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Project Number: DCB9950-43

COMPUTERS AND EYESTRAIN

An Interactive Qualifying Project Report

submitted to the Faculty

of the

WORCESTER POLYTECHNIC INSTITUTE

In partial fulfillment of the requirements for the

Degree of Bachelor of Science

By

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Date: October 19, 2000

Approved:

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1. **computers**
2. **eyestrain**
3. **monitors**

Abstract

The hypothesis of this IQP is that prolonged and sustained usage of Visual Display Terminals (VDT) or Monitors is responsible for a noticeable and cumulative degradation of eyesight.

Most of the current research suggests that use of monitors affects people only in the short term, with such common ailments as dry eyes, blurred vision, head ache, drooping eye lids, eye fatigue, and others. The purpose of this IQP will be to show that prolonged monitor usage has some long-term effect.

Acknowledgements

We would like to thank Professor Brown for his work on advising this project. We would also like to thank Professors Doyle and Petrocelli for their technical advice on the creation and analysis of the survey.

We would also like to acknowledge the research we attained through e-mail correspondence with Drs. Jeffrey Anshel and James Sheedy. We would further like to acknowledge the research done by Brian Felouzis in the beginning stages of this IQP.

Finally we would like to acknowledge and thank the students who completed the surveys for this IQP and the Professors who gave up a portion of their class time to allow the surveys to be administered.

1. Introduction

Although the positive effects of computers are well known, general knowledge of negative consequences due to computer use is less well known. Computers have been integrated into almost every part of life without much opposition. Since the integration has been so accepted, the effects of the drastically increased time spent in front of a computer screen have gone largely unnoticed, which therefore makes the potential for problems higher.

One of the most marked areas of integration has been in the corporate world. Computers have replaced older technologies, such as typewriters and adding machines. Jobs that were once classified as "unskilled labor" such as an assembly line worker now require basic computer skills.

The amount of time spent on a computer depends on the particular application. Some professionals such as programmers and graphic artists are required to use the computer constantly, and can spend between eight and ten hours a day in front of a monitor. On the other hand, a division manager of a large corporation may use his computer only for email communication and to generate reports.

Another noticeable area of integration has been in colleges and universities. With the advent of the Internet, e-mail and word processing programs, it is almost essential for a college student to own a computer. In addition to these more necessary uses, there are computer games that usually require an hour or so for each sitting.

Also depending on the major, different students have specific computer uses. Students majoring in computer science are required to do programming, which involves extensive amounts of time going over text on the computer. Since the hypothesis of this IQP is that extensive use of monitors increases the likelihood of eyesight degradation, we would expect that computer science majors would have a more significant reduction in overall eyesight quality in relation to the Biology students or any group that uses the computer to a very small degree. To this end a historical questionnaire will be issued to both groups of students to determine the changes in the quality of eyesight over the students' college career.

Due to the pervasive nature of the computer into all manners of academics at WPI as well as to society in general, it is very difficult to have a non-monitor using control group. To provide a more statistically accurate view of the students of WPI there will be two distinct population samples questioned: computer science and biology majors. It is also the hypothesis of this IQP that computer scientists by the very nature of their courses will be predisposed to increased monitor usage, while biology students would be the most likely students not to use the computer for any more than is necessary. The expected result of this survey is that, while both groups will have a downward trend in eyesight, the computer scientists will have a steeper decline.

2. Computer Vision Syndrome

Computer Vision Syndrome, commonly referred to as CVS, is one of the health risks involved with frequent use of computers. CVS occurs in 50 - 90% of workers who consistently use a video display terminal. (Sheedy, 1999) Computer users feel the effects of CVS due to the strain on the human eye system. CVS results in both physical and nonphysical effects.

The human eye system functions at its best when it is concentrating on a focal point that is hundreds of yards away from the body. CVS results from setting the focal point of vision too close to the eye. Continual concentration on a monitor starts to cause eye strain due to the abnormal focusing distance of the screen from the eye. (Ankrum, 1996) Prolonged concentration of the eyes on a computer monitor also forces the eyes to be opened wider than normal (most likely due to the brightness of the monitor), and to blink at a much lower rate. (Berliss-Vincent, 2000)

There is also the possibility of receiving a damaged monitor with a computer system. Damage could upset the placement of electromagnets inside the monitor, causing numerous problems including a slightly lower picture quality which may force the eyes to squint.

These problems resulting from extended exposure to a computer monitor produce an array of physical effects. Short-term physical effects of CVS include blurred vision, tired eyes, eyestrain, aching of the upper body,

headaches, eye fatigue, and dry eyes. (www.essl.net (1), 1999) General body fatigue can also occur as a product of strain on the eyes.

CVS, unfortunately, is usually ignored since the effects of this disorder are usually thought of as common problems. Once these common problems become frequent and more exaggerated, the non-physical side effects start to arise.

Side effects of the physical symptoms are apparent in the workplace as well as in colleges and universities. A worker who experiences even a few of the physical effects of CVS can decrease his or her work performance by up to 19%, which calculates into an average loss between $1,200 and $5,700 per employee per year. (Eye2Eye, 1999) Some effects, such as blurred vision or eyestrain, result in a higher error rate as the day progresses. CVS causes discomfort not only in the employee or computer user, but also disturbs job performance.

The elimination of CVS is essential in the workplace. The employer is responsible for assuring that a user's workstation strictly adheres to the advice of ergonomics to totally rid employees of these symptoms. Employers should use caution in assigning employees jobs where the causes for CVS are prominent, and should take steps towards preventative techniques and corrective techniques for employees who have already aquired CVS.

One method of resting the eyes and preventing eystrain is to observe the "20/20" rule. Every twenty minutes you should look at something more than twenty feet away. (F-One Ergonomics, 1999) This allows for the eyes to rest

from constant fixture on the monitor and return to their normal position of fixture on far-sighted objects. As an extreme option, there are lenses specifically made to reduce stress on the eyes for frequent VDT users.

The employer must also be sure that there is proper illumination in the workplace. Improper illumination or glare from sunlight due to the absence of drapes or blinds will cause strain on the eyes. While these window treatments eliminate natural light problems, filters in front of the computer screen should be considered to remedy artificial light problems. Correcting and preventing CVS is time consuming and possibly expensive but necessary for those with prolonged exposure to video display terminals.

3. Refining IQP and Survey Creation

The main goal of this IQP was to confirm the validity of the hypothesis, that the prolonged and sustained usage of Visual Display Terminals (VDTs) or Monitors is responsible for a noticeable and cumulative degradation of eyesight.

3.1. Term 1: Research

During the first term of the IQP we tried to do as much research as possible on the possible eye problems associated with computer use. Our goal was to show that there were long term consequences to VDT use. One of the larger problems with this subject is that since it is such a new phenomenon, there was scarcely any primary research to be found. Most of the articles we found only described the short-term effects of VDT usage, often in connection with the medical condition known as Computer Vision Syndrome (CVS). We had to rely on scientific articles and web sites geared towards CVS for most of our data.

There was also very little previous IQP research based on this topic. The only paper with any relevance to this topic was "Health Effects of VDT Use" by Richard Blanchette from 1986. That IQP dealt with the effects of electromagnetic radiation of a VDT as it affected the user. The conclusions he

reached were from lack of conclusive evidence rather than a substantiated result.

In addition to health problems directly relating to the eye, the other main area of research available was with ergonomics. Several sources cited the short-term effects of improper monitor usage and it's connection to improper ergonomic conditions.

The most speculated long term effect of CVS is myopia, or near-sightedness. According to Dr. Anshel, myopia is still being diagnosed into the early to mid twenties, past the accepted age of full eye maturation. He proposes that this has to do with the increased usage of computer monitors in today's society. This hypothesis seems to be validated by strong connection between highly educated countries, and the rising rate of myopia. The more educated a country is, the more likely it is for its population to develop myopia. The assumption is that it is a result of the increased reading that occurs for education. In non-educated countries, myopia is virtually non-existent. (Anshel, 1999)

Dr. James Sheedy was commissioned by the American Ophthalmological Association to study the effect of VDT use on users' eyes. He concluded in his report that 15% of patient scheduled eye exams are the result of computer vision syndrome. (Forte, 1997) Another study by Dr. Stephen Dain shows that a person's blink rate will slow down after extended use because of the ultraviolet rays from a computer screen. This in turn causes the eyes to dry out. (Caprio, 2000)

The overall data that we were able to find was ultimately inconclusive. Many sources stated that there was, in fact, no known long-term cumulative damage to the eyes due to VDT usage. References written about CVS stated that all symptoms were short-term and could be corrected by a proper amount of preventative care and rest after the fact.

After completing the research for the IQP we refined the information found into two different possible topics. Each topic was a possible IQP that we could do. The first topic was to show that there was indeed a long-term negative effect to using computer monitors. The second topic was to show the correlation between short-term eye problems, Computer Vision Syndrome, and ergonomics.

The first topic required a study of some kind to determine the rate of eyesight degradation in students after engaging in increased usage of VDTs. The second topic would require a study of the ergonomic factors of the computer labs at the school and the degree of occurrences of the symptoms of CVS in students at WPI.

Both topics were similar in that they would be studying the effects of VDT usage among students, but they differed in that the first dealt with establishing a correlation between excessive computer monitor exposure and eyesight degradation, while the second accepted that there were no long term effects to computer usage and proposed to attempt to see how many students at WPI were affected by computer vision syndrome. The second topic would have also included an educational section to discuss how to alleviate the

problems cause by improper ergonomic factors, and both topics would have required a survey of some kind to discover the information that was necessary to prove their hypotheses.

In the end it was decided that we would conduct a survey to prove or disprove the hypothesis in the first topic.

3.2. Term 2: Methods of Data Collection

The first objective was to decide how to measure the degradation of eyesight in students at WPI. It was hard to find a method of judging eye damage given the lack of quantifiable data. The eye records of all the students on campus are not available, nor do all students get eye exams on an annual basis. Due to this, we cannot judge the level of degradation with anything but relative loss year to year. Unfortunately this method is completely subject to the interpretation of each individual student.

We decided to create a survey to gather data about the relative degree of eyesight degradation in each student over their college career. The survey is located in Appendix A

We also asked questions that we felt would show contributing factors. We felt these factors would show trends that increased monitor usage would lead to eyesight degradation. The factors were: type of computer, average time spent at computer per day, use of vision corrective lenses.

The next objective was to identify the study sample sets that were available on campus. One sample set needed to be the most likely to be affected by constant computer use. This would be our "experimental" group. Another sample set needed to be the most likely not to use computers if possible. This would be our "control" group. The sample sets we decided on were the Computer Science (CS) majors and Biology (BB) majors respectively.

It was very hard to have a true control group for this project given predisposition to computer usage by Worcester Polytechnic Institute (WPI) students. WPI is largely a technology driven college, and almost every major has classes that require the use of a computer in some manner. Also, given the rising use of technology in everyday lives, it becomes increasingly harder to find subjects who have not had even occasional computer use.

In optimal conditions students would be tracked in a long-term study where they would undergo eye exams every year starting in high school and lasting two to three years into their professional career (approximately age 24-25). Also a control group should be high-school aged children from a society where computer use is extremely minimal.

The experimental group was chosen due to the fact that the computer science major is entirely based upon programming and other activities that require several hours per day of intensive computer usage. It has also been assumed that CS students are also more likely to utilize their computers overall, resulting in a higher average time used per day.

The control group was chosen since it was felt that biology students are most likely not going to be required to use the computer in their major-centric courses. Also, given the lack of computer interaction in the major it is assumed that the amount of overall use would be less than that of the CS students. It is important to note that the assumptions on the difference between the two majors' recreational use were unconfirmed, due to the inability to gather the necessary information on the BB students.

After picking the groups to study it was decided that a survey would be the most efficient way of discovering the answers to the questions we had. A seventeen-question survey was then developed to cover several areas of usage patterns. The questions were designed to correlate the various factors of computer use and to establish the demographics of the both groups.

The surveys were to be distributed to the classes of the different survey groups. The finished surveys would be collected and the resulting data would be put into a matrix that would allow us to easily compare the correlation between questions.

3.3. Term 3: Analysis

To analyze the surveys we collected from the computer science students, we set up a matrix relating each question on the survey to every other

question. This way we could directly analyze the affect that one particular answer of one question had on another question.

In setting up the matrix, we listed each possible answer for each question horizontally and vertically. This created a grid pattern with boxes being formed from the intersection of the rows and columns. We then took each survey and entered the results in one at a time. If a person answered that they had a 15" monitor and that they experienced headaches, then we would look for the intersection of the row with 15" monitors and the column for headaches. Now we would just increment the number in the box by one. After we were done, the number in this box would be the total number of people who owned 15" monitors and experienced headaches.

We could then take this number of students and divide it by the total number of students who owned desktops to find out what percentage of students who owned desktops experienced headaches. We used this same procedure for analyzing all of the other factors from the survey.

3.4. *Survey Design*

The first major criterion to list on the survey was the major of the student taking the survey. The two groups that were studied in this survey were Computer Science (CS) majors and Biology (BB) majors.

The next question, concerning the year of entrance to college, was asked to establish the length of time a student has been attending college. Use of the general term "year of entrance," as opposed to "year entered WPI," was to take into account transfer students. The inherent flaw of this question was that it does not take into account years taken off during college, co-ops, or delayed entrance to college, all of which can add to the amount of computer use a student has up to the point of the survey.

Another question was about living arrangements. This was included in the survey to find out whether the location of a student's living area has anything to do with their computer usage.

After the question of living arrangements is a determination of the type of computer. It was assumed that there were differences to the amount of eyestrain incurred by using a cathode-ray tube (CRT) monitor or a liquid crystal diode (LCD) monitor. This was due to the fact that a CRT monitor is constantly writing the image from the top of the screen to the bottom extremely fast.

The image you are seeing on a CRT is not static. It is being refreshed so fast that most people don't notice it, but it still causes your eye to fill in the

missing pieces while it waits for a new signal. With a LCD monitor, the image is being edited on the pixel level as things change so most of the screen is static while only the small portion that is being changed is affected. This allows for less compensation by your eyes to see the image. It is closer to reading a hard copy.

Also considered a factor of eyestrain was the size of the monitor. This fact was ascertained by the next question in the survey in which the respondent had to choose between one of three size ranges.

Next was a question to determine whether a student uses WPI campus lab computers more than their own. This question seeks to show if there is any correlation between the types of computers at home or at the lab and the incidence of eyesight degredation.

Given the supposition that eyesight degradation is related to extended computer use and the possible pre-existing eye damage, the next set of questions seeks to establish the current level of eyesight defect. Average length of time using a computer in a given day, use of vision corrective lenses, use of vision corrective lenses while at the computer, and when the corrective lenses were first acquired are all explored.

Next a series of yes or no questions are asked to determine what symptoms, if any, of CVS are apparent in the student. These will allow for us to show a correlation between CVS and eyesight degradation.

Following this is a table for students to express what level of eyesight damage they feel they have suffered year-to-year while they were students at

college. The student is then asked to consider the idea of computer glasses for the next two questions. They were asked if they currently had them. If they didn't have them they were asked to decide if they felt that using computer glasses would be beneficial to their eye health. "Computer glasses" are vision corrective lenses specifically designed for the unique distance requirements working at a computer cause. They solve the problem caused by the fact that reading glasses are for items closer than the screen, and by the fact that long distance glasses are, as the name implies, for viewing items much further away than computer screen. Computer glasses allow the user to have glasses fitted to focus on items the exact distance that a computer monitor is located, which results in less compensation by the eye muscles.

The next question deals with the problem bi-focal glasses cause, due to the fact that the positioning of the secondary lens is situated in such a way that viewing a computer monitor is not easily accomplished unless the user is sitting in a position that causes bad posture. The user is forced to either utilize the lower "reading" lens of the bifocals by tilting their head up, causing neck and eye strain, or sitting closer to the monitor and tilting the upper body back a bit, causing back pain.

Finally the last question is to determine whether or not the student is bothered by low scan rates on the computer screen. This is referred to as a "flicker" to describe the way that the screen seems to blink noticeably at low scan rates.

These questions will be able to be analyzed both individually and against each other in order to conclude the validity of the hypothesis of this IQP. Also they will provide valuable data that will allow future studies to more accurately target study groups and will provide an understanding as to the type of usage patterns that exist in the different student groups on campus.

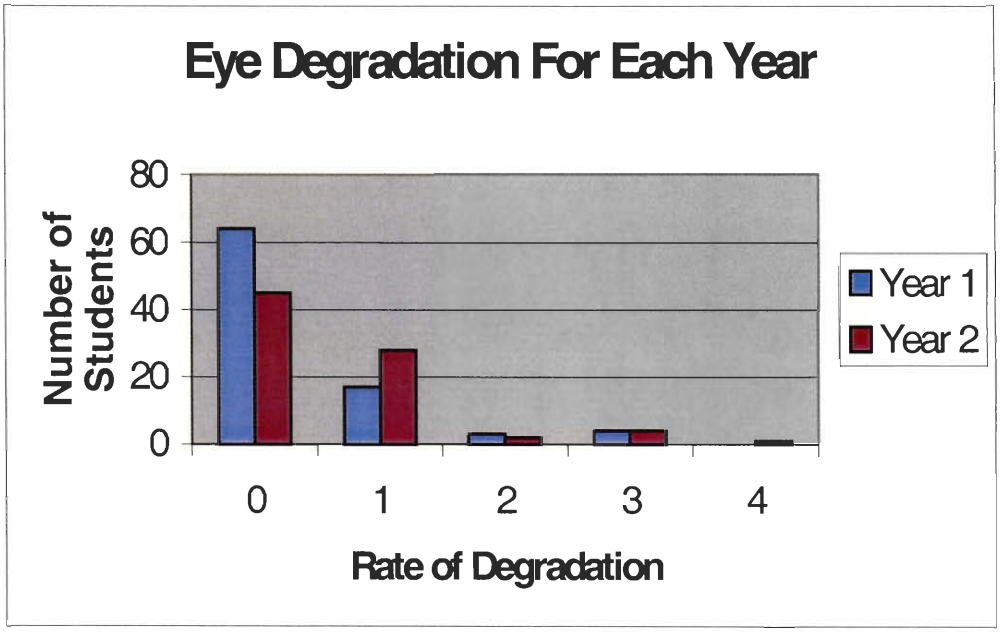
4. Analysis of Final Data

One of the purposes of this IQP was to determine if there was a correlation between certain user factors and symptoms of Computer Vision Syndrome. We refer to user factors as the type of equipment or the actual physical habits of computer users. For example, some user factors used in our study were monitor size, type of computer, hours of average daily use and whether or not they use WPI computers more than their own. To ascertain how much one of these user factors affected a user getting a particular symptom, we set up a matrix relating each of the factors to each of the symptoms. This way we would have a way to directly analyze the effects of each factor.

4.1. Rate of Degradation

On the survey, we asked students to choose a number that describes how much their eyes degraded during each year. A zero means that the student experienced no change in vision during that year, a one represents a slight change in vision and so on. Since we are measuring an amount of degradation (zero, one, two, etc.) per unit of time (one year), we are measuring a rate of degradation for each year. For example, if a student circles zero for year one, then that means that the student experienced no change in vision during that year. Since the student experienced no change in vision, we say that the student's rate of degradation of eyesight was zero for year one. Now if the

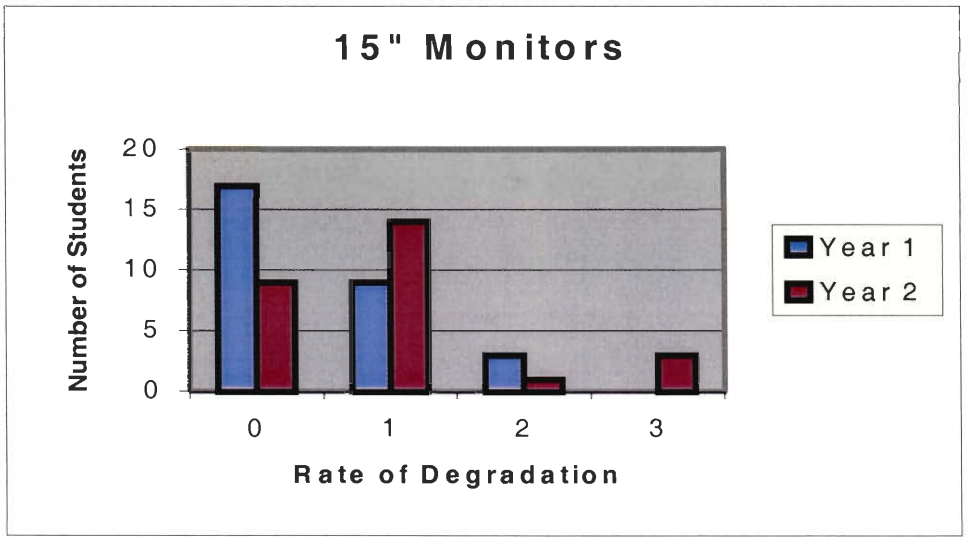
student circles one for year two, then he/she is saying that there was a slight change in vision during year two. This means that the student's vision degraded at a slight rate during the second year. We can not calculate this rate exactly in terms of actual medical units used by optometrists because each student interprets the one, two, three or four differently. However, we can determine if the rate increases or decreases from the first year to the second year. The following graph shows the rate of degradation of eyesight of CS students for each of the first two years they have spent at WPI. Since most of the students were sophomores, only the first two years are shown.

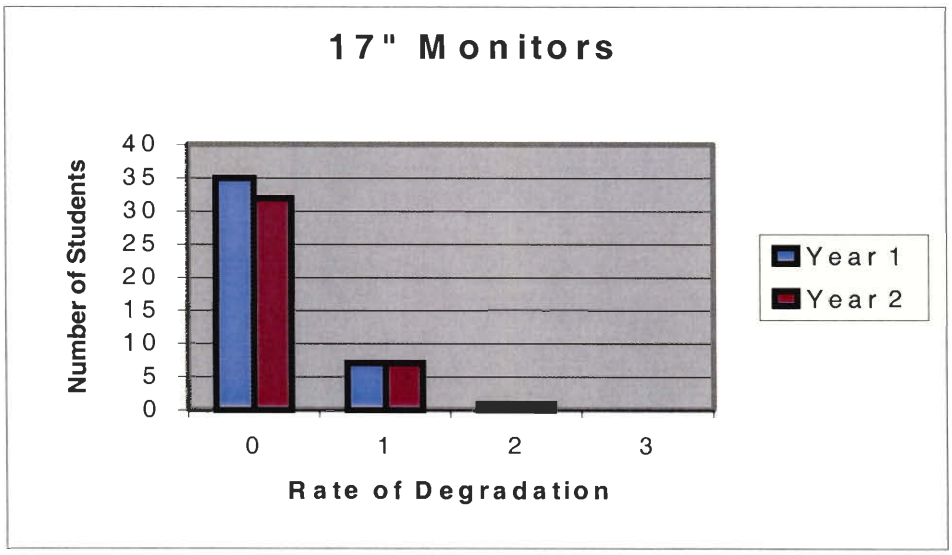


As you can see, most students reported that their vision did not change much during their first year of school. Sixty-four saying that they experienced no change and 17 saying there was only a slight change (degree one). But after their second year only 45 reported no change while the number that reported a

slight change increased to 28. This suggests that the rate of degradation of vision increases from the first year to the second year. This result forms the basis of our IQP. We will now show that certain user factors either speed up or slow down this rate of degradation.

The first factor we are comparing shows that there is a correlation between the size of a student's monitor and the rate of degradation of eyesight. The following graphs show the rate of degradation for the first two years.



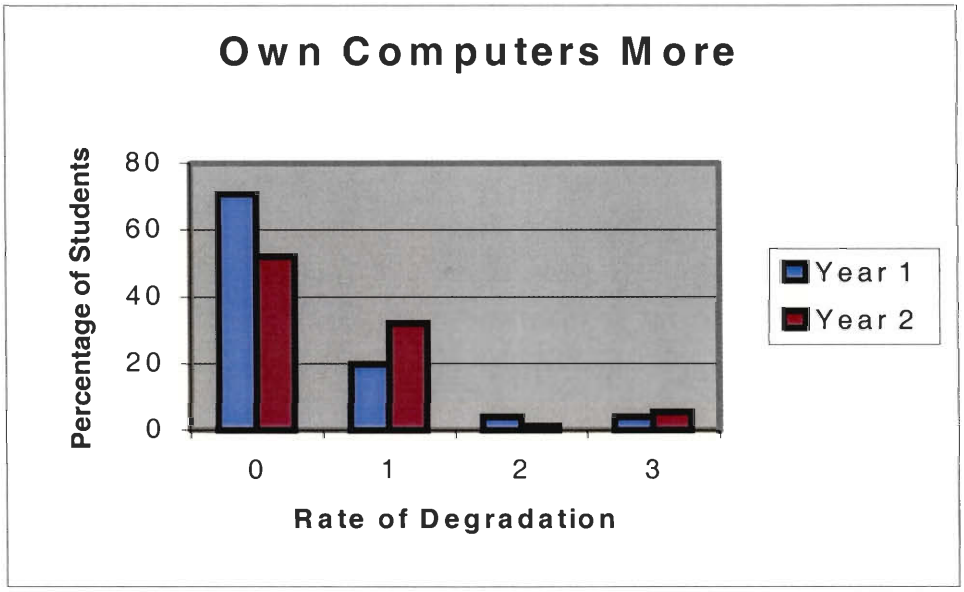


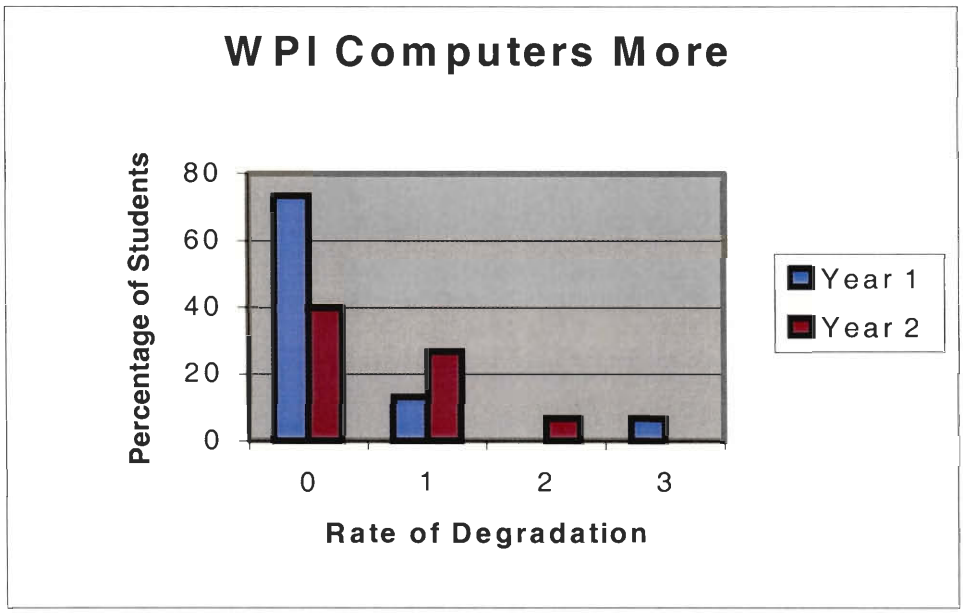
These two graphs show an interesting result. If you look at the graph for 15" monitors you will see a pattern similar to the general graph for degradation on the previous page. By this we mean that during the first year, 17 students reported no change and 9 reported a slight change. During the second year, only 9 reported no change and the number that reported a slight change increased to 14. This rate of degradation is very similar to the overall results we found above. Students are experiencing more of a change in vision during their second year. However for the 17" Monitor users, 35 reported that there was no change and 7 reported a slight change for the first year.

During the second year, 33 reported that there was no change and 7 reported a slight change again. The numbers are very similar for both years, indicating that the rate of degradation is almost zero. This indicates that people who use 17" monitors are experiencing a lower rate of degradation of vision than the people who use 15" monitors. Both 15" and 17" monitor users may be experiencing degradation in eyesight, it's just that the rate of degradation will not increase from year to year for the 17" monitor users. This result agrees with our intuition that using a larger monitor is easier on the eyes.

Next we tried to see if students who used the WPI computers more than their own, experienced more of a rate of degradation. The number of students who reported that they used WPI computers more than their own was 15 and the number of students that didn't was 75. Because these numbers are so different, the resulting plots will be skewed and a pattern will be difficult to see.

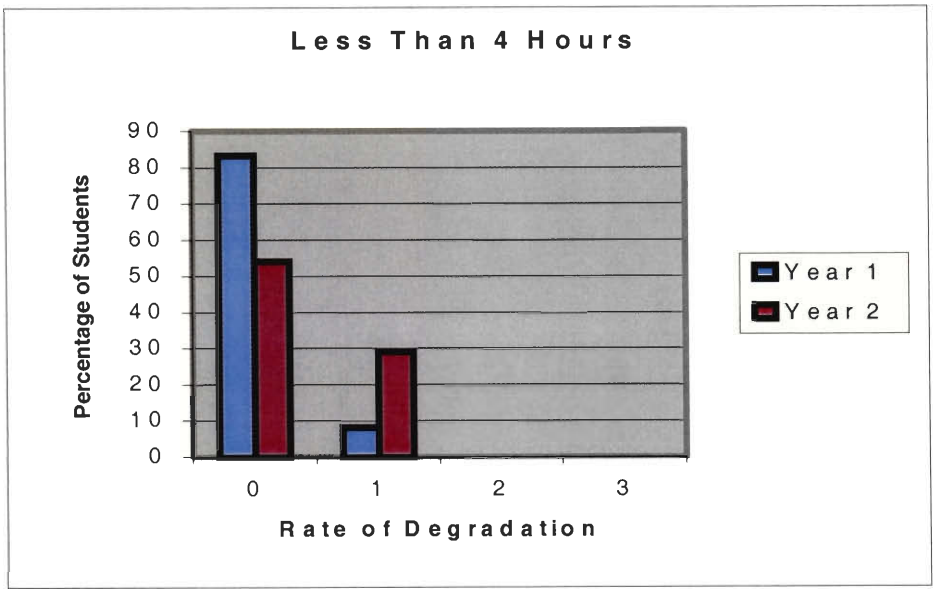
To correct this, we statistically weighted each result to show equal numbers for both responses on the survey. This means that we will in fact be looking at percentages of each total rather than the actual numbers. The following graphs showed the results we obtained from our survey.

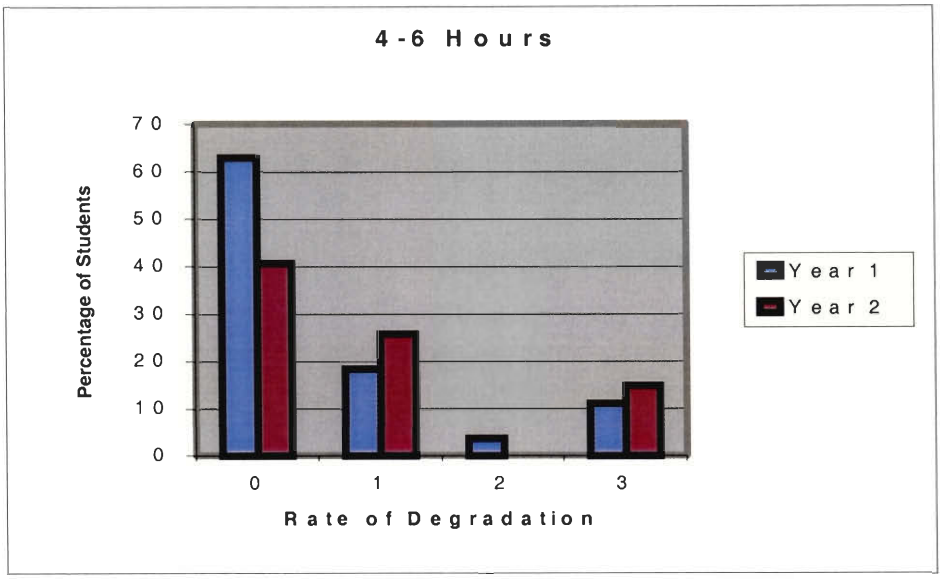


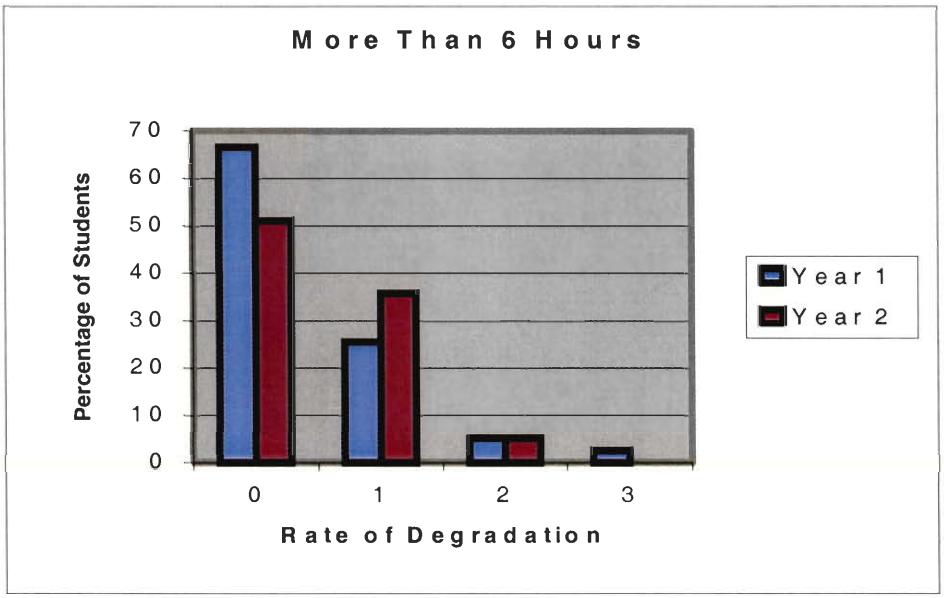


As you can see, both of these graphs look similar. They both show the pattern for increasing degradation as you go from year 1 to year 2. This tells us that the effects are the same if you use your own computer more or the WPI computers more. We somewhat expected there to be less degradation for people who use the WPI computers more. This is because the WPI computer labs have been set up to be ergonomically correct, with proper lighting etc., which would help prevent vision degradation. This is usually not the case for people who use their own computers. The average person typically is either unaware or doesn't care about such ergonomic factors as lighting, etc... For these computer users, we would expect their rate of degradation to be worse.

The next user factor that we will discuss will be the average number of hours per day using a computer. On the survey, we allowed students to choose one of five possible answers: less than two hours, two to four hours, four to six hours, six to eight hours, and more than eight hours per day. For our analysis however, we will combine the results from the first two choices into one choice and the last two choices into one choice. So now we get the following choices for average hours of daily use: less than four hours, four to six hours, and more than six hours. We decided to combine these survey answers due to the fact that relatively few people chose the extreme answers (less than two hours and more than eight hours). Once again for this comparison we will be using the percentages of the students who replied for each answer. The following graphs show the results from our survey.


Less Than 4 Hours
Percentage of Students
90
80
70
60
50
40
30
20
10
0
0
1
2
3
Rate of Degradation
Year 1
Year 2

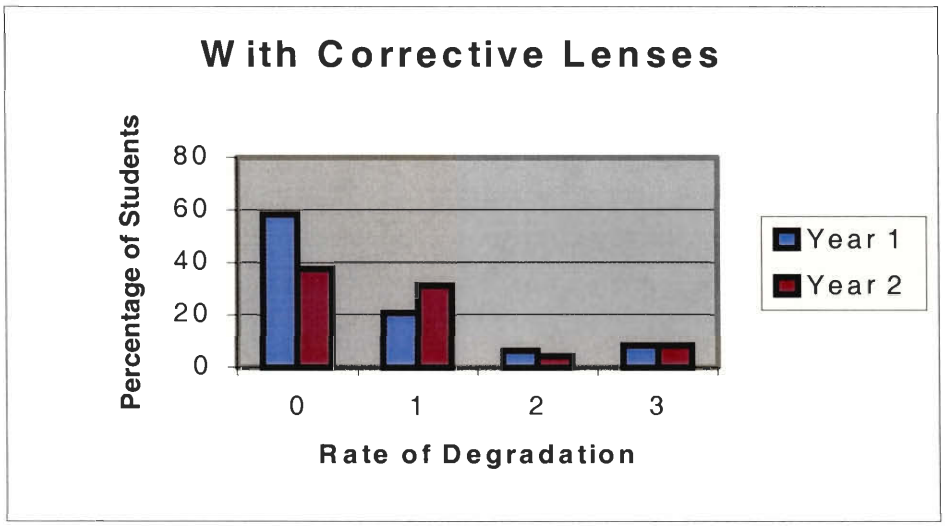

4-6 Hours
Percentage of Students
70
60
50
40
30
20
10
0
0
1
2
3
Rate of Degradation
Year 1
Year 2

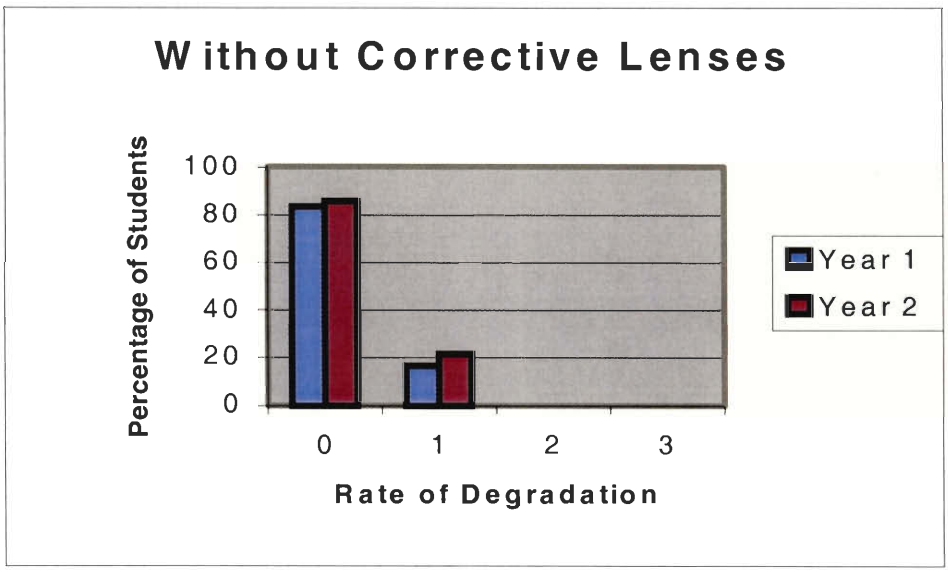


Each of these graphs show the typical pattern we have seen indicating an increasing rate of degradation. We can therefore conclude that the amount of time spent on a computer will not affect the rate of degradation of vision. However, if we look at only one year at a time, we can see a trend not in the rate of degradation but in the degree of it. For example, if we look at only year one, we see that 83% of the students who use computers less than four hours per day, experience no change in vision. But for students who use computers between four and six hours or more than six hours, we see this percentage drop to 63% and 67%, respectively. Also for year two, 55% of the students who use computers less than four hours per day, experience no change in vision. But for students who use computers between four and six hours or more than six hours, we see this percentage drop to 41% and 36%, respectively. This

shows that the more you use a computer, the more your vision will degrade. However, the rate of this degradation will not increase the following year based on the time spent using a computer per day. All this information comes from the last three graphs or from the matrix.

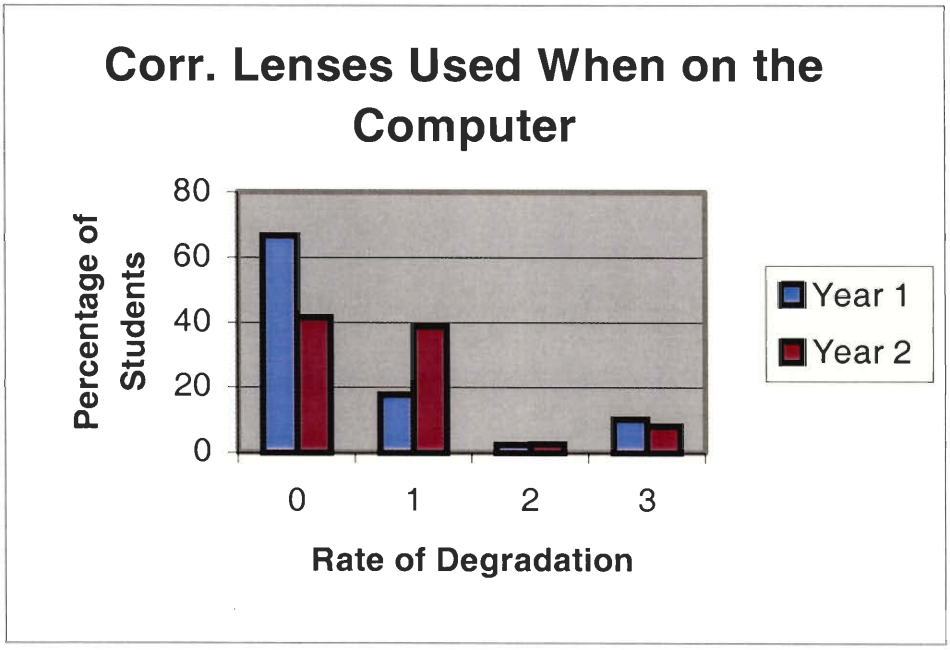
The next comparison will be made between students with corrective lenses and students without them. The following graphs show our results.

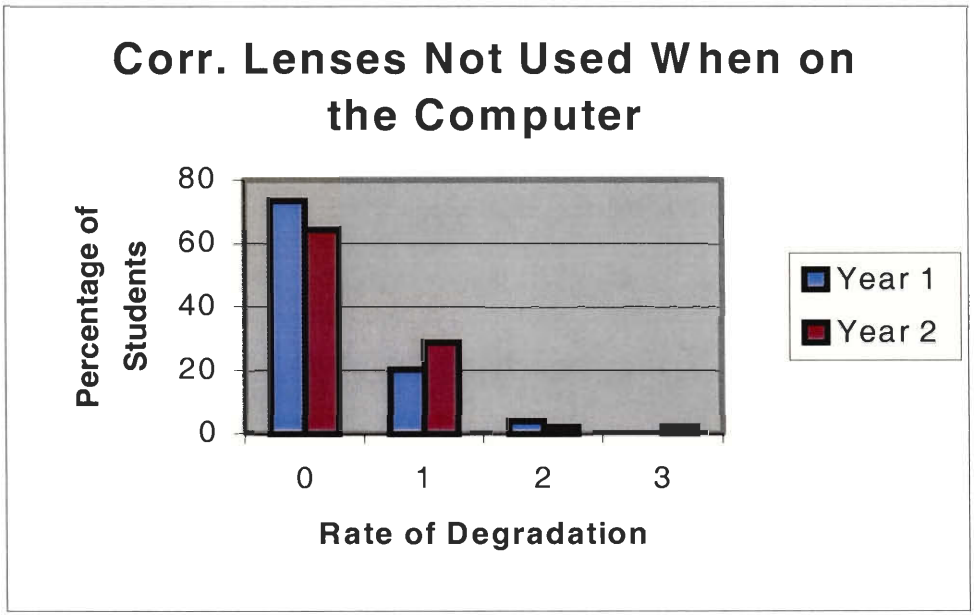




On the survey, 48 students said that they have corrective lenses while 42 said that they did not. For students that use corrective lenses we see that the rate of degradation of their eyesight increases but for students who don't use corrective lenses, the rate stays the same. In other words, students with corrective lenses will find that their eyesight gets worse each year with an increasing rate, while students who don't use corrective lenses will find that their eyesight may get worse each year but not with an increasing rate. We could then conclude that corrective lenses don't prevent students vision from getting worse.

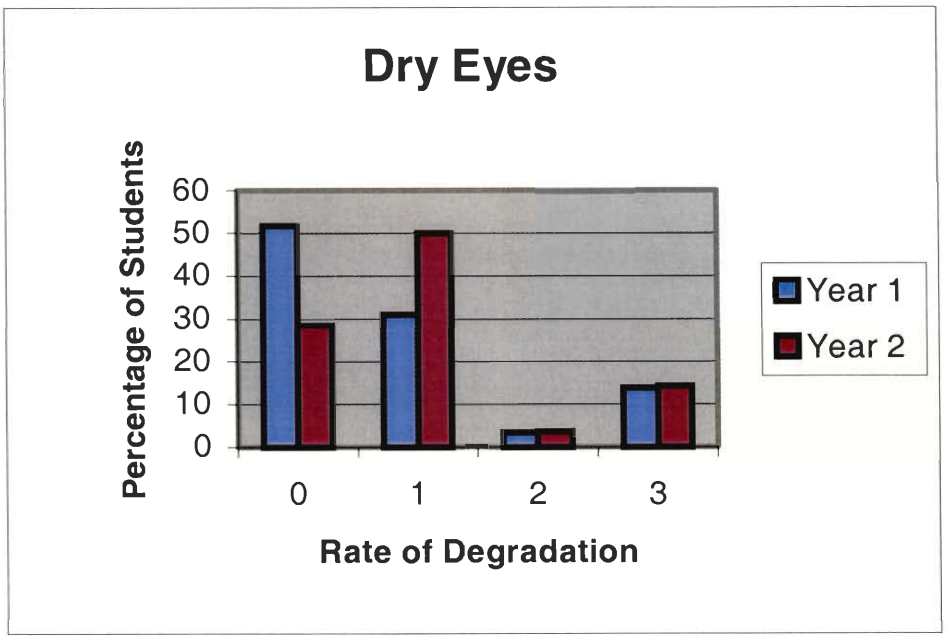
Now we will perform the same comparison for students who use corrective lenses while working on the computer.

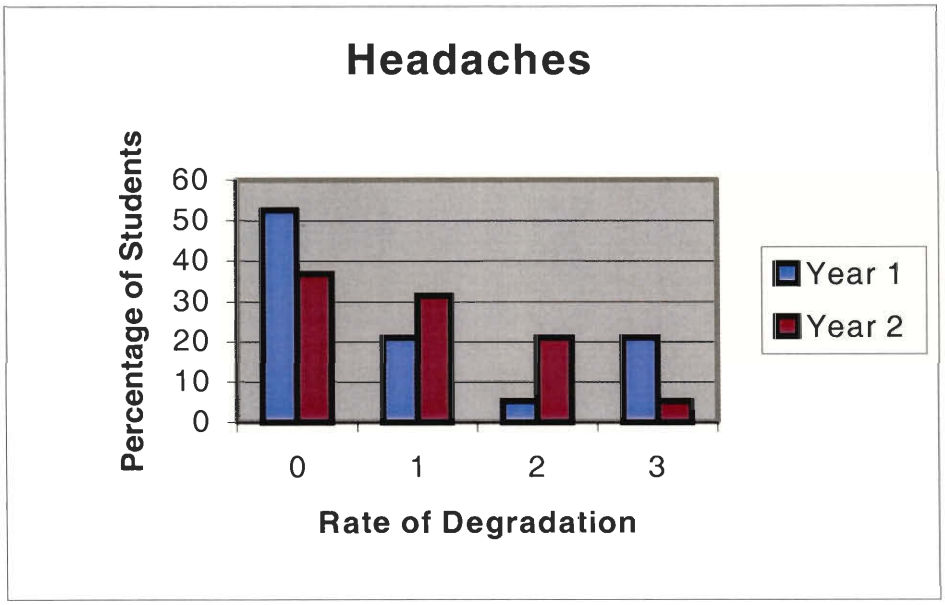




For students who use corrective lenses while on the computer, their eyes still show the same rate of degradation from one year to the next. This is also true of students who don't use corrective lenses while on the computer. In conclusion, we can say that using corrective lenses does not affect the rate of degradation of eyesight.

All of the previous comparisons determined whether or not certain user factors affected the rate of degradation of eyesight during the first two years of college. The next series of comparisons will be used to determine if certain symptoms experienced by students affects the rate of degradation of eyesight. The first and second of these symptoms to be analyzed are dry eyes and headaches.


Dry Eyes
Percentage of Students
60
50
40
30
20
10
0
0
1
2
3
Rate of Degradation
Year 1
Year 2


Headaches
Percentage of Students
60
50
40
30
20
10
0
0
1
2
3
Rate of Degradation
Year 1
Year 2

The first graph shows that there was an increase in the rate of degradation from the first year to the second year. During the first year, about 52% of students reported that they experienced no change in vision and 31% reported that they experienced a slight change. During the second year, about 30% of students reported that they experienced no change in vision and 50% reported that they experienced a slight change. This shows us that students who experience dry eyes while working on a computer will most likely not notice a change in vision during the first year but will notice a change during the second year. We can conclude that this increase in the rate of degradation is typically accompanied by the symptom of dry eyes.

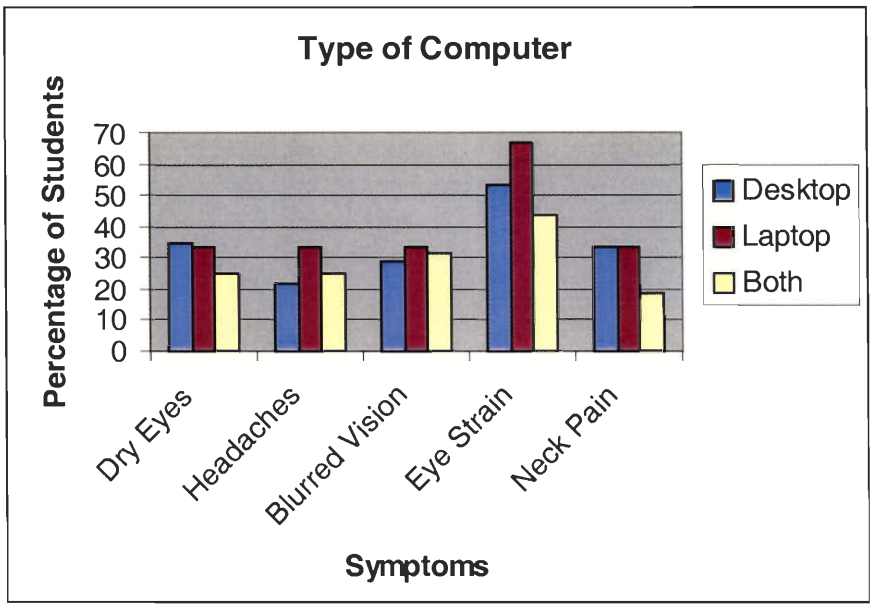
The second graph shows how students who experience headaches while working on a computer rated their degragation in eyesight during each year. This graph is similar to the graph for dry eyes except for the second year statistics. During the second year, 21% of students who experienced headaches while working at a computer experienced a significant decline in vision (degree two).

4.2. Symptoms

In the previous section we showed how certain user factors affected the rate of degradation of eyesight. In this section, we will show if there is a

correlation between those same user factors and some of the symptoms experienced by students while using a computer.

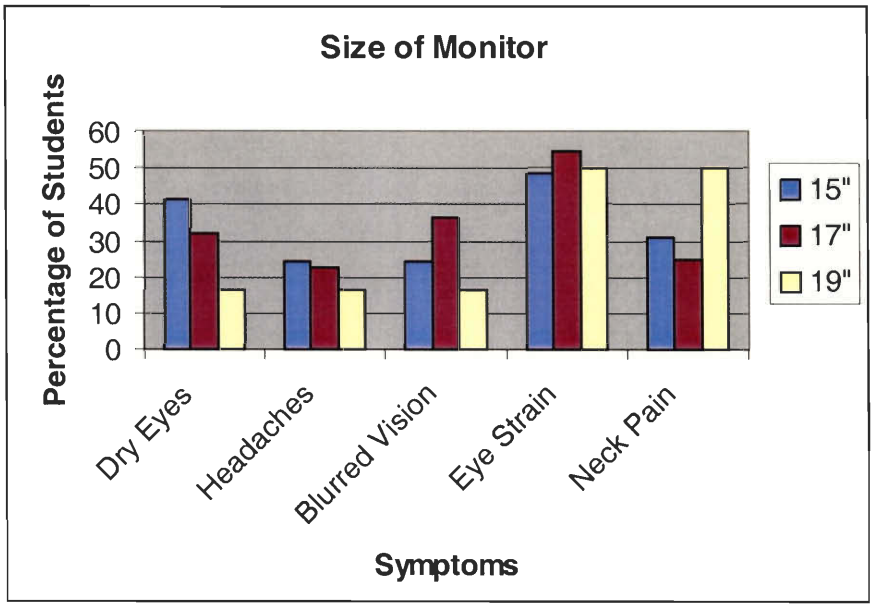
The first user factor we will discuss is the type of computer. On the survey, we gave students four different choices: desktop, laptop, both, and neither. The following graph shows the results we obtained. For this graph as with all the other graphs, the percentage of students is out of the total number of students within that particular type.



From this graph we can see that each of the symptoms were experienced by roughly the same percentages of students regardless of the type of computer they had. Since using each type of computer forces the eyes to focus on a point typically only a foot away, they both cause Computer Vision Syndrome. So this graph agrees with our intuitive guess. The only noticeable difference between the two types of computers is that there is a greater percentage of

laptop users that experience eye strain. This could be due to the fact that laptop screens are smaller than desktop screens. The smaller size puts more of a strain on the eyes and usually causes the user to have to look closer at the screen. Another possibility is that the portability of laptop computers encourages an odd placement for working which can cause eyestrain.

The next factor we will discuss is the size of computer users' monitors. From our survey, we had 29 users with 15" monitors, 44 with 17" monitors and 12 with 19" monitors. The data for 19" monitors does not show a good representation of the symptoms experienced by those users because there were so few responses. However, we decided to show the data anyway to look for possible trends. The following graph represents the data we found.



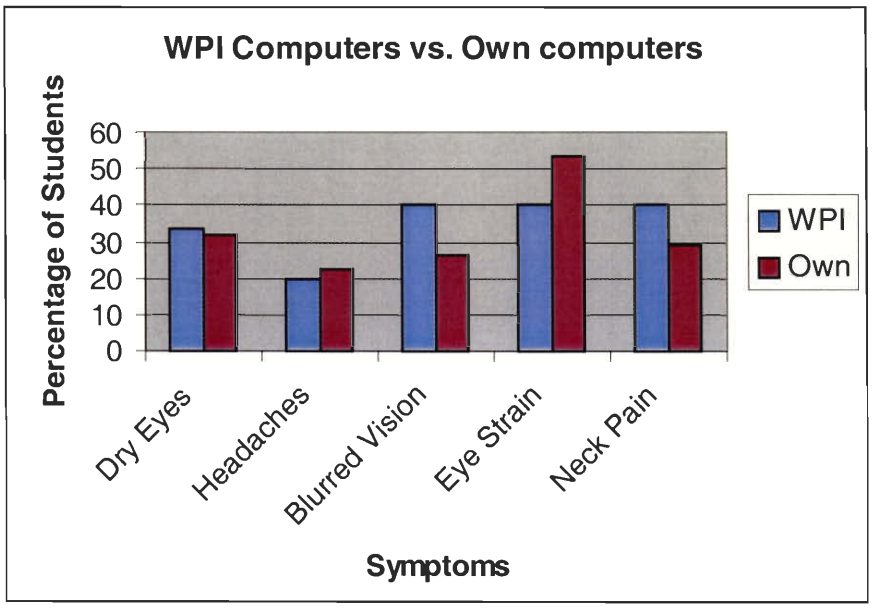
From the graph it appears that the symptom of dry eyes decreases as you increase the size of your monitor. One possible explanation is that larger monitors are usually more expensive and more sophisticated with better safety features for the user. One of these safety features is the reduction of ultraviolet radiation that is emitted from the computer screen. Ultraviolet radiation causes a person's blink rate to go down which usually results in dry eyes. Perhaps the smaller, cheaper monitors don't have as much ultraviolet radiation reduction and as a result cause the user to experience the symptom of dry eyes.

The symptom of headaches appears to decrease slightly as you increase your monitor size. From our research we found that headaches experienced during computer use are almost always associated with eyestrain. Since there are many factors that influence eyestrain, we cannot say for certain that there is any correlation between the size of a monitor and the symptom of headaches. This also explains why eyestrain was experienced by about 50% of the students regardless of the type of monitor they were using.

There does not seem to be any correlation from our graph between the size of a user's monitor and the symptom of blurred vision. We didn't find any evidence that could explain why the number of users that experienced blurred vision was higher for users of 17" monitors than for users of 15" and 19" monitors. About 30% of users of 15" and 17" monitors experienced neck pain while 50% of users of 19" monitors experienced it. Once again there were relatively small numbers of 19" monitor users that took the survey but there is

a possible explanation. The larger monitor size may force the user to have to look upward at a greater angle than the users of the smaller monitors causing stiffness and pain in the neck.

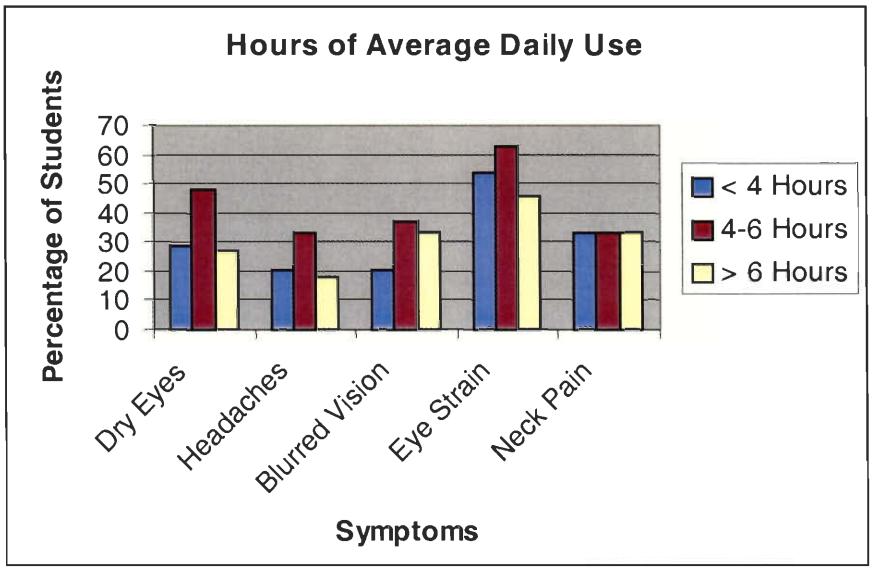
Next we will try to find a correlation between vision symptoms and whether or not students use WPI computers more than their own. We expect there to be fewer symptoms among the students who use WPI computers the most since those computer labs have been set up to be ergonomically correct. The following graph shows the results we obtained from our survey.



The symptoms of dry eyes and headaches appear to be the same for students who use their own computers and for students who use the WPI computers more than their own. This may be because most of the students who owned their own computer reported that they used a 17" monitor which is the typical size monitor found in the WPI computer labs.

Blurred vision and neck pain were experienced more by people who use the WPI computers more than their own. This could be caused by a number of reasons. One is that sometimes when people work on computers in the labs, they work in groups. When this happens, there is usually one person sitting in front of the computer and one or two more sitting beside that person. The people sitting on the left and right of the computer user have an awkward viewing angle to the screen. This forces them to change their normal sitting position which could cause pain in their necks. Eyestrain was experienced by more people using their own computers than by those using the WPI computers. This is most likely caused by improper lighting in the students dorm rooms or apartments. Since the lighting in the computer labs is generally adequate, students using those computer don't have to squint as much and strain their eyes.

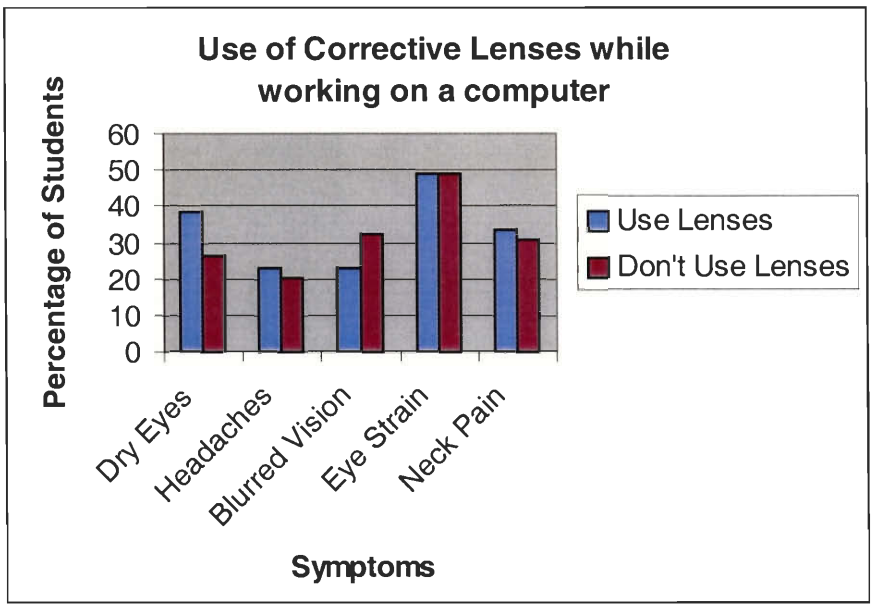
Next we will analyze the data concerning the average hours spent on a computer per day. We are expecting to find that the more a user uses a computer, the more that user will experience the symptoms of computer vision syndrome. The graph below shows the data we received.



As you can see, the results do not agree with our initial guess. It seems that people who use a computer between four and six hours per day are more at risk of experiencing the symptoms of dry eyes, headaches, eyestrain and blurred vision. Perhaps the users who consistently use a computer more than six hours per day develop some kind of immunity to these symptoms. There doesn't seem to be any linear correlation between these symptoms and the average daily use of a computer. The same percentage of people experienced neck pain regardless of the number of hours spent in front of a computer.

We will next try to see if these symptoms are experienced more by people who use corrective lenses while on the computer. It is our understanding that ordinary corrective lenses are usually only used to correct vision and not to correct computer vision syndrome. We therefore expect to see that these

symptoms are experienced equally by people who use corrective lenses and those who don't. The following graph shows the data from our survey.



The results for the different kinds of symptoms are for the most part equal for those who use corrective lenses and those who don't. More students who use corrective lenses reported that they experience dry eyes than students who don't use them. It is difficult to find the reason for this because there are different types of corrective lenses that could have been used by the students who filled out the survey. For example, students who wear contact lenses are obviously more likely to experience dry eyes than those who wear glasses.

One of the main results of this IQP was that students experience a higher rate of degradation during their second year at WPI than during their first year. We also found that certain factors influence this increased rate more than

others. Some of our findings were that the rate of degradation is reduced if you use a larger monitor or use a computer in the WPI labs versus one of your own. Another one of our key findings is that use of a laptop computer increases the chances of a user experiencing the symptoms of Computer Vision Syndrome.

This concludes the analysis portion of the IQP. Since there were usually only a few choices for each student to pick on the survey, actual statistical analysis would be impractical. For example, if you examine the graph relating size of monitor and percentage of students experiencing symptoms you will see this more clearly. For the symptom of dry eyes, you can see a linear relationship between the percentage of students and their monitor size. The larger the monitor, the less percentage of students will be experiencing dry eyes. This information comes from the matrix we used to analyze the data and gives us only three data points. This is not enough information to fit an accurate line to. The only way to get more data points is to give the students more choices for monitor size and measure the results for those extra choices. For example, if we allowed students to circle 13", 14", 16", 18", 20", and 21" monitors, we would then have six more data points for a total of nine. It would then be feasible using statistical analysis on all these points.

5. Noted Problems and Recommendations for Future Work

One of the problems with this IQP was unavailability of comparative data. Several attempts were made to collect the surveys from Biology students but due to circumstances beyond our control we were not able to collect the surveys in time to complete this project. What surveys we did collect we felt were inaccurate and unreliable. Rather than allow the Biology data to skew the final results we felt the IQP would be best served by restricting the final analysis to the Computer Science data.

Future students wishing to pursue a project in this subject should review the data we have collected and our analysis of it as a base for creating future surveys. Given our analysis, future questions to students should be able to be more refined and allow for a more focused study.

Also, future students may wish to use one of the other consortium schools as a possibility for the control group, as there are more likely to be non-technological majors outside of WPI.

6. Appendix A: The Survey

1. Date: _____

2. Major: _____

3. Year of Entrance to College (circle one):
   a) 1995
   b) 1996
   c) 1997
   d) 1998
   e) 1999

4. What type of housing do you current live in:
   a) Dorm
   b) Apartment
   c) Commute

5. What kind of computer do you own:
   a) Desktop
   b) Laptop
   c) Both
   d) Neither

6. If you own a Desktop what size is your monitor:
   a) Not Applicable
   b) 15" or less
   c) 17"
   d) 19" or larger

7. Do you use the WPI Lab Computers more than your own?
   a) yes
   b) no

8. How much of your day is spent in front of the computer?
   a) Less than 2 hours
   b) 2-4 hours
   c) 4-6 hours
   d) 6-8 hours
   e) More than 8 hours

9. Do you use vision corrective lenses (glasses, contact lenses, etc)?
   a) Yes
   b) No

10. Do you use vision corrective lenses when working at the computer
    a) Yes
    b) No

11. If you use corrective lenses, when did you get them?
    a) Not Applicable
    b) Before College
    c) 1st Year of College
    d) 2nd Year of College
    e) 3rd Year of College
    f) 4th Year of College

12. After using the computer for extended periods of time do you get:

Dry Eyes	yes	no
Headaches	yes	no
Wrist Pain	yes	no
Blurred Vision	yes	no
Eye Strain	yes	no
Neck/Shoulder Pain	yes	no

13. How much worse, if at all, has your eyesight become since coming to college?
    (0 – No Change, 5 – A Lot Worse)

Year 1	0	1	2	3	4	5
Year 2	0	1	2	3	4	5
Year 3	0	1	2	3	4	5
Year 4	0	1	2	3	4	5
Year 5	0	1	2	3	4	5

14. Do you use computer glasses (prescription glasses used specifically for computer use) when you use the computer?
    a) yes
    b) no

15. If you don't use computer glasses, do you feel that you need them or that they would be beneficial to your eyesight?
    a) yes
    b) no

16. If you wear bifocals, do you find that it forces you to sit in a position that causes physical discomfort?
    a) yes
    b) no
    c) n/a

17. Do you ever notice any flickering on the screen?
    a) yes
    b) no

7. Appendix B: The Data Matrix

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