase II Extreme Test Condition Comments

1. I do all kinds of manual labor, and I used to work construction, so any time I'm sitting at a desk, its relaxing; even if the room might be a little uncomfortable (it wasnt).
2. I was comfortable because i was relax and not worrying about the result of the tes.

3. The seats were cushioned. The use of computers made the test less tedious than if it was on paper. There was good lighting. There was moderate noise but I am used to working with noise.
4. Too hot
5. I was comfortable because it felt like a normal classroom that I am in everyday so i was used to it.
6. i was uncomfortable because i was too hot and irritated
7. Surprised at the technology inside the study.
8. I was confortable as you can be in a classroom setting.
9. The only thing that made me uncomfortable was the temperature and air; other than that, everything else was pretty comfortable. I'm use to the keyboard and monitor because I own a Vaio.
10. The chairs were padded so that was nice, and the computer was easy to use.
11. The lighting was to bright. temputure was very uncomfortable. constan noise made it very difficult to focus on material. most importantly the material was so monotone and lacking and vibrancy that it was hard to focus and retain the material within the video. The was surprising to me because I am a person who is very interested in the type of material that was discussed in the video. This just proves for a person like me that pictures and visualizations help in maintaining my interest and help with retaining information.
12. Too hot and bored
13. The chair could have been a little more comfortable but I that was it. The temperature of the room was good and the lighting of the room was good.

14. I was comfortable today in this room, no complaints.
15. It was a bit too warm and it was making me feel tired.
16. The room was too hot and noisy. Both of those combined put me to sleep very easily.
17. Environment too warm. Computer & tv monitors seemed abnormally bright.
18. The chairs were comfortable, the desk was a bit too high. The computer was as comfortable as any other.
19. It's hot and stuffy; Small room w/ a lot of people; Quiet and comfortable enough to concentrate
20. The bright light and hum were a little distracting and the desk was bright and too low, I felt myself hunching a lot.
21. At the begining of the study the room felt very warm, towards the end I could feel the air in the room.
22. Just was.
23. Sound was not in synch with the video. I found it distracting.
24. It wasn't a very stressfull envrionment.
25. I was comfortable because there was plenty of space between me and the surrounding people. there was no cluster on or around the desk or computer.
26. It seemed like during the middle of the lecture the room became very warm, made me feel tired and I even closed my eyes a couple times.
27. Conditions were great for a learning environment. I would rather be in a slightly warm room although they do tend to put me to sleep.

28. Generally, the rooom atmosphere was comfortable enough. But the placement of students directly behind each other inhibited my view of the screen, and therefore forced me to hold my neck at an angle. This caused my neck to become very stiff and made me move often in order not to become too inconvenienced.
29. It was a tad bright a warmier than what i am used to so that made me a tad unconfortable.
30. It was slightly warm throughout the room, and the movie itself wasn't very entertaining so it was difficult to focus on that when I was trying to get comfortable in my chair and the lights were also slightly bright it made me want to squint.
31. The noise from the vent made it extra hard for me to pay attention to the video. It was a little too warm, and I got clammy for a second. Other than thatm the conditions were not bad so for the most part I was comfortable.
32. The chair was soft and comfortable overall.

REFERENCES

[1] U.S. General Accounting Office. 1995. School facilities: America's schools not designed or equipped for 21st century. GAO report number HEHS-95-95. Washington, D.C.: General Accounting Office. (ED383056)

[2] Reynolds, Douglas D. 2007. International Study Program for Indoor Environmental Research Second Workshop Write up. University of Nevada Las Vegas.

[3] U.S. Department of Education, National Center for Education Statistics, 2000. Condition of America’s Public School Facilities: 1999, NCES 2000-032.

[4] Mallino, D., Woods, J. E., and Novosel, D. 2004. Final Report: National Center for Energy Management and Building Technologies Task 5 – Sector Based Interactive Educational Seminar for Education. National Center for Energy Management and Building Technologies (NCEMBT-040731-5), 601 North Fairfax Street, Suite 250, Alexandria, VA 22314.

[5] U.S. General Accounting Office. 1996. School facilities: America's schools report differing conditions. GAO report number HEHS-96-103. Washington, D.C.: General Accounting Office. (ED397508)

[6] Bates, J. 1996. Healthy learning. *American School & University* 68(5), pp. 27–29.

[7] Harner, David P. 1974. Effects of thermal environment on learning skills. *The Educational Facility Planner* 12 (2): 4–6.

[8] King, J., and R. W. Marans. 1979. The physical environment and the learning process. Report No. 320-ST2. Ann Arbor: University of Michigan Architectural Research Laboratory. (ED177739)

[9] Wyon, D. P., I. B. Andersen, and G. R. Lundqvist. 1979. The effects of moderate heat stress on mental performance. *Scandinavian Journal of Work, Environment, and Health* 5, pp. 352–61.

[10] Wyon, D.P. 1991. The ergonomics of healthy buildings: Overcoming barriers to productivity. In IAQ '91: Post Conference Proceedings. Atlanta, Ga.: American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., pp. 43–46.

[11] Dunn, R., J. S. Krimsky, J. B. Murray, and P. J. Quinn. 1985. Light up their lives: A review of research on the effects of lighting on children's achievement and behavior. *Reading Teacher* 38 (9): 863-69.

[12] Jago, E., and K. Tanner. 1999. Influence of the school facility on student achievement: Lighting; color. Athens, Ga.: Dept. of Educational Leadership; University of Georgia.

[13] Mayron, L. W., J. Ott, R. Nations, and E. L. Mayron. 1974. Light, radiation, and academic behavior. *Academic Therapy* 10 (1): 33–47.

[14] Phillips, R. 1997. Educational facility age and the academic achievement of upper elementary school students. D. Ed. diss., University of Georgia.

[15] Lackney, J. A. 1999. Assessing school facilities for learning/assessing the impact of the physical environment on the educational process. Mississippi State, Miss.: Educational Design Institute. (ED441330)

[16] Boman, E., Enmarker, I., & Hygge, S. 2005. Strength of noise effects on memory as a function of noise source and age. *Noise & Health, 7,* 11-26.

[17] Hygge, S., Evans, G.W., Bullinger, M. 2002. A prospective study of some effects of aircraft noise on cognitive performance in school children. *Psychological Science, 13,* 469-474.

[18] U.S. Architectural and Transportation Barriers Compliance Board, 2002. Progress toward a new standard on classroom acoustics for children with disabilities.

[19] Mendell, M. J. and Heath, G. A., 2005. Do indoor pollutants and thermal conditions in schools influence student performance? A review of the literature. *Indoor Air*, 15, 27-52.

[20] Daisey, J. M. and Angell, W. J., 1998. A survey and critical review of the literature on indoor air quality, ventilation, and health symptoms in schools. Lawrence Berkley National Laboratory, Berkley, CA

[21] Daisey, J. M., Angell, W. J., and Apte, M. G., 2003. Indoor air quality, ventilation and health symptoms in schools: an analysis of existing information. *Indoor Air*, 13, 53-64.

[22] National Research Council. 2007. *Green Schools – Attributes for Health and Learning*. The National Academies Press, Washington, D.C.

[23] Baddeley, A. D. (1986). *Working memory*. Oxford: Clarendon Press.

[24] Baddeley, A. D. (2001). Is working memory still working. *American Psychologist, 56*, 851-864.

[25] Robustness P-Diagram. Overview.The Quality Portal. (2008, May 9). *The Quality Portal organizing the web with a focus on quality*. Retrieved June 23, 2010, from http://thequalityportal.com/p_diagram.htm

[26] Royer, J., Greene, B., & Sinatra, G. 1987. The Sentence Verification Technique: A Practical Procedure for Testing Comprehension. *Journal of Reading, 5,* 414-422.

[27] Spielberger, C.S. 1980. Test Attitude Inventory. Redwood, California: Mind Garden.

[28] Watson, D., & Clark, L. A. 1988. Development and Validation of Brief Measures of Positive and Negative Affect: The PANAS Scales. *Journal of Personality and Social Psychology*, *54*(6), 1063-1070.

[29] ANSI S12.60-2002, "Acoustical Performance Criteria, Design Requirements and Guidelines for Schools.

[30] ANSI/ASHRAE Standard 55, Thermal Environmental Conditions for Human Occupancy.

[31] Illuminating Engineering Society. IES Lighting Handbook: The Standard Lighting guide, 9th ed. p. 10-13.

[32] Chase, M. 1973. The Matriculating Brain. *Psychology Today*, *2*, 82.

[33] Carson, R., & Longworth, A. R. 1951. *The sea around us* . New York: Oxford University Press.

[34] Landsberger, B., L. Tan, X. 2008 Hu. Energy and Acoustic Performance Effects Due to VAV Duct Design and Installation Practice Variation. Las Vegas, NV: HVAC&R Research. 14(4)

[35] T-10 Series-Illuminance Meters | KONICA MINOLTA. (n.d.). *KONICA MINOLTA Global*. Retrieved February 6, 2011, from http://www.konicaminolta.com/instruments/products/light/illuminance-meter/t10/specifications.html

[36] Svantek. (n.d.). *SVANTEK - human vibration acoustic dosimeter sound measurements monitoring station occupational health and safety monitoring vibration measurements*. Retrieved February 6, 2011, from http://svantek.com/sound-vibration-analysers/svan-958four-channels-sound-and-vibration-analyser-11.html

[37] i-ceiling Sound Systems - Armstrong Commercial Ceilings. (n.d.). *Flooring, Ceiling and Cabinet Products by Armstrong*. Retrieved February 6, 2011, from http://www.armstrong.com/commceilingsna/article21963.html

[38] Krueger E-Catalog. (n.d.). *Krueger*. Retrieved February 6, 2011, from http://www.krueger-hvac.com/ecatalog/family.aspx?refid=156

[39] BDV-E370 | 3D Blu-ray Disc™ Home Theater System | Sony | Sony Style USA. (n.d.). *Sony Style USA | Sony VAIO® Computers | Sony Consumer Electronics*. Retrieved March 18, 2011, from http://www.sonystyle.com/webapp/wcs/stores/servlet/ProductDisplay?catalogId=10551&storeId=10151&langId=-1&productId=8198552921666240 5

[40] HDTV Televisions | LCD TVs, LED TVs, Plasma TVs | Samsung. (n.d.). *SAMSUNG*. Retrieved March 18, 2011, from http://www.samsung.com/us/video/tvs

[41] Warner, R. (2008). *Applied Statistics*. Thousand Oaks, CA: Sage Publications.

[42] Cause and Effect Diagram. (n.d.). *Balanced Scorecard Institute*. Retrieved September 29, 2010, from www.balancedscorecard.org/Portals/0/PDF/c-ediag.pdf

VITA

Graduate College
University of Nevada, Las Vegas

Stoil Pamoukov

Degrees:
Bachelor of Science in Mechanical Engineering, 2009
University of Nevada, Las Vegas

Special Honors and Awards:
Senior Design Project Award- First Place in Mechanical Engineering, 2009

Thesis Title: International Study Program for Indoor Environmental Research

Thesis Examination Committee:
Chairperson, Douglas Reynolds, Ph.D.
Committee Member, Brian Landsberger, Ph.D.
Committee Member, Darrell Pepper, Ph.D.
Graduate Faculty Representative, Gwen Marchand, Ph.D.