WC003I
RXV-2552-51

The Foxboro Company Classroom Design Project

An Interactive Qualifying Project Proposal

Submitted to the Faculty of

WORCESTER POLYTECHNIC INSTITUTE

In partial fulfillment of the requirements for the

Degree of Bachelor of Science

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Date: December 19, 2000

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Abstract

The Foxboro Company commissioned this IQP in order to redesign and remodel their Lifetime Learning Center, which was last updated years ago. We provided them with five classroom designs that we recommend for them to use. We accomplished this by conducting interviews, evaluating questionnaires, and researching adult learning styles, interior classroom design, and education technology.

Acknowledgements

First and foremost, we would like to thank The Foxboro Company for providing us with this project. We would also like to extend our sincerest gratitude to our liaison at The Foxboro Company, Michael Bleyhl. He was very receptive to our plans and ideas and guided throughout our project. Without his assistance, this project would not have been possible.

Next, we would like to thank the staff and faculty at WPI that we had the privilege of interviewing:

- Dr. Judith Miller
  Director of Educational Development
- Dr. Nicholas Kildahl
  Professor of Chemistry
- Ms. Pennie Turgeon
  Director of the Instructional Media Center at WPI

Finally, we would like to thank our advisors Professor Richard Vaz (main advisor) and Professor David DiBiasio (co-advisor). They provided us with guidance and assistance that helped us to successfully complete this project.

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Executive Summary

Companies are beginning to believe that educating their employees may be one of the most important investments they could make. This has increased the significance of adult education, and companies like The Foxboro Company have started rethinking and renovating their teaching strategies and learning environments to better suit the education of its customers.

The goal of this project was to design five classrooms for The Foxboro Company to create a more learner-centered environment for its LifeTime Learning Facility. The environment consisted of different educational settings: General-Purpose (lecture-style), Distance Learning, Control System Simulation Lab, Simulations Lab, and Instrumentations Lab. Each of these settings would provide a successful learning experience, where instructor-led training would become only a part of the education.

To accomplish this goal, the team performed background research on topics such as adult learning psychology, how educational technology effects learning, currently existing learning environments, distance learning environments, and Foxboro's competitors. In order to obtain more accurate and applicable information, we asked Foxboro instructors and students to each fill out a questionnaire. We also attended a class at Foxboro, as well as took some physical measurements of the classrooms themselves. We sought more expert advice by interviewing a few professors from WPI whose work dealt with these topics. We then performed a market search on what types of educational equipment are available for our classrooms' needs. Finally, based on all this information and the needs of The Foxboro Company, we designed learner-centered classrooms, which would suit each class setting, and created a cost estimate for each type of classroom.

Many factors contribute to successful learning. When training adults one must keep in mind that adults do not learn in the same way as children, to whom the lecture method can be effective. Instructor-led training is no longer sufficient; and a learner-centered environment, where the instructor no longer teaches, but facilitates learning, is necessary for the adults to truly learn how to solve their respective problems.

In addition to teaching strategies, the technology used in teaching is another important factor of a successful learner-centered environment. Studies have shown that there is little difference between the results of traditional on-site training and those of distance learning. However, some studies have shown that better results are achieved when computer programs are used to assist in communication. Some of these may be e-mails, two-way audio/video media (such as a teleconferencing software), and chat programs. High levels of student motivation and intensive student support, along with strong work ethic, also contribute toward a more effective distance learning experience, since the students are far apart from the instructors.

The questionnaires that we had asked Foxboro's instructors and students to fill out were helpful in getting the actual needs and wants of the instructors and students. The questionnaire for the instructor addressed issues such as their teaching strategies, as well as the usage of the A/V equipment in the classroom. The students' questionnaire covered issues ranging from how well they were able to perceive the instructors, to the degree of comfort level in the classrooms, and their learning styles in these environments.

To assist with our design process, we interviewed three faculty members at WPI. Professor Judith Miller, Director of Educational Development, agreed with other experts in terms of adult learning. She suggested that student learning can only really be

enhanced by changing the teaching styles of the instructors; unfortunately, most instructors are resistant to this change. Ms. Pennie Turgeon, Director of the Instructional Media Center, spoke about distance learning environments and the advantages and disadvantages between different types. She also suggested on the types of equipment to be used for the Foxboro Company. Professor Nicholas Kildahl, whose outside interests include classroom design, was helpful in citing examples of good and bad classrooms in WPI, based on his own experience. He also gave us pointers to use when considering issues such as workspaces, color schemes, lighting, and dimensions.

After the research was collected, we were able to design five prototype classrooms: the general purpose classroom, the distance learning classroom, the controls lab, simulation lab, and the instrumentations lab. We've made recommendations on improvements to each of these rooms in terms of furniture and audio-visual equipment.

In the general purpose and distance learning classrooms, a flat floor would better allow mobility of tables and chairs, whenever this is needed. Based on our research, we decided that trapezoidal tables that seat three per station should be used. Such a table would provide sufficient workspace for each student, and can be easily spun around and moved to combine with another table, allowing larger groups to be formed on the fly. Using wheeled, rotating chairs would further enhance this environment, so that the students could quickly turn around to pay attention to the instructor. In addition, we have recommended A/V equipment to the distance-learning classroom that would facilitate communication and interaction between students and instructors in different locations.

The control system simulation laboratory is a setting in which the students learn to use computer software to manipulate their equipment, such as fluid control systems.

We rearranged the current configuration of the room so that each group doing the simulations would have a module in front of them. Also, the instructor could easily glance around the room and see the progress of each student, and quickly reach the student to help with whatever problems might have arose. With such an arrangement, there would be a reasonably large clearing in the middle of the room, where demonstrations could be performed. We concluded that the student stations could be made into a T-shape, each branch of the 'T' seating a team of two students with one computer. Each team could also form into a group of four at the stem of the 'T' to perform discussion and other group work.

The purpose of an instrumentation laboratory would be to allow students to do hands-on work, such as repairing a module. We decided to use the same T-shaped workstations in this setting. The workstations could still seat two teams of two, and also have the lab material on the table. Again, in this setting, the teams of two could form a group of four at the stem of the 'T'. We placed pairs of the workstations to face each other (but not attached) so that two stations could be attached to for a larger group of eight for collaborative work. The instructor would be able to move easily to any team in the classroom.

A computer simulations laboratory's main purpose would be to allow students to understand and run simulation software on their computer. While this setting might not include much student-to-student interaction, much demonstration by the instructor would be necessary. Thus, we concluded that a recessed-monitor computer workstation would allow students to easily see over the monitor to the projection screen up front, where the instructor would be. We recommended a two-user station, to allow minor group work.

This kind of table would also allow some paperwork in the presence of the computer and peripherals.

To make all these learner centric and technological enhancements, we had to take a look at the overall prices for each room. These classrooms ranged in cost from around $10,000.00 for the Instrumentation Lab, to the comparatively more expensive $30,000.00 for the Distance Learning classroom, including all furniture and AV equipment. The cost variations were mainly due to the types and amount of audio-visual equipment used in each room. We did not consider labor, lighting, painting, flooring, computers, and Foxboro's own equipment, when creating the cost estimate, since Foxboro already has contractors working on these features.

Creating a learner-centered learning environment is a necessity today for educating adults, especially in facilities such as Foxboro's LifeTime Learning Center. Adult learning styles simply do not work well with only traditional, instructor-led training. While teaching styles and strategies must be altered and improved to facilitate these learners, technology and other physical factors are also important to a successful educational experience. An environment in which the instructor aids in learning and promotes group and interactive work will ultimately result in better achievement by these students. Therefore, these guidelines and recommendations would help The Foxboro Company and any companies in the industry providing educational services to working adults.

1.0 Introduction

As we move into the twenty-first century, education plays an increasingly important role because of technological demands set forth by society. It is important that companies efficiently train their employees and keep their skills on par with the current technology. There is a lot of information that is involved in learning how to utilize new equipment or software. Understanding this information in a short period of time is an extremely hard task. Experts agree that conventional methods of teaching are becoming less effective. Also, the environment in which the material is taught in has become less conducive to the needs of the student. Therefore, in order to set higher levels of education, teaching strategies and the environment in which people are taught need to be re-examined.

Although changing the curriculum is important in changing the education process, making changes to the learning environment is also crucial. Most of the current lecture-based, learning environments are instructor oriented, with all of the students facing the instructor. For students to better understand difficult course material and its application requires a new method of delivering information. Changing the learning environment to one that is more learner-centric would be one of the steps in this process. One company that realizes this problem in the education process is The Foxboro Company.

The Foxboro Company is a company situated in Foxboro, Massachusetts that develops and builds process control systems. At the LifeTime Learning Center they train employees and customers through courses and workshops. At this facility students are taught to become proficient with operating process control systems. These are complex systems that require knowledge of the concepts of chemical engineering, electrical

engineering and various math and sciences. Foxboro's classrooms are very basic and need to be updated. They are typical classrooms geared towards twenty-five to thirty students in a lecture setting. The classroom is teacher oriented and equipped with very limited technology, which makes it difficult to teach complex subject matter.

The Foxboro Company asked us to design new classrooms for their newly proposed LifeTime Learning Center. They need classrooms that would best allow students to understand and simulate how these process control systems function. They are also interested in creating a cutting-edge, distance-learning classroom in which an instructor can simultaneously teach students in the classroom and students over the Internet. These new classrooms will hopefully be very beneficial to the Foxboro Company because they will allow customers to appreciate Foxboro's products. Companies that do business with the Foxboro Company demand products that demonstrate quality performance. They purchase not only the product, but also information on how it is operated. Therefore, the creation of an improved learning environment is vital to the Foxboro Company's financial success.

The goal of this IQP was to design five classrooms: general-purpose, distance learning, and three laboratories. We have recommended these designs to The Foxboro Company so they might apply them to the LifeTime Learning Center.

In order to fulfill the wishes of the Foxboro Company we established objectives to accomplish this goal. The first objective was to research topics relating to education, teaching styles, learning environments, and classroom design. With this research, we formulated strategies on designing prototypes of a few specific types of classrooms. We designed a general-purpose classroom that would be more learner-centered than

instructor-centered, three laboratory classrooms, and a distance learning oriented classroom. Once these designs were completed, we presented them to The Foxboro Company as a recommendation for use in the design of their new Lifetime Learning Center facility.

By using these new classroom designs, The Foxboro Company would be able to provide its students with modern facilities that would enhance their learning experience. This may attract more students to enroll in their programs and help students learn more effectively. Furthermore, with a distance-learning classroom, the Foxboro Company would be able to provide instruction to students around the world while saving money on travel expenses.

The Foxboro Company is definitely not the only company concerned with upgrading their facilities. Technology is changing and advancing very rapidly, and in order to keep pace with these changes, schools and companies will have to target their teaching toward technology. This means improving on the current designs of old facilities in order to develop designs for new facilities. By designing these classrooms for them, The Foxboro Company will have the capabilities to set the standard in control systems and engineering education for years to come.

2.0 Literature Review

There are many concerns involved in designing classrooms. The first part of this chapter will discuss learning and teaching strategies. This will include characteristics of adult learning styles, how education technology affects the learning process, and learning-centered methods. The next topic is interior design and physical characteristics of the classroom, such as furniture, lighting, acoustics, etc. The last main topic that is covered is education technology, which is mainly comprised of distance education methods and considerations. Audio and visual equipment as well as other learning aids are also discussed. These topics served as research that we applied in the design of the classrooms.

2.1 Learning and Teaching Strategies

Understanding the learners' styles and needs is a crucial part of designing a learning environment to ensure the success of the students. Many psychological factors can affect the learning mentality of students. These will be discussed in Section 2.1.1 Adult Learning Styles. Technology and its uses in education may also have a heavy impact on the success of the learners. Section 2.1.2 on Educational Technology and Learning Effectiveness will look at how technology can affect the students and how well they learn. Learning spaces and environments, according to experts and companies, can directly affect how well a student can absorb information. Section 2.1.3 on Adult Learner-Centered Classrooms will cover the theories and factors to consider when creating a learner-centric environment.

2.1.1 Adult Learning Styles

According to the article "Developing Intellectual Capital" by Dave Harrold, educating the employee is one of the most valuable investments that a corporation can make. However, Harrold also suggests that old methods of teaching by lecture are becoming out-of-date and may not be nearly as effective as a more learner-centered program. (Harrold 2000) Mr. Paul Fasoli, Manager of the LifeTime Learning Center at The Foxboro Company (Foxboro, Massachusetts), stated that learning is only truly complete and effective after students have actually used what they have learned, and solved a real-world problem.

Experts like Ellen L. Nuffer, Ed. D. at Keene State College, suggest that adult learners want to know how what they're learning is relevant to their situation; they want to know how to apply what is being taught in the classroom to relevant work. (Nuffer 1994) "They want to know how it alters, extends, or pushes the limits of what they already know," claimed Nuffer. "Faculty can easily sympathize with this need; don't we engage in the same kind of internal dialogue with every article, newsletter, and meeting we encounter?" (Nuffer 1994)

Tania H. Reese suggested several thoughts to be kept in mind when teaching adults, in her article "Are you teaching adults?"

"1. Adults need to feel secure in their learning.

2. Adults do NOT want to deal with theory in learning situations.

3. Adults learn more by being active rather than passive.

4. Adults find little success in most formal learning situations.

5. Adults are NOT flexible in their thinking.

6. Adult learners do NOT prefer that their teacher do all the planning.

7. Adults need to see the application to real-life problems.

8. Adult learners do NOT deal well with isolated facts.

9. Lecture method does NOT work well for adults.

10. Adult learners are easily discouraged." (Reese 1994)

Reese also states, "Adult learning is a transformational process, not one of formation as it is with children." In her article, "Are you teaching adults?" Reese said, "Adults need to know why they're learning what is being taught, to understand where they are and where they could be; affected by relevancy and readiness to learn." (Reese 1994) Nuffer agreed, saying that they "want to know how this reading, discussion, lab or classroom activity will connect to something else." (Nuffer 1994) Also, adult learners succeed much better on self-directed learning, and are discouraged by "subordination to others' ideas," wrote Reese. "The quantity and quality of each adult's experience precludes the role of the 'teacher as the authority figure.'" She claims that, "The key to success with adult students is knowing that personal involvement is at the heart of all adult learning." (Reese 1994)

Ellen Nuffer also suggests that adult learners need to feel that they're participating in the class. This can also mean that they have the freedom of choosing and deciding upon what they want to learn, and the way they learn it. Experts agree that an impersonal educational experience that tries to make "one size fit all" really challenges the adult learner. They never want to feel as if they have gotten away with something, but instead, "they want to accomplish that which they set out to do to get their 'money's worth'." (Nuffer 2000)

The Educational Resources Information Center (ERIC), a national information system of an extensive body of education-related literature, published an article in the ERIC Digest number 154 by Susan Imel, titled "Guidelines for Working with Adult Learners." Imel discussed the "andragogy" model made popular by Malcolm Knowles in his book "The Modern Practice of Adult Education", written in 1970. The underlying assumptions of Knowles' model were:

"1. Adults tend to be self-directing.

2. Adults have a rich reservoir of experience that can serve as a resource for learning.

3. Since adults' readiness to learn is frequently affected by their need to know or do something, they tend to have a life-, task-, or problem-centered orientation to learning as opposed to a subject-matter orientation.

4. Adults are generally motivated to learn due to internal or intrinsic factors (such as helping their child with homework) as opposed to external or extrinsic forces (such as a raise in salary)." (Imel 1994)

Imel suggested that, in formal institutions, adults might need direction in learning because they might not have the required knowledge and skills to be self-directed. They also may need support, because of their lack of confidence, or lack of commitment to learning. To help in shaping a direction for the adult learner, the needs and problems can be assessed, so that the instructor can create a starting point for them. She also recommended that the instructor should listen to the adult learners before the course, so that their themes are heard and respected (via faxes, phone, e-mail, etc.). Her article also suggests capitalizing on the first session, to form a healthy first impression and relationship. Incorporating group work can create a "collaborative, participative learning

environment in which the instructor is perceived as a partner." If classes meet several times, it is also a good idea to meet at different locations to keep the adult learners from falling into a rut. Of course, these locations must not interfere with the schedules or lives of the adult learners. (Imel 1994)

2.1.2 Educational Technology and Learning Effectiveness

Many studies have been performed on how the technology and physical attributes of the classrooms and environments can factor into the success of the adult learners. A representative from Lucent Technology wrote one such study titled "Impact of Technology on Learning Effectiveness." In the paper, the main question, "Does educational technology truly contribute to student learning?" was addressed. Many studies have shown that there are no obvious differences between the traditional classroom teaching using lecturing and class discussions as well as some other methods, and distance education. (Barker 1992, Beare 1989, Haynes 1992, Hobbs 1990, Grimes, Krehbiel, Nielsen, Niss 1989, McNeil 1991) This indicates that the mode of education does not truly effect student achievement. However, a few studies indicate that slightly better results were achieved by the use of interactive computer programs, including e-mail, one- and two-way video, and audio media. (Martin, Rainey 1993, Williams 1983) Also, in distant classrooms, "High levels of student motivation, a strong work ethic, and intensive student support" often achieved good results. (Reid 2000)

2.1.3 Adult Learner-Centered Classrooms

Pratt, a supporter of Knowles' andragogical model, has published an article that discussed his own model of adult learning in formal institutions. The model views adult learning in terms of direction and support needed by the learner, in the following ways: "Learners need both direction and support, learners need direction, learners need support but are reasonably self-directing, or learners are moderately capable of providing their own direction and support." (Imel 1994)

Steelcase, a leading producer of office equipment, classroom equipment, furniture, and a leading designer of office and classroom interiors, stated in an article on their webpage, that "organizations increasingly are coming to realize that physical space is a critical, and often overlooked, factor in success." (Steelcase 1996-2000) The company has created their own model to classify learning environments. (Fig. 1)

> "The two attributes of collaboration and self-direction can be combined into a two-dimensional model to better understand types of learning environments. Examples illustrate how the teaching/learning approach varies with the degree of collaboration and self-direction."
> (Steelcase 1996-2000)

High Collaboration **Low Self-Direction** A teacher identifies a problem and directs a group of students to brainstorm options for solutions.	**High Collaboration** **High Self-Direction** A team of students completes a term project by developing a marketing plan for a new product.
Low Collaboration **Low Self-Direction** A teacher delivers a lecture on medieval history with a multiple-choice test two days later.	**Low Collaboration** **High Self-Direction** A student researches the Civil War as part of a thesis.

Figure 1: Classifying Learning Environments
(Steelcase 1996-2000)

According to Steelcase, learning environments come in all shapes and sizes. "Just as a podium doesn't double as a conference table, the space that works for a traditional lecture won't automatically work for a collaborative team study." Steelcase Inc. admits, "Different learning environments can support different teaching and learning styles." Thus, from the classification model, the company has categorized several physical environments into the model, as follows.

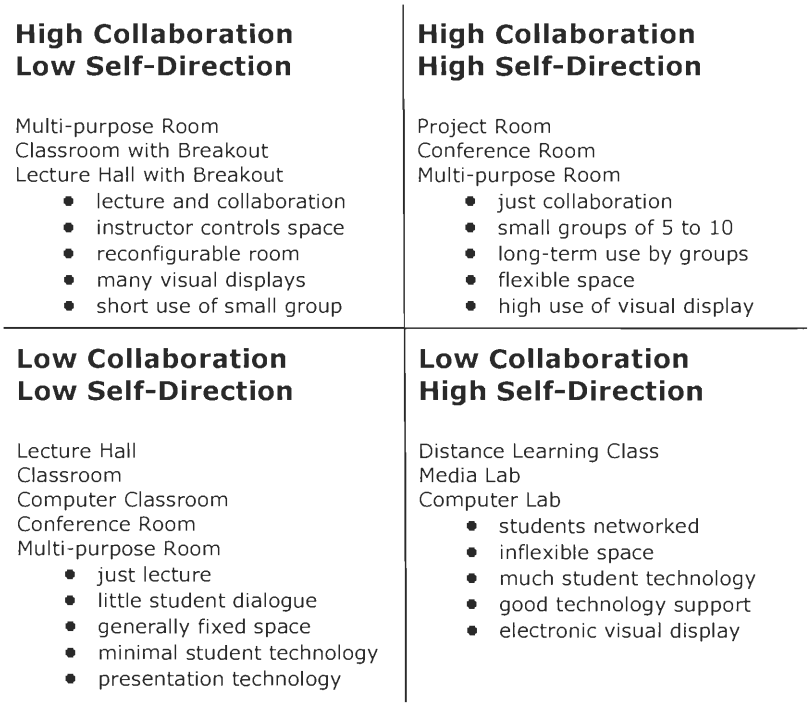


Figure 2: Categorizing physical environments (Steelcase 1996-2000)

According to Paul Cornell, Ph.D., Director of Human Factors and Cognitive Environments, Steelcase Inc., "Schools, universities and training rooms were designed with an industrial age, factory model. These fixed, one-size-fits-all environments do not support all the ways we teach or all the tools we use." Cornell further states, "Customized with supportive tools and furnishings, they can shape and encourage the kind of learning that an organization seeks to promote." (Steelcase 1996-2000)

With respect to a collaborative lecture environment, Steelcase suggested that the furniture as well as media equipment be mobile, to support small-group activities. Their suggested designs also recommended a U-shaped formation of tables and chairs for such a collaborative environment. Though for smaller groups, "a breakout room offers privacy for short-term group work or learning", and thus is preferred. (Steelcase 1996-2000")

2.2 Interior Classroom Design

Experts agree interior design is an important aspect of a student's classroom experience. The physical layout is the direct connection between the student and the classroom, which is the intermediary that allows ideas to be transferred to the student. If there are distractions it makes the learning process much harder and nothing is more distracting than discomfort. It is very important to find the right balance between discomfort and being too comfortable. The following is a compilation of suggestions to create the most effective learning environment.

2.2.1 Room Layout

Walls of a classroom should have chair rails that are 8 inches wide and mounted 25 inches of the floor in order catch chairs and tables from putting gouges in the wall. (Dr. Daniel Niemeyer Consulting Services 1998-2000)

The NCSA recommended that the ceiling height, if possible should be nine feet or less to optimize acoustic and lighting systems. (The NCSA, The National Computational Science Alliance 2000)

2.2.2 Colors Schemes in the Classroom

According to Cornell University Color schemes should include traditional white or off-white colored walls, because they bring light to the room and they do not distract the students. Furniture should be a neutral color to avoid light reflection. The design guidelines say that anything to bright will enhance any glare and anything to dark will make room very hard to light sufficiently. (Cornell University)

Color can have a direct influence on physiological reactions, because the human body responds to cycles of light and dark. Also mentioned is that in a learning environment, colors can affect the participant's sense of time. The Department of Education in Tasmania recommends that any painting of classrooms be in pastel colors that complement the desks or other furnishings. (Department of Education in Tasmania 2000)

2.2.3 Furniture

A survey conducted says that large writing surfaces are essential to students. If tablets on the sides of chairs are used, the student's workspace should be at least be 130 sq inches and that 10% of the tablets in the classrooms should be made for left handed people. (Dr. Daniel Niemeyer Consulting Services 1998-2000)

The NCSA suggests that student desks be 36" in length by 30" in width for an adult learner. The desk needs to be at least 28" to fit an adult, but 28" may not be enough for a larger adult. (The National Computational Science Alliance 2000)

The Steelcase Company recommends that the overall design of a chair affects how people sit and should support a variety of postures to promote comfort, work effectiveness, and long term well being. The choice of seating is dependent on how the room is to be used. For highly interactive classrooms it is important that chairs be lightweight and moveable. Stackable seating is recommended for larger classes. (Steelcase 1996-2000")

Chaffin and Andersson have reported that the two most important considerations in seating are adequate back support and the ability to make postural change. Good seating should allow a worker to maintain a relaxed, but supported, posture and should allow for freedom of active motion over the course of the day. A backrest should allow for stimulation of the back and trunk muscles by moving through, and holding the back in, various postures. While freedom of movement is beneficial, extended association of muscle forces on the trunk also generates spinal compression, and a backrest can support the trunk and serve as a secondary support mechanism, thereby reducing the necessary muscle forces and reducing the compressive loading of the spinal column. (C. Anderson, D. Chaffin 1986)

The Smartdesk Company says that there are key differences between ideal classroom task chairs and other types of chairs, and although budgetary constraints are a limiting factor making a choice just because of price can be a costly mistake. They stress that because of the increase in computer usage in classrooms and the growing concern for health and safety issues it is important to recognize the need for proper ergonomics training. They also say that unlike office chairs, which are purchased for a single individual, classroom chairs need to seat a variety of body types. They need to be

adjustable, but also the method of making adjustments should be easy and extremely durable since these chairs will go through numerous adjustments. They recommend that chairs have these ergonomic, durable and safe, and that for classroom requirements chairs have certain options as seen in Appendix C-1. (The Smartdesk Company 1996-200)

2.2.4 Flooring

The NCSA recommends carpeting for floors because carpets are durable, easier to remove soil and are vandal-resistant. (The National Computational Science Alliance 2000)

The Department of Education in Tasmania, Australia says that floor coverings may lead to a build up of static electricity on people in the room, which could be discharged into the computers through electrostatic discharge ("ESD"). ESD effects on computers depend on the computer construction and vary from model to model, and range from no effect through software lockup to corruption of stored data or physical damage to internal electronic circuitry. On the other hand smooth, hard floor coverings like vinyl tiles can result in echoing all the little noises in the room. Also if chairs on wheels are used smooth floors can cause chairs to roll around the classrooms too easily. The Department of Education in Tasmania recommends carpeting as an effective tool to minimize noise in rooms generally. If re-carpeting of classrooms is being considered, it is essential to note the static-reduction qualities of available carpets. This aspect may be a more important factor in dedicated computer laboratories, but potentially can be just as big a problem where a few computers are spread out in general classroom situations, because of the movement of computer users around the classroom. (Department of Education in Tasmania 2000)

2.2.5 Acoustics

The NCSA says carpeting a classroom floor is the first step in noise abatement. Acoustic ceiling tiles are also very beneficial. Sound absorption is a must, because in addition to muffling keyboard clatter and other technology noise at the source, carpeted panels reduce overall sound levels by interrupting and absorbing ambient sounds from inside and outside the classroom. (The National Computational Science Alliance 2000)

The Steelcase Company says that noise is one of the most distracting elements of a learning environment and state that acoustic properties of a room are thus important factors for classrooms. Students need to be able to hear teachers and audio equipment clearly, and without echoes. Its very disturbing for a student trying to follow a teacher when there are annoying noises in the background or the teacher can not be understood clearly. The room must facilitate sound movement from the front of the classroom to the rear; it must also dampen ambient noise; noise from computers, overhead projectors, HVAC (Heating, Venting, and Air Conditioning), and outside noises. The following are acoustic considerations:

- Polyurethane Cushions under Carpets and above Ceiling absorb noise in the room reducing echoes and ambient noise
- Use Ceiling tiles that absorb noise
- Computer monitors reflect noise, the larger the monitor the greater the echoes (a problem with today's high tech classrooms).

- Do not use hard paneling or hard floors because they reflect noise.
- Make side and rear walls textured this reduces noise reflection from sides and back. Allows students to hear the sound waves directly from teacher and not jumbled echoes or reflections. Reduces other noises that may come from anywhere, but the front of the classroom. (Steelcase 1996-2000)

2.2.6 Lighting

The Ledalite Lighting Solutions Company has made recommendations about classroom lighting. They stress that the modern classroom encompasses a range of visual tasks not found in the past. Computers and multimedia equipment like videos and films require flexible lighting; also, glare and reflected glare must be considered. Whatever lighting that is chosen must properly illuminate the many vertical visual tasks in the room, including seeing chalkboards, wall displays, and bulletin boards. Natural lighting is a popular choice and providing many windows can bring daylight into the classroom and can reduce the lighting power load. Ledalite also caution that natural lighting can become a problem because of glare unless techniques are used to prevent it. (The Ledalite Company 1998-2000)

The NCSA recommends that lighting configurations be adjustable parallel to the main display board in the classroom. This makes it easy to adjust the lighting so that the optimal lighting to see what is being displayed. (The National Computational Science Alliance 2000)

2.2.7 Handicap Accessibility

The Americans with Disabilities Act is a collection of guidelines that all public buildings must abide by. Many of these regulations will be important in classroom design. All ground and floor surfaces along accessible routes and in accessible rooms and spaces including floors, walks, ramps, stairs and curb ramps must be stable, firm, and slip-resistant. Changes in level of elevation up to ¼ in. may be vertical without edge treatment. Any change between ¼ in. and ½ in. should not be beveled with a slope no greater that 1:2. If carpets or carpeted tiles are used on a ground or floor surface, then it shall be securely attached to the floor. If the carpet is padded the maximum carpet thickness is ½ in. Exposed edges of the carpet should not be fastened to floor surfaces and have trim along the entire length of the exposed edge. Walks, halls, corridors, passageways, aisles or other circulation spaces must have 80 in. minimum clear headroom. Doorways should have a minimum clear opening of 32 in. with the door opening at least 90 degrees. The maximum force for pushing or pulling open a door should be 5 lbs. Fixed or built in seating needs to provide 1 accessible space for every 4 seats. Tables need to be at least 27 in. high, 30 in. wide, and 19 in. deep. The tops of these tables or counters cannot be less than 28 in. or more than 34 in. off the ground. (National Disabilities Act 2000)

2.3 Technology in the Classroom

The changes occurring in today's classrooms are not only due to recent change in learning style theories, but also because of advancements in technology being introduced into the classroom environment. These new technologies give instructors better options

of conveying information to the students. Besides rapidly advancing computer technology, there are also many new devices that could be used to assist the instructor.

2.3.1 Distance Learning

WestEd, a non-profit research, development and service agency dedicated to improving education, defines distance education as an instructional delivery that does not require the student to be in the same location as the instructor. WestEd says that while many people interchange the terms "Distance Education" and "Distance Learning", they are not the same thing, as the instructor controls education, while the student controls learning. WestEd considers the defining elements to Distance Education as the separation of the teacher and learner during the majority (if not all) of the instructional process, the use of educational media to unite teacher and learner and carry course content, and the provision of two-way communication between teacher, tutor, or educational agency and learner. (DLRN's Technology Resource Guide, 2000)

2.3.1.1 Views on Distance Learning

According to the article "Faculty and Administrators Attitudes Toward Distance Education" by Lucent Technologies, personal opinions about distance education are a leading factor in its effectiveness. Negative attitudes create negative atmospheres and therefore, less effective distance education. A parallel situation involving positive attitudes also holds true. (Lucent, 2000)

2.3.1.1.1 Instructors

In "Faculty and Administrators Attitudes Toward Distance Education," the authors say that, in general, teachers who have never taught a distance education course feel uncomfortable with the idea, but 75% of teachers who have taught at least one distance education course say that it is a good way to deliver information and that it has improved the overall quality of their teaching. These teachers also believe that it would be a good idea for institutions that offer distance education courses to offer professors training in the subject to promote positive attitudes. (Lucent, 2000)

In "Perspectives on an Internet Based Synchronous Distance Learning Experience" by Williamson, Bernhard, and Chamberlin, the distance education professors who had participated in the study were surveyed at the conclusion of the courses and agreed that they thought course material was delivered more effectively than in a traditional lecture. Teachers noted that the amount of preparation necessary to deliver course material was increased due to the need to convert information into a usable format. (Journal of Engineering Education, 2000)

2.3.1.1.2 Students

Williamson, Bernhard and Chamberlin state that it is common for students beginning a distance education course to feel anxiety and uncertainty toward the effectiveness of the method. The author also says that they find the course proceeds more easily when preceded by at least one face-to-face meeting of all of the participants. Factors that are a detriment to the effectiveness of the delivery of the material include: time delays in the method of information exchange (i.e., internet, phone, satellite), a poor

surrounding environment, unwilling or unmotivated students, and oversized classes. (Journal of Engineering Education, 2000)

In this study, the students who were surveyed at the conclusion of the courses agreed that they thought course material was learned more effectively than in a traditional lecture. Students thought that having all of the information at their fingertips was much more convenient than having to sit in lecture and write everything down while also trying to listen to the professor lecture. (Journal of Engineering Education, 2000)

According to Research in Distance Education, a part of the *Distance Learning Resource Network*, many studies of adult learners have indicated that there are generally positive attitudes about distance learning. (DLRN's Technology Resource Guide, 2000)

2.3.1.2 The Distance Learning Environment

According to Tim Cape, consultant for Waveguide Consulting, Inc, for the most part, those factors that affect the design of an in-house learning environment will hold true for a distance-learning environment. However, when designing an environment tailored to distance learning applications, certain special considerations must be taken into account. (CCUMC Videoconferences, 2000)

2.3.1.2.1 Lighting

Tim Cape, a consultant for Waveguide Consulting, Inc, and a panelist in the CCUMC/PBS videoconference *Designing Classrooms for Technology Integration and Accessibility*, is considered an expert in the field of distance education systems design and implementation. According to Cape, proper lighting in a distance education

classroom is crucial to an effective delivery of displayed information. Since one of the most common methods of delivering information in distance education settings is via video screen/projector, it can be seen why this is important. Mr. Cape suggests that the factors to keep in mind are that there are adequate light levels for both the students and instructors, that the lighting is controlled to keep light off of displays using careful fixture selection and placement, that zoned lighting is used to promote good image quality, and that control of the audio/visual system is possible for the instructor or person running the room. (CCUMC Videoconferences, 2000)

When designing a distance-learning environment, Mr. Cape suggests that lighting be directional in projected display environments, avoiding overhead lighting as it causes dark, shadowy eyes through cameras. Indirect lighting *can* be used, but is only good when using direct view monitors, such as CRT, LCD, or Plasma displays. (CCUMC Videoconferences, 2000)

Mr. Cape also suggests that lighting be wall mounted, to provide adequate lighting in the camera background, and that the wall and furniture finishes be light colored and mid-range light reflective to absorb less light and utilize available light. When mounting lighting on or in the ceiling, mounting grids over the fixtures can be used as a tool to control the direction of the light. (CCUMC Videoconferences, 2000)

When designing the lighting setup for a room, Cape says to create light zones, which can be separately controlled from inside the room, to promote good image quality with exported images. The lighting control, as well as other controls, should be placed near the instructor to minimize wasted time caused by frequent walking across the room to access the controls. (CCUMC Videoconferences, 2000)

2.3.1.2.2 Projectors

The panelists of the CCUMC/PBS videoconference *Designing Classrooms for Technology Integration and Accessibility* agree that, when utilizing projection technology to deliver visual information it is best to use rear screen data projection as opposed to front projection, as it reduces the amount of noise in the room, making important audio information easier to pick up and understand. While rear projection has its downside (more expensive, uses more space), the panelists agree that it is still better than front screen projection. (CCUMC Videoconferences, 2000)

2.3.1.2.3 Windows

CCUMC/PBS videoconference *Designing Classrooms for Technology Integration and Accessibility* panelists agree that when designing a distance-learning environment, a room with no windows is most desirable, as it would reduce the amount of interfering light in the room. When having windows in the room cannot be avoided, they suggest using opaque screens to cover the windows during any visual presentation of information. (CCUMC Videoconferences, 2000)

2.3.1.2.4 Cameras

As suggested in the CCUMC/PBS videoconference *Designing Classrooms for Technology Integration and Accessibility*, when using video cameras in a distance learning environment, it is easiest, and for the most part, most effective, to mount video camera on the ceiling of the room. To reduce the number of cameras, and to give the

instructor more control, it is suggested that the cameras have the ability to move and focus on different parts of the room. (CCUMC Videoconferences, 2000)

When delivering notes to students, panelists from the videoconference suggest using a video camera mounted above the instructor's workstation. With this setup, an instructor can work at a desk and project the notes out to the students through a video or projection screen. (CCUMC Videoconferences, 2000)

2.3.2 Computers and Classroom Equipment

According to the CCUMC/PBS videoconference *Designing Classrooms for Technology Integration and Accessibility*, technology is the most common way to transfer information between people and between locations. Therefore, knowledge of the available technology and how it can be integrated are important aspects in designing modern learning environments. (CCUMC Videoconferences, 2000)

2.3.2.1 Information Exchange

According to the definition of Distance Learning provided by WestEd, information exchange between parties would be accomplished through the use of educational media. There are a large number of utilities available for use as educational media, and the more common and more general of which are discussed in the ensuing sections. (DLRN's Technology Resource Guide, 2000)

According to Technologies & Applications, an abstract by Lucent Technologies, understanding the technologies of distance education is important when implementing a new distance learning system. Lucent breaks up the technologies into three areas:

telephones, video, and computers. Lucent says that while, traditionally, these technologies were separate, now they often interact with each other. (Lucent, 2000)

When transferring information electronically, there are two options: analog or digital technology. Lucent Technologies says that, "Traditionally, voice and video technologies were analog. Computer technology is digital. The convergence of these medias is creating all digital systems." (Lucent, 2000)

2.3.2.1.1 Audio

According to Lucent, one of the cheapest and simplest audio transfer devices available is the telephone. It is very easy to transmit audio information through the telephone. The telephone is also often used as the audio component to complement a video system. (Lucent, 2000)

Audio technologies range from the simple telephone, to rooms set up with microphones, cables, mixers, and echo canceling equipment. In order to ensure effective communication between parties, audio is one of the most critical components of the system. (Lucent, 2000)

According to Lucent, audio conferencing can be used for meetings, delivery of courses and training, remote guest lectures, and a variety of other applications. Audio can also be used as a device to allow students in a remote location to call in to the originating location of the class to interact with the instructor and students. Other applications of telephones include voicemail; fax transmission of information from one location to another, backing up other distance learning environments. (Lucent, 2000)

2.3.2.1.2 Computers

According to Lucent, the base of computer based distance learning is the personal computer. Whether it includes peripheral devices and communication tools or not, the computer can serve well as the primary distance learning tool, as well as a support device for other distance learning systems. Computers are often combined with phone lines through a modem to connect the computer to a network or the Internet. (Lucent, 2000)

According to Lucent, some applications for computers include communication, gathering of information from a network environment, access to collaborative learning environments, and desktop videoconferencing. (Lucent, 2000)

One application of the personal computer is for computer-based training. Computer based training is the electronic version of a correspondence course, in which the material to be learned would be accessed from a computer network or through a CD-ROM or laser disk. (Lucent, 2000)

Connecting the personal computer to the Internet or a network provides more possible applications, such as email, allowing the student and instructor to communicate with one another across time and distance. The connected computer can also be used to conduct on-line classes, either in real time or asynchronously. The instructor can upload lectures, notes, assignments, etc., to a class site for access by the students, or the class can be conducted in real time using available software. (Lucent, 2000)

Another application of the combined telephone/computer is audio graphics, in which the telephone is used as the audio device for voice interaction, and the computer is used to present visual material. The computer would be set up with a modem and

speakerphone to allow transfer of both voice and computer signals between locations. (Lucent, 2000)

2.3.2.1.3 Video

Video technology includes the use of video cameras and projection devices to transmit visual information from instructor to students, as well as from students to instructor. Common methods of delivering video information include by satellite, by videotape, and through a computer. (Lucent, 2000)

When using video technology, it is also necessary to use some sort of device to receive the information. These devices can include monitors, televisions, VCR, and computer software. (Lucent, 2000)

Compressed video is a video technology that involves audio and video information being sent through a digital signal processor and compressed using computer technology. The quality of a compressed video picture depends on the amount of bandwidth used when converting the signals. Higher bandwidth produces higher quality video data. (Lucent, 2000)

In order to produce a picture quality comparable to television quality when transmitting video digitally, fiber optic cables and high capacity circuits are typically required. A full motion system such as this would be difficult to implement over distances due to cost factors. (Lucent, 2000)

As said by Lucent, "Distance learning applications using video technology fall into two general categories, one-way video and two-way or multi-way video." One-way video is simply the delivery of video from the instructor to the students, most commonly

via satellite. When done in real time, one-way video can be complemented by the use of telephones to allow interaction. Another common way to transmit one-way video is through the videotaping of lectures and/or visually presented materials. The videotapes can be copied and sent out to various locations for use by the students. (Lucent, 2000)

Two-way video is a combination of video and audio communications between instructor and students. When students are in multiple locations, this is referred to as multi-way video. "All locations in a two-way video network are equipped with cameras, monitors, and microphones," says Lucent. Connecting the separate locations via point-to-point or multipoint systems completes the two-way video network, allowing all parties to interact with each other in real time. (Lucent, 2000)

Compressed video is often used to reduce the size of a large amount of information that needs to be transmitted between locations. The compressed video can be transmitted by satellite, switched telephone network, or switched digital service. (Lucent, 2000)

3.0 Methodology

In order to accomplish this project, we had planned several actions to collect the necessary information that we needed to best complete the designs to be recommended to The Foxboro Company. To provide the best classrooms and learning environments for The Foxboro Company, we interviewed the students and faculty at the Lifetime Learning Center to get an opinion of the wants and needs of both sides. We have also interviewed several of the on-campus faculty at WPI who have dealt with the design and implementation of technological learning environments. Next, we researched companies that focus on classroom design, and those that make products for educational purposes, so that we would know what is available. It was also important to research into competitors of The Foxboro Company so that we could compare our ideas with what is already out there. By knowing what the competition had, we could improve on those ideas and keep The Foxboro Company one-step ahead of the competition. Once all of the research was done, we implemented it into our designs. When we completed the designs, we presented them to The Foxboro Company.

3.1 Defining the Needs of The Foxboro Company

It was important that we inquire about the future plans and needs of The Foxboro Company so that we could establish a goal and set objectives for this project. This process involved interviewing representatives from The Foxboro Company and reading their memos and goal statements.

After we had finished that, we began defining the needs of The Foxboro Company. They want to create an atmosphere in which students feel at home and are excited about learning. We designed these classrooms around the needs of the student as well as the needs of the instructor, but with more emphasis on the student. The Foxboro Company is in the process of changing their teaching methods and focusing more on applications and hands-on instruction than on lecturing. Also, these classrooms need to be durable and long lasting in terms of flexibility and upgradability. As technology rapidly changes, The Foxboro Company must improve their equipment and facilities. If some breakthrough were to occur, these classrooms would need to be able to adapt to changes. The Foxboro Company has also expressed the need for upgrading its distance learning facilities, exemplifying a push toward the future.

3.2 Main Topics of Research

There are three major areas of research for this project. They are learning and teaching strategies, technology in the classroom, and interior classroom design. The majority of the research was acquired over the Internet because many of the topics being researched are fairly new and are just now being discovered. All the pertinent research that we could collect has been documented in the Literature Review.

3.3 Questionnaires

It is not only important for the teacher to be able to get through to the students, but for the students to be in a comfortable enough setting to be able to absorb the

information taught by the teacher. We had designed a questionnaire for the faculty at the Lifetime Learning Center, as well as another one for the students. These questionnaires collected pertinent information such as preferences in learning and teaching conditions, opinions on currently existing facilities, and a wish list of what the students as well as the faculty would like to see implemented on the campus.

We designed the questionnaire with specific questions that would help us to determine the preferences of both the instructors and students. A copy of the questionnaire can be found in Appendix A. We passed the questionnaires out to the instructors and at the end of the course the students would fill them out. Once the questionnaires were filled out and returned to us, we evaluated them. Grouping similar answers together was the evaluation process of the questionnaire. However, we also took all suggestions into consideration. We then applied the considerations of the instructors and students to our designs by suiting them to their needs while maintaining the direction of The Foxboro Company.

3.4 Interviews with WPI Faculty and Stuff

Several faculty members and staff at WPI have been involved in the research, design, and implementation of classrooms in academic buildings. There are also other faculty members who are very knowledgeable about teaching strategies and learning styles. Therefore, we interviewed some of them on learning and teaching strategies, interior classroom design, technology in the classroom, and other factors that may affect the teaching and learning experience at any institution. After the interviews, we used the responses in planning our design of the classrooms.

The first faculty member that we interviewed was Professor Judith Miller. Professor Miller is the Director of Educational Development at WPI. As such, she was familiar with teaching strategies and learning styles and what adult learners are like.

Another faculty member that we interviewed was Professor Nicholas Kildahl. Professor Kildahl is a professor of Inorganic Chemistry at WPI. His numerous outside interests include classroom design. He has done his own studies on the subject, and has written papers regarding his ideas and suggestions.

The last person that we interviewed was Pennie Turgeon. She is the Director of the Instructional Media Center at WPI. We chose to interview her because of her knowledge of distance learning education and technology in the classroom.

3.5 Researching Companies and Colleges

It was not only important to research books and articles, but to also research current examples of classrooms. There are already many good examples of classrooms in both companies and colleges. These classrooms exemplified the kinds of characteristics we were looking for when designing our classrooms. There are also other companies that compete directly with The Foxboro Company. It was extremely important that we investigate these companies so that we would know how The Foxboro Company rates against the competition. There also were companies that provide classroom equipment or that act as classroom design consultants. These companies were essential to our design because they manufacture and sell furniture and other products that The Foxboro Company may purchase. We were able to submit a financial estimate from the quotes

that they provided us. With all of this information, we were then able to go forth with our designs and proposal to The Foxboro Company.

3.5.1 Researching Institutions of Higher Learning

Many institutions of higher learning, such as colleges and company education facilities, have prime examples of classrooms that are prepared for the future. We found this by researching over the Internet. Some of the designs found were quite helpful in our designs. We took what we learned from these classrooms and applied certain characteristics to our classroom designs.

3.5.2 Researching Competitors of The Foxboro Company

It was important to research Foxboro's competitors to see how our plans compared with theirs. Some of these companies had radical ideas that would greatly enhance the teaching-learning experience at their own institutions. We first researched them using the Internet and then talked to representatives. We have investigated these competitors and taken from what they have done in order to create new ideas to benefit The Foxboro Company's Lifetime Learning Center.

3.5.3 Researching Education Equipment Suppliers

There were many office and classroom equipment suppliers available for us to contact. Our research into these suppliers increased our knowledge of what is available and may be used in our recommendations to Foxboro. We researched companies that

deal with equipment ranging from electronic whiteboards to computers to carpeting. Some of these companies are classroom design consultants and have their own strategies on designing classrooms. We have tried to acquire all available information from them. We have referred companies to Foxboro as professional consultants when the need arose.

3.6 Designing for the Future

The classrooms we designed not only needed to be pleasant and technologically advanced, but they also needed to be modifiable to suit the immediate needs of the class. Furthermore, the classrooms needed to be upgradeable. We looked into the benefits of easily movable furniture, adjustable lighting, window shading, display devices, wire conduits, and other possible factors that affect the flexibility and upgradability of certain classrooms.

When we designed these classrooms we first identified the needs of The Foxboro Company. We needed to determine how many students and what type of equipment will be in each room. We then used the information we had gathered on learning strategies, technology, and interior design as well as anything else that we had picked up from existing model classrooms. Other considerations were drawn from interviews and questionnaires. Once we had collected and synthesized all of our research and considerations, we were ready to write up specifications for each of the classrooms. We came up with several design ideas and implemented the one that best suits the needs of The Foxboro Company for each type of classroom we designed. We then made drawings of our designs. After the design process was complete, we wrote a financial report for the entire project based on the education equipment suppliers we have researched. In the

financial report (Appendix F), we have provided total estimates for each classroom and also have price estimates of all of the equipment and supplies that are needed.

We have designed five classrooms: a general-purpose classroom, a distance learning classroom, a computer lab, a simulation lab, and an instrumentation lab. We had also looked into designing combinations of different types of classrooms, such as a combined distance learning and general-purpose classroom. Ideas like this are what we have suggested to The Foxboro Company. This was important because we have provided The Foxboro Company with several different choices and let them use these various designs to best suit their needs. This will keep them one step ahead of their competitors in the future.

3.7 Presenting our Designs

Once our designs were completed, we were ready to present them to The Foxboro Company. We have presented our designs orally using PowerPoint and we have also provided scaled CAD drawings of the classrooms. We then turned in a written copy of our project to The Foxboro Company. We hope that our designs will give them significant solutions to the problems that they are currently facing. We have not only given them designs, but we have also given them suggestions on how to predict future changes in classroom design and technology. Once we had presented our designs, we were able to get feedback from The Foxboro Company determining what they may use from our proposal. With their input, we have gone back and redesigned certain features that may better suit their needs. We have presented our revised designs to them we believe that our designs satisfy the needs of The Foxboro Company.

4.0 Results and Analysis

After gathering all of our research, we were able to start analyzing the information. We chose from our research what we needed and figured out its importance. From there we were able to start formulating our designs. Throughout the design process we continued to do some further research and applied it to our designs. Once the designs were complete, we put together a cost analysis for the products in the designs. Finally, we presented our designs to The Foxboro Company.

4.1 The Needs of The LifeTime Learning Center

The Foxboro Company is currently in the process of updating its training facility, The LifeTime Learning Center. The facilities that they have now are adequate classrooms. However, The Foxboro Company is in search of new technology and designs to help enhance the learning and training that they can provide. The Foxboro Company would also like to transform the training that they provide by emphasizing collaborative learning.

Our team has been commissioned by The Foxboro Company to design new classrooms for the LifeTime Learning Center. The classrooms that we designed were based off of the existing classrooms that are currently being used in the LifeTime Learning Center. There are certain criteria that need to be met for each classroom. More specifically, there need to be designs for a lecture classroom, a distance-learning classroom, and three separate laboratories. The laboratories include an instrumentation laboratory, a computer laboratory, and a process control system simulation laboratory.

There were certain items that remained in the laboratories because they were vital to the training that takes place there to include process control system simulators and instrumentation devices.

There were three main necessities for the new classroom designs that The Foxboro Company wanted us to focus on. The first was to consider and provide new technology for the classrooms and laboratories. The second was to make the classrooms and laboratories more learner-centric and compatible to all learning styles. The third was to ensure that the new designs would last for years to come.

Of major importance to The Foxboro Company is the welfare of its customers and employees. The Foxboro Company already provides some different means of receiving classes. These include classroom learning, on-site learning, and self-directed training. Self-directed training falls into the category of distance learning. Distance learning incorporates the use of new technology with computers, video-capturing devices, and presentation equipment. The Foxboro Company is striving to expand its distance learning capabilities so that they may reach more customers around the world.

The focus of these classroom designs is how they can benefit the learner more effectively than the classrooms that currently exist in the LifeTime Learning Center. The Foxboro Company is trying to put more emphasis on learner satisfaction and the quality of training. The strategy they have to promote this is to shorten the length and amount of classroom-based sessions and increase the amount of time spent doing hands-on applications and group work.

The last major need is for the designs to be long lasting and effective in the future. It is important that the technology in the classrooms is updated. Technology is constantly

changing so it is hard to stay on top of it at all times. Therefore, it is essential to provide the LifeTime Learning Center with enough capabilities to be useful for years to come while allowing room for further improvements.

The Foxboro Company knows that in order to be competitive, it needs to improve its facilities and provide more ways of educating its customers and employees. Our designs will fulfill the needs of The Foxboro Company and hopefully surpass them.

4.2 Results from Questionnaires

Our group created two different questionnaires that would help us to understand how instructors and students currently used the classrooms. These questionnaires provided us with information on what both instructors and students preferred to have and need in the classroom.

4.2.1 Questionnaire for Foxboro Instructors

Our first questionnaire was given to the instructors of the Lifetime Learning Center (see Appendix A-1). The questionnaire covered issues such as teaching styles, equipment in the classroom, and inquiries on the duration of classes. For the most part, the instructors tend to teach with a passive teaching style, although some do practice active teaching techniques when they can. The majority of the instructors tend to lecture for 60 to 90 minutes with breaks in between lectures. While giving lectures, the instructors all use some type of projection device. Many of them use a LitePro to display PowerPoint slides, while others still use the old-fashioned overhead projector. When

asked about having a combined laboratory/classroom environment, the majority of the instructors wanted to have one that was separated within the room because many of the students get distracted with the laboratory equipment while lectures are being given. The instructors tend to go back and forth between lectures and work in the laboratory, but they feel that moving to a different part of the room is a good break for the students.

4.2.2 Questionnaire for Foxboro Students – Evaluation of Responses

See Appendix A-2 for a complete copy of the Student Questionnaire.

1) **Do you think that the equipment being used in labs fulfills the class requirements?**

Of the 60 respondents, 52 of them believed that the lab equipment being used during training fulfilled the course requirements, while 2 respondents felt the lab equipment did not fulfill the requirements. Some issues that respondents brought up were that they felt the computers were in need of update, and that some would rather train with actual equipment in place of running computer simulations.

2) **Do you find it hard to see the instructor from any seat in the classrooms? If so, in what classrooms did this occur?**

Every one of the 60 respondents felt that they had no problem being able to see the instructor from anyplace in the classroom.

3) **Can you hear the instructors well enough in the classrooms?**

Out of 60 respondents, none of them had any problem being able to hear the instructor at any time.

4) **Do you think there is ample lighting in the classrooms and laboratories? Does the glare from the windows affect your vision?**

As pertains to there being ample lighting in the classrooms, 46 of the 60 respondents felt that the lighting was fine, while the other 14 respondents felt that the lighting in the classrooms was lacking. One of the respondents reported having two burnt out lights in their classroom for the entire duration of the course. Suggestions by the respondents include installing dimmers in the classroom, and installing desk lights at student workstations to facilitate note taking while the room lights are turned off during projector use. Students also expressed concern over not being able to clearly see the material on the projector screen when the room lights were left on.

5) **Does the room provide a good "comfort" level for the students? (A/C in summer; heat in winter)**

Out of the 60 respondents, 54 of them felt comfortable with the environment in the classroom they were in. Of the other 6 respondents, common opinion was that discomfort due to temperature was caused by the thermostat in the room being set at a level they weren't accustomed to.

6) **Do the professors use enough audio/visual equipment? When it is used is it used effectively and efficiently? Can you see it well enough when it is used? Explain briefly.**

Of the 59 respondents, 4 of them were not in a course using A/V equipment. Of the remaining respondents, 50 of them felt they could see the material presented from the projector well enough. The other 5 felt that either the content on the screen was too small for them, or that the noise from the projector was disruptive.

7) Is the classroom furniture conducive to a learning environment?

Out of the 60 respondents to this question, 49 of them felt that the furniture in the classroom they were in was conducive to learning. The other 11 respondents suggested such things as more workspace and mobile, more comfortable chairs to improve on the current furniture.

8) What kinds of relaxation facilities do you think would be beneficial to this facility?

Of the 34 people responding to this question, 10 of them felt that the current available relaxation facilities at The Lifetime Learning Center were adequate. The other 24 respondents offered suggestions, in order of frequency, such as Internet access, a lounge with couches, a health facility, concessions such as snacks and drinks, a walking path, music, a television, and magazines.

9) Would you rather learn the relevant information first and then conduct laboratory exercises or learn the information and perform the lab simultaneously?

This question yielded 54 responses. Of those respondents, the opinion was almost evenly split, with 29 respondents feeling it would be best to learn material and perform lab exercises afterwards, and 25 respondents feeling it would be better to perform lab exercises while learning the material.

10) Are Computers used effectively in this course?

Out of 57 respondents, 56 of them felt that computers were used effectively in their course. The 1 other respondent felt that more time could have been given to computer usage.

4.3 Analysis of Interviews

There were three interviews that were conducted at Worcester Polytechnic Institute that helped us to design classrooms for the LifeTime Learning Center. Primarily, we used these interviews as somewhat of a starting point to lead us in the right direction in designing these classrooms.

4.3.1 Interview with Professor Nicholas Kildahl

The interview with Professor Kildahl went very well and was very helpful on general classroom information. Professor Kildahl's philosophy on classroom design was very basic and simple and therefore he had a very simple approach to classroom improvements.

4.3.1.1 Class Layouts and Table Configurations

Although he wasn't too familiar with current educational technology advances or distance learning, he was very knowledgeable about general classroom improvements such as groups seating and interactive classroom setups that facilitated learner centric learning. He made of us very aware of some very important aspects of general classroom designs, especially table design, where he recommended amounts of student workspace and seating arrangements. He made some extremely helpful recommendations that eventually contributed to our final table design.

4.3.1.2 Lighting, Acoustics, and Classroom Dimensions

Professor Kildahl also informed us about color scheme, lighting condition, and classroom dimension issues. He gave us examples of classrooms on campus that he

thought had both good design and those who were designed very poorly. He talked about differences in teaching styles that require different classroom layouts and requirements. We also received his opinion on our preliminary ideas and he was very supportive of our work.

4.3.2 Interview with Professor Judith Miller

In this interview Professor Miller gave us some useful information on instructor's ideas on classroom design. She also gave us information on the evaluation of learning styles. What she said about adult learners agreed with our research. Also, she gave us a few good research sources to use.

4.3.2.1 Adult Learners and Adult Learning Habits

Professor Miller indicated that adult learners are different from child learners, such as elementary, middle school, and to some extent, high school. Adult learners are more motivated to learn. They are also less tolerant of abstract and theoretical methods of teaching, and prefer a straightforward presentation of course information. Adults are also more knowledgeable, allowing them to use their past experiences to learn new information.

4.3.2.2 Teachers

According to Professor Miller, 99% of today's teachers are far more used to teaching by lecturing, than any other method. Professor Miller said to improve student learning, developing the faculty will be necessary. Many times the faculty members are

usually accustomed to their standard instructional methods and often find it difficult to adjust.

4.3.2.3 Physical Factors that Effect Motivation and Mentality

When asked, what physical attributes of the environment can effect the motivation and mentality of learners, especially adults, she recommended studio classrooms would be beneficial. She said that it allows the instructor to carry the lecture directly to the lab bench, and apply the theory into practice. Movable furniture also helps, according to Professor Miller. This allows the students to easily move around the classroom and into groups.

Professor Miller suggested that in a distance-learning environment, fixed furniture might be more suitable, although in a traditional classroom setting movable furniture would be more beneficial.

4.3.3 Interview with Ms. Pennie Turgeon

The primary focus of this interview was to gather information and opinions on distance learning and classroom technology. We were also interested in the products that the Instructional Media Center provides for WPI.

4.3.3.1 WPI's Distance Learning Program

Ms. Turgeon confirmed that WPI has a distance-learning program, which is aimed mostly toward part-time graduate students. She stated that WPI's distance program is run asynchronously, as synchronous delivery creates scheduling problems with prospective

students. Ms. Turgeon showed us the WPI TV studio, which also doubles as the distance-learning classroom. While there, Ms. Turgeon went over some key aspects of the room, including the setup of the cameras and monitors throughout the room, the acoustic paneling, the lighting, and the controls of the room. She also showed us the production aspect of the distance learning courses, where videotapes are edited, dubbed, and sent out to students.

4.3.3.2 Instructors and Students in Distance Learning Situations

Ms. Turgeon said that instructors should teach their distance learning courses in front of a live class if possible, because instructors are used to teaching in front of a class, and their comfort level will be much higher in this type of setting. This setup is also advantageous to the distance student, as they can benefit from questions and comments that live students may make to the instructor.

Ms. Turgeon also suggested that instructors receive training on the equipment and effective methods of delivery in their distance learning system. Also, when applicable, another staff member should be equally trained in the use of the equipment in order to help the instructor during class time, or to run the class equipment from a separate control area.

Ms. Turgeon stated that one helpful factor when involving adult learners in a distance learning setting is that adult learners tend to be much more motivated to learn than younger students, and therefore will be more apt to get a lot out of the course. However, Ms Turgeon said that even though they may be more motivated, there are other factors that could cause adult learners to not work well in a distance-learning

environment, so she suggests testing the students to see if they are the right type of student for distance learning. One test to do this is a book called Student Guide to Distance Learning.

4.3.3.3 Technology Options

Ms. Turgeon felt that there is not one overall best way to transfer information between parties. She said that the best way to choose between methods is to assess the needs of the courses, and fit them in with whatever methods will suit that course. She also said that using a method the instructor will be comfortable with is helpful.

Ms. Turgeon gave us the advantages of some of the different types of delivery, such as that when you use videotapes, the ability to rewind and playback allows the student to go back to anything they did not understand the first time, and when you have synchronous delivery, such as in video conferences or web chats, you allow interaction between the students and instructor.

4.3.3.4 Designing towards Learning Styles

Ms. Turgeon feels that versatility is the best option. Designing toward one type of learner creates a much easier experience for that learner, but makes it more difficult for another type of leaner. She suggests designing toward a few of the more common learning styles, so that the learner will be able to access information easily, and also have the chance to strengthen their weaker styles.

4.3.3.5 The Internet as a Mode of Delivery

Ms. Turgeon had some suggestions for programs to use when delivering information via the internet, including Blackboard Suite, Web CT, and Web in a Box, all of which utilize virtual chat rooms and shared whiteboards, and allow such functions as file transfer, discussion boards, and email.

Some poor points about using the Internet are that there is no way to gauge the amount of attention or participation of a student in a remote location, and there is a greater possibility of cheating occurring.

4.4 Analysis of Colleges and Companies

In the process of collecting information and trying to find products for the classrooms, we came across many college websites concerned with learning environments and educational technology. We also found the products we were looking for on websites of companies that make and distribute classroom furniture and audio/visual equipment. Finally, we researched the competitors of The Foxboro Company to get an idea of what they offer their customers.

4.4.1 Colleges

There were many colleges that had excellent information on education technology. A growing trend for colleges is to have an entire staff involved with equipping the campus with technology. Here at WPI we have the Instructional Media Center. As seen in our interview section, we interviewed Ms. Turgeon, the director of the

Instructional Media Center. She gave us useful information on what types of products to use and provided us with guidelines on equipping classrooms with audio/visual equipment. We also consulted other college websites. Those in particular that were the most useful were the following: University of Colorado, Rensselaer Polytechnic Institute (RPI), Stanford University, Cornell University, Lehigh University, and North Carolina State University. Many of these colleges have recently updated its own facilities and are striving to create more learner-centric environments for its students. They are also taking advantage of the available technology that allows them to be able to institute distance learning in their programs. Stanford University's Flexible Class-Lab was very influential in our designs and sparked our interest in possibly combining different room types. The Flexible Class-Lab is a multipurpose room that incorporates a laboratory environment with a general-purpose classroom along with distance learning capabilities. There were many other resources like this provided by colleges that we consulted. We were able to retrieve important information on learning and teaching strategies and also we were able to view layouts that we considered when creating our designs.

4.4.2 Competitors

There are a few companies that are direct competitors to The Foxboro Company. Likewise, they are in the market of educating customers on their products. The only investigation we were able to do was over the Internet. This makes it hard to tell whether the training facilities they have are up to date without going to see them in person. Therefore we researched these companies with the understanding that it is possible for a company to have an excellent website, but not have a good product to back it up. The

companies that we investigated are Honeywell (GE), Fisher-Rosemount (Emerson Electric Co.), and Bailey (ABB).

Each of these companies had fairly sophisticated websites that boast of e-learning and professional training. The ABB website even provided the user with an interactive virtual tour of the facilities. It seems that these companies are taking steps to continually update its facilities and improve the services that they offer. This is the same direction that The Foxboro Company is taking by undergoing the LifeTime Learning Center redesign project.

4.4.3 Consultants

During the design process, we had to look for companies that sell the products we planned on using. This was a hard task because we were not sure whether we could find companies that had the products we were looking for. In some cases, however, we had already consulted the company in our research. An example of this would be the Steelcase Corporation. Steelcase is a company that deals with interior classroom and office design, ideology, and furnishing. Another company that we found useful was Computer Comforts Inc. Their website gave us some interesting ideas on which tables we should use and how to possibly configure them in the classroom. From these two companies we chose the chairs and tables that we have proposed in our designs. Another company we consulted was Markey's Audio-Visual. Their website provided a very useful e-catalog from which we found the majority of our prices listed in the cost estimate for audio/visual and presentation equipment. There were several other

companies like these listed above that we were able to find that gave us vital information to our design project.

4.5 Analysis of Research

After the research is collected, it is very important to analyze and synthesize the information. This is crucial to any project because it determines what parts can or cannot be used. The analysis of research that is done should then be applied to the physical object that is being constructed. Fortunately for us, the majority of the information that we researched was used.

4.5.1 Analysis of Learning and Teaching Strategies

The purpose of the research into teaching strategies and adult learning styles is to understand how the learning process works in the mind of the adult learner, and what factors in the environment may affect this process.

Improving teaching strategies and recognizing physical factors affect how well the learner will succeed. Adults, being active learners, do perform well by merely sitting in a lecture and take notes. The instructor can help by organizing lessons, which involve an active participation, such as group discussions, problem solving, and device troubleshooting. By turning classes into more of a personal help-session type of meeting, the adult learner can feel more involved and encouraged. This would be a way of compensating for their inflexible thinking and motivation.

Since a collaborative setting is essential to successful adult learning, the environment itself plays an important role in making this possible. In the traditional, instructor-led training classroom, student tables should be shaped and placed so that they can be quickly rearranged into a group setting. Tables that seat a small group of students are conducive to group work. The flooring should be flat, thus facilitating movement of furniture. If discussion is an integral part of the classroom, chairs will need to rotate and have wheels. This makes the students much more willing to turn to look at the speaker.

The combined distance learning and lecture classroom will need to accommodate both purposes. Today, such a setting will need to include more technology than the traditional video camera. Digital capture devices enable information to be transmitted from the on-site lesson to any destination in the world, while the class is going on. Recording the transmission allows asynchronous distance learning. Audio equipment is a prime concern because of the reduction in quality when recorded. Therefore, educational service providers should not sacrifice quality over price, because the quality of the class itself will decline as well. The instructors need to wear a microphone and microphones placed at each of the students' tables will also help to create a more involved experience for the distance learner. To help such a learner see the instructor's demonstrations, an object display camera is needed to zoom into and project the demonstration. The instructor, in addition to a digital capture device focused on him or her, will also need a computer, if solely to interact with his distant students. All this technology, and more, will contribute to better achievement by a distance learner.

A laboratory environment should also be able to provide group work and group interaction. Many companies today invest in the education of their employees, and often

such education is needed to solve problems in a group. A controls simulation laboratory and a hands-on instrumentations laboratory may achieve this by having the students seated so that teams are already formed in the default setting, while larger or smaller groups can be created by rearranging the furniture. A T-shaped workstation would work, since a two-student team can sit at each top branch of the T, and groups of four can be formed at the stem, while a group of eight can be formed by combining two stations. Such class work often requires much interaction between each team and the instructor. To make this feasible, stations should be arranged so that the instructor can easily move amongst the stations to reach any team. In a controls simulation setting where students learn to manipulate a module by use of computers, a U-shaped formation of the stations with students facing the walls would enable the instructor to see every process going on, and reach any team in need of aid. A laboratory that was for instrumentation could be arranged so that the same stations face each other. This way, everyone can see and help everyone else, and groups are more easily formed.

A variation of the laboratory environment is one that has the sole purpose of processing computer simulations. In many cases, such as the Foxboro Company's Lifetime Learning Center, each student has access to his own station, and performs individual work. To suit this need and provide student-instructor interaction, recessed computer tables can be used. This kind of table would allow the student to easily look over their computer monitor to see any demonstrations provided by the instructor, and allows the instructor to easily spot a student with a question.

4.5.2 Analysis of Classroom Design Research

The research about Classroom Design in the Literature Review was that basis for the creation of our designs. The primary purpose of these classrooms is to provide a learning environment centered on the students and their individual needs. From our research it was determined that students need at least 36" by 30" of space. Using this information we then designed tables for the students that provided this. The next issue to consider is seating for the students. We determined through our research which features would be appropriate for the seating in these classrooms and figured out which ergonomic features needed to be adjustable to accommodate a variety of body types for the duration of a typical class. In addition to ergonomics the mobility of the chairs is very important in highly collaborate classroom. Having wheels on the chairs allow students to move into and out of our various arrangements very quickly without much aggravation.

After providing the individual student with workspace there is the consideration of handicap accessibility. The room must allow all students to have equal accessibility to education. Therefore we avoided tiered classrooms or any change in floor elevation, as such features would present multiple unnecessary handicap accessibility considerations for the classrooms. We also made it very convenient for physically disabled people to reach any area in classroom by spacing all furniture at least 4' apart and adhering to handicap accessibility regulations.

A few other considerations that were applied in our designs were carpeting, lighting, and acoustics. Carpeting was found to beneficial for many different reasons. It reduces ambient noise, prevents the floor from the wheels on the chairs, and provides good traction for students, especially handicapped ones. From our research we realized

that the lighting plays an important role in our classrooms. We therefore recommended the use of contractors and consultants to outfit the classrooms with appropriate lighting.

4.5.3 Analysis of Research on Education Technology

When designing our classrooms, one major area of concern was the educational technology involved in each room. Because of this, we decided to research into available technology, how technology would help create a better learning process, and how to incorporate technology into the classes.

Our largest area of concern with educational technology was distance learning, a system that Foxboro is very interested in. This system could benefit the company very much in the long run, as they have customers from all over the world who might be interested in training on Foxboro's product, but for some reason may not be able to spend a week or two weeks in Foxboro to take one of their courses.

One area of concern with setting up a distance learning system was the motivation of the instructors and students. Due to a lack of motivation caused by the unfamiliar settings of a distance learning environment, we had taken from research the idea to suggest that the Foxboro Company train its distance learning instructors in the use of the classroom equipment available to them, so that they will feel more comfortable using the classroom to present material. We also suggested that, since students will be more motivated to learn in a synchronous environment, an interaction between students and instructor via two-way video would benefit the courses.

When designing the distance-learning classroom, we tried to heed the advice of experts that we had found in our research as much as possible. A rear projection system

was incorporated into the distance-learning classroom. This system would reduce the amount of noise in the room, cut down on image distortion, and interference from ambient light, and cut down on the amount of equipment situated inside of the room. Since the most effective way to deliver material to students in this type of situation is visually, we felt that the benefits of a rear projection system were a great fit in the distance-learning classroom. Students being most attentive to things right in front of them, and projection being our main mode of delivering course content, we decided it would be most beneficial to place the rear projection screen in the center of the front wall of the classroom.

Since most design considerations in a distance-learning environment are the same as considerations in a general classroom environment, we decided to make our basic classroom structure the same as our general classroom, and then modify it where necessary or pertinent. The tables and chairs, as well as the instructor workstation are all the same.

Acoustics and lighting in the distance-learning classroom are more of an issue than in the general classroom. While we can suggest options such as acoustic paneling on the walls and ceiling, thick carpeting, and zoned lighting, with zones going from front to back, we feel that it would be best to bring our designs to expert consultants. There are many more factors to take into account when designing for acoustics and lighting concerns that someone without experience in those fields would not account for, so we feel the issue would best be handled by someone with more experience than our project group.

While trying to eliminate all detrimental factors, one issue was the presence of windows in the distance-learning classroom. Research leads us to believe that, if possible, the elimination of windows in the distance learning environment is the best option, as it completely eliminates the chance of interfering light causing difficulty when trying to view the projector screen. We designed our distance-learning environment under the assumption that the exterior of the building would go unchanged, and therefore, the windows would still be a part of the distance-learning classroom. Due to this, we suggest thick, opaque screens, which can be hung from above the windows and which are long enough to cover past the bottom of the window. These screens should also cover the entire length of the window, with a few extra inches on each end to make sure that no light is coming into the room from around the perimeter of the screen.

Based on our research into the use of video capture in the distance learning environment, and our decision to promote interaction in a synchronous environment through video capture, we have placed classroom cameras, which capture the students in the classroom, on the ceiling in the front of the room. As the classroom is not very large, we feel that two cameras should be sufficient. We have also placed an instructor camera in the rear of the room, mounted on the ceiling, and movable, so as to be able to follow the instructor as they walk around the front of the room. In place of the suggested overhead camera at the instructor's workstation, we have decided to use a document camera in our distance-learning environment.

To facilitate the transfer of course material between locations, we have weighed the pros and cons of the different options we had researched, and decided that the best method is to use personal computers and the internet. The document camera and

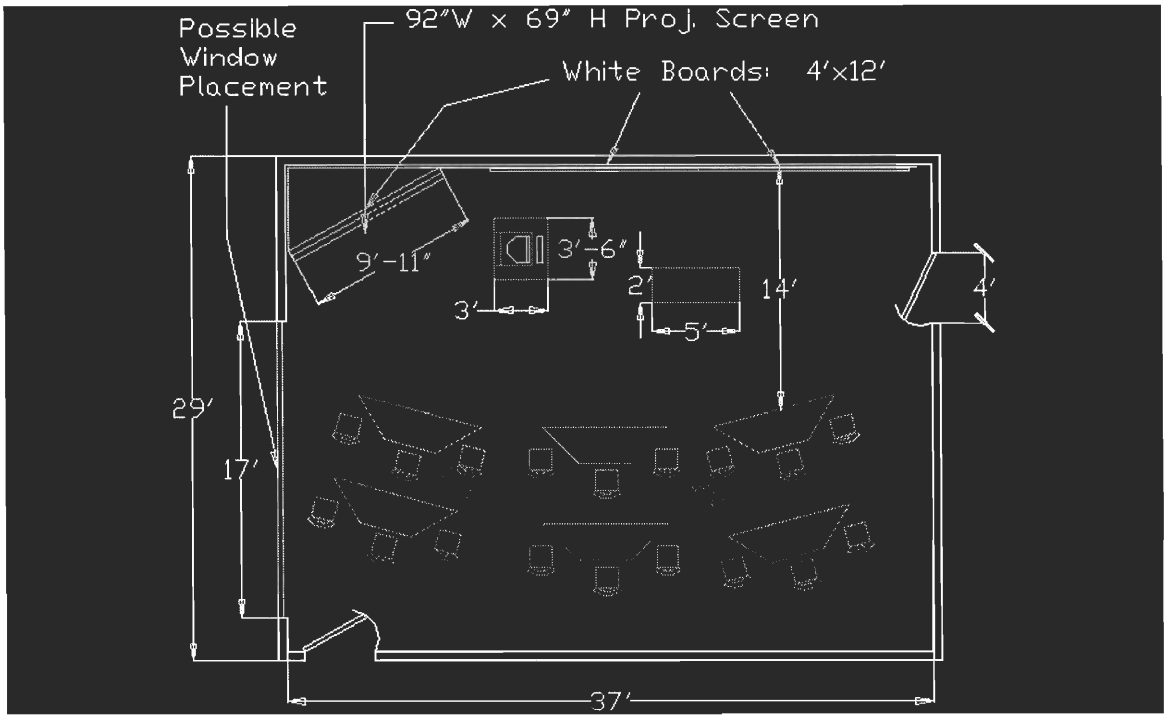
projector both connect to a computer located at the instructors workstation, and from there, software that comes with the products, along with an internet connection, can be used to capture and transfer course material between locations.

To facilitate interaction between locations, the previously mentioned cameras are combined with monitors and microphones located in the classroom. A monitor had been placed below each camera in the classroom, with the monitors at the front of the room showing a remote instructor when applicable, and the monitor at the rear showing the remote students when applicable. The instructor will be wired with a lapel microphone to capture their audio, and button-activated microphones are placed at each workstation in the classroom, thus allowing audio interaction as well as video.

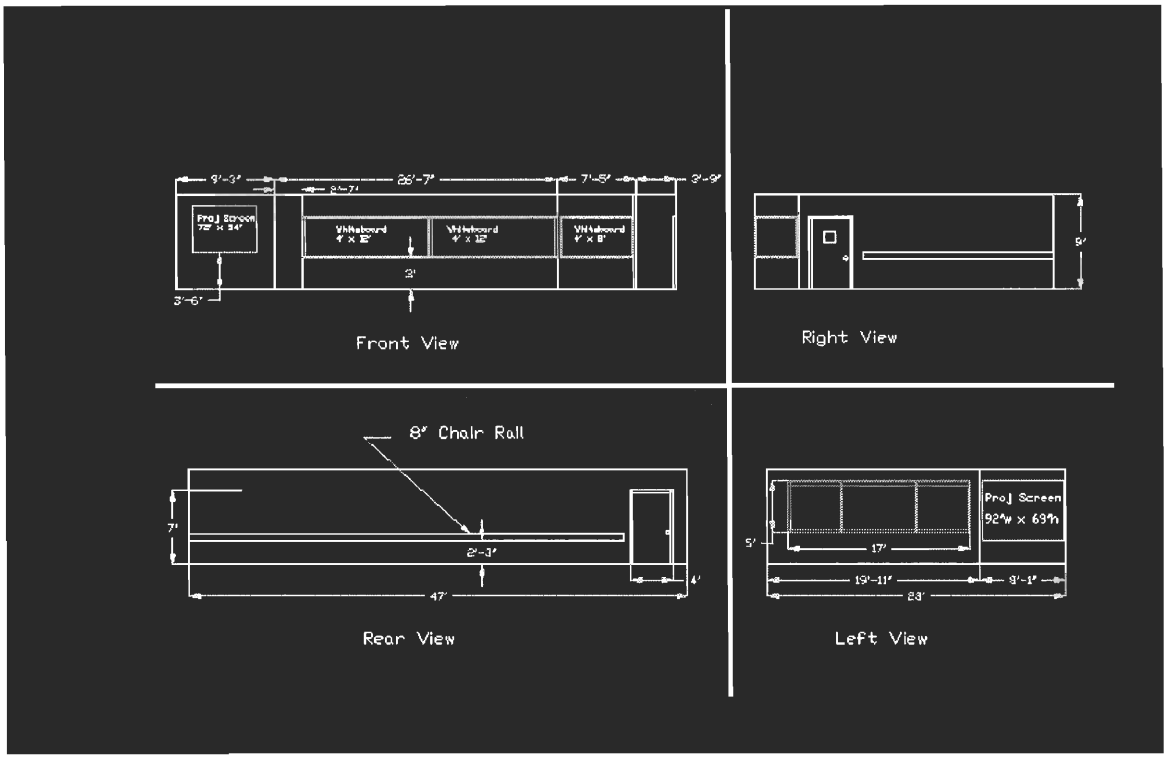
4.6 Design Analysis

The following is an explanation of the designs for each of the five classrooms and laboratories that we designed.

4.6.1 General Lecture Classroom



General Purpose Classroom – Top View



General Purpose Classroom – Front, Rear, and Side Views

From our research it was determined that for these classrooms an instructor to student ratio should be below 1:20; after discussing this issue with The Foxboro Company it was decided that the average class size would be 16 students. In order to emphasize a learner centric classroom the individual student must be the primary concern in the design process.

In our research we found that a student should have a workspace 36" by 30". In our design we provided each student with the necessary workspace. This workspace provides ample space for books, paper, and any other course material. We chose a trapezoidal table design that would allow students to collaborate and interact with each other, but also concentrate on the instructor and work individually comfortably. The tables had to have at least a 29-inch clearance off the ground in order to adhere to the National Disabilities Act. Our tables were designed to have a 30-inch ground clearance; this allows all students to be seated at this table comfortably regardless of body type or handicap.

The students would all be seated in chairs that had adjustable height, lean, and tilt allowing students of all body types to be seated comfortably. These chairs have a five-point wheelbase that give good stability and allow them to easily and rapidly be moved and rearranged around the classroom. This allows students to break into groups swiftly without wasting valuable class time.

Once the individual students' requirements were determined, the next design issue was how to fit at least 16 students into a room while considering instructor's needs, handicap accessibility requirements, and how to arrange each of the student workstations so that no interferences would hinder the educational process. Possible interferences

could stem from visual obstructions, poor acoustics, and insufficient or inadequate education technology. In our research we found that students should be placed 10 to 15 feet from display surfaces at the front of the classroom. This spacing presents the students with an excellent view of all display surfaces in the front of the classroom, but also provides the instructor ample room to teach, perform demonstrations, and use AV equipment effectively. We placed our first row of tables 14 feet from the front wall; because the throw distance of the front screen projector we were using was 14 feet and since this distance fell within the recommended spacing distance we decided to go with 14 feet.

The other factor that greatly affected our spacing was handicap accessibility regulations. According to these regulations doors should be at a minimum of 32 inches wide. We decided to make this distance larger since we wanted a design that would make movement around the classroom easy for all people and especially to allow group work to be a feasible option for the instructor. Otherwise collaborative working and movement around the classroom would be awkward and time consuming. Therefore, we chose a distance of 48 inches for the doors, spacing between furniture, and the spacing between the furniture and the wall. This would allow physically disabled people access to all areas of the classroom and truly give them an equal opportunity in this learning environment. We also chose to make all of our rooms flat and level, because it allows all furniture to be quickly rearranged into different configurations but also avoids possible complications in making the room handicap accessible.

After we decided on these distances we constructed the room dimensions to fit our needs. With the six student tables each being placed 48 inches apart configured in

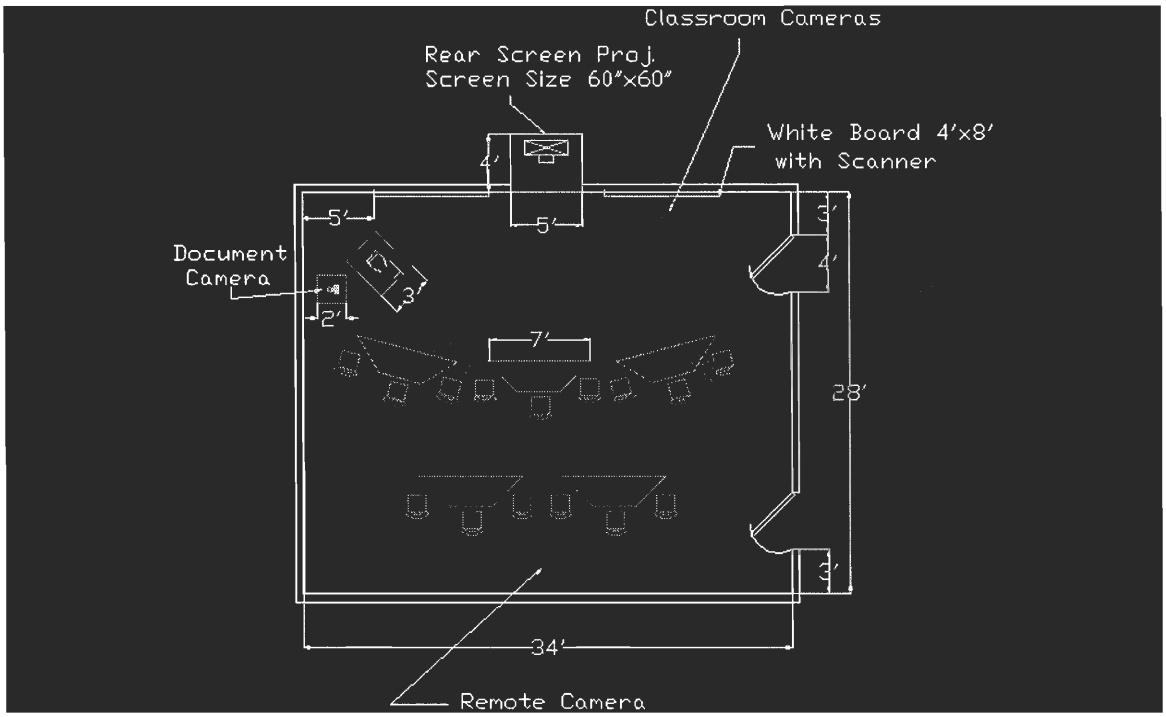
two rows of three tables and the first row being spaced 14 feet from the front of the room we proceeded to design a room around this area. The final room dimensions of the classroom were 37 x 29 feet. We also decided on a nine-foot ceiling because this is the standard height in most single level rooms. There are also two doors in order to adhere to Fire Codes for public buildings. Once we had the room itself designed we proceeded to implement education technology and AV equipment that would enhance the learning environment.

We implemented the simple whiteboard in of our design because it provides the instructor an effective mode to quickly convey ideas to the students in a visual manner. Providing several whiteboards in the classroom provides instructors enough display area so that the instruction is not delayed because the board needs to be cleaned in the midst of explaining an important concept. These whiteboards would be 30 inches off the ground making them easily seen from any where in the classroom. In addition to whiteboards a front screen projector and screen are also included.

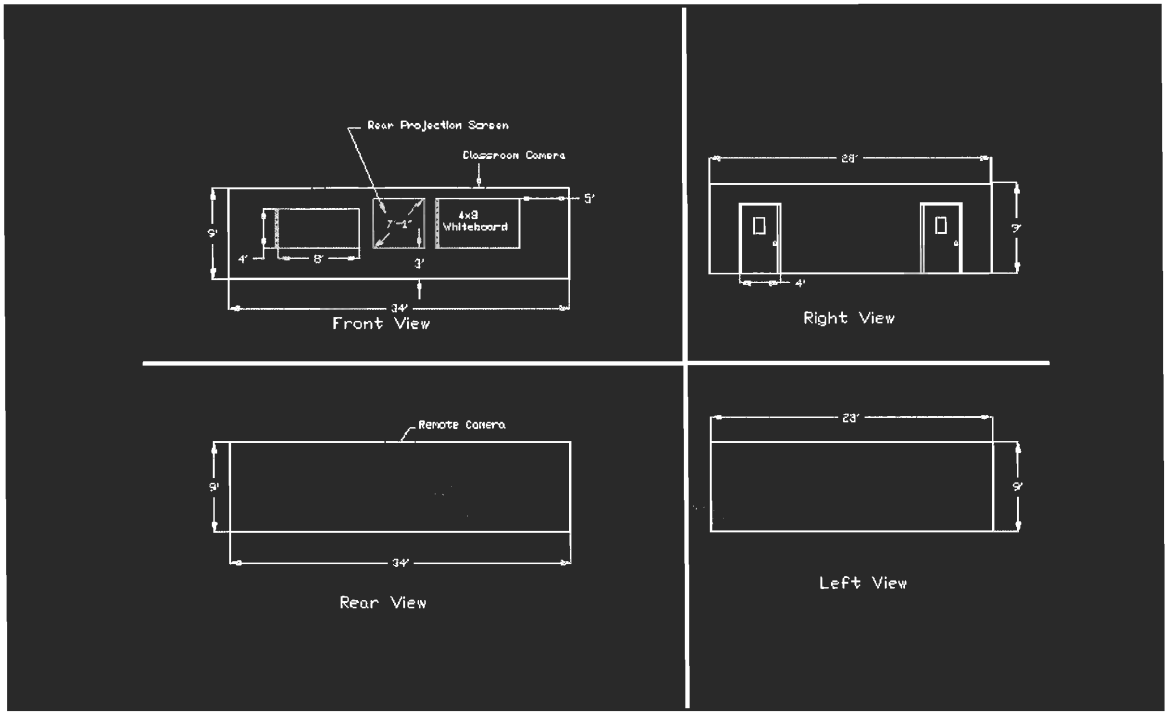
The screen size would be 92 x 69 inches and would be electronically raised and lowered, allowing the screen to be raised and lowered provides the instructor with an additional writing surface behind the screen. The wall with the screen was tilted at a 15-degree angle in order to provide the entire class with a better viewing angle of material being projected. If the wall had been left flat students on the far side of the room would see only a distorted view of what was being projected, because front screen projections become harder to see the further off center-screen the viewer is according to our research. The projector would be attached to the ceiling at the 12-foot throw distance from the screen. This projector would be connected to a personal computer positioned in low

profile computer station in the front of the class. That would allow the instructor to control all AV equipment through the computer, but the station would not hinder the students' line of sight. Also a small table positioned in the front of the classroom would give the instructor space to layout class notes or perform demonstrations. All of the other classrooms designed use many these considerations in their designs.

4.6.2 Distance Learning Classroom



Distance Learning Classroom – Top View



Distance Learning Classroom – Front, Rear, and Side Views

This classroom uses many of the same considerations as the general lecture classroom and was designed very similarly. The only real difference is that either the instructor or the student is at a remote site and the additional technology is needed to connect the instructor to the student and vice versa. The physical layout is very close to the general lecture room, some of the differences are the placement and types of AV equipment.

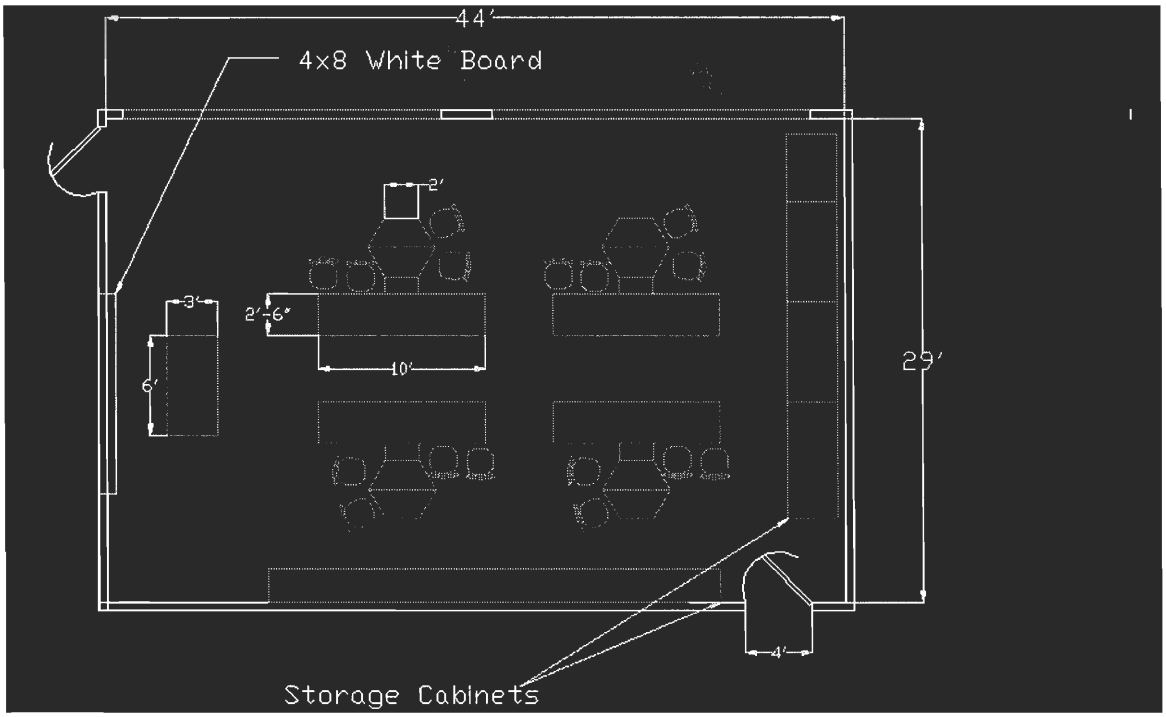
All of the AV equipment would be controlled by the instructor's personal computer positioned in a low profile station. The projection in this classroom is a rear screen projector. This is more visible and quieter then a front screen projector and allows a clearer picture to be captured and transmitted. The screen is placed in the middle of the display area because for a class of students receiving instruction from a remote instructor it will be the primary area of focus. The rear projection screen would be 60 inches by 60

inches. The projector behind the screen would be setup with space reducing mirrors that would reduce the projector's throw distance from 8 feet to 4 feet. This cuts down on space needed behind the projector. There are also two whiteboards that are attached with mimeo scanners, these scanners digitally capture what is written on the board allowing that information to be transmitted or saved digitally.

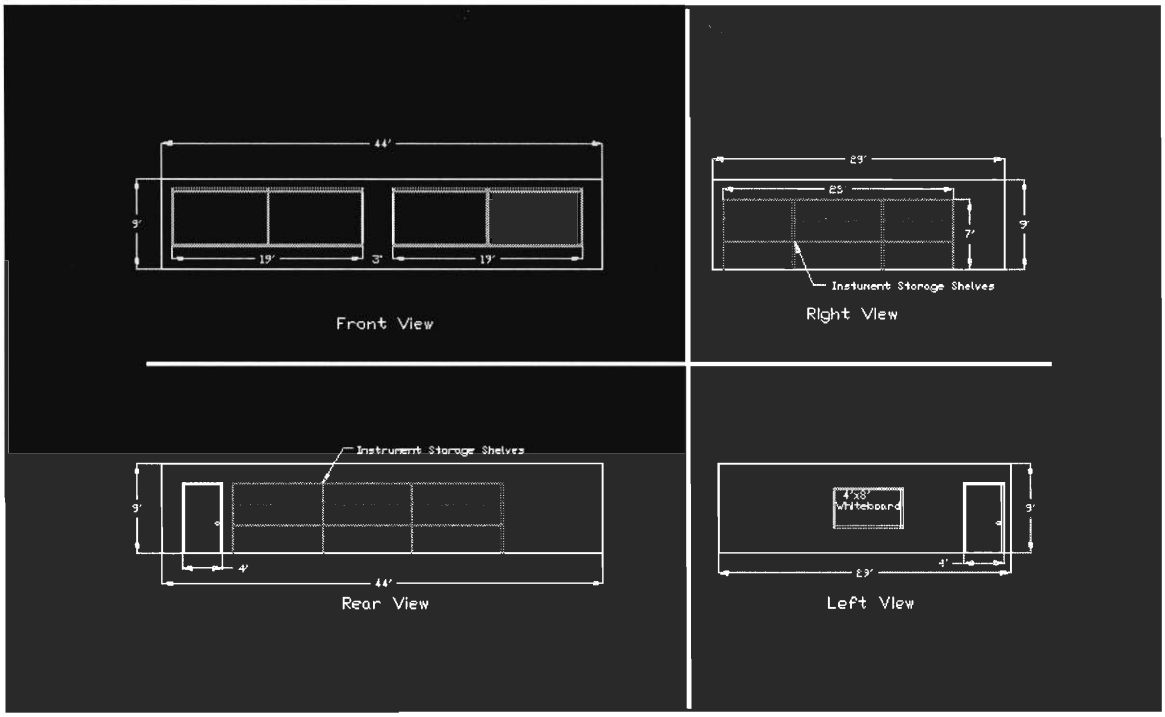
Also there are three types of cameras that allow the remote end to see what is happening in the distance classroom. Each of these cameras has a monitor below the camera in order to show what it is digitally capturing. There is a remote camera positioned in the rear of the room that digitally tracks the instructor in the front and allows remote students to see the instructor. Two classroom cameras are installed in the front of the class that shows the remote instructor the students in the class. These cameras would focus on the class as a whole until individual students pressed a button at their table, which would then focus in on preset student positions. There are also microphones installed at each table that would also be activated by the button. The third camera installed is a document camera that could captures and transmits documents, slides, and even small demonstrations.

This room would be outfitted with an audio system that allows either the students or the instructor in the distance classroom to clearly understand what is said by the remote end of the class. The instructor would be outfitted with a lappel microphone in order to capture audio digitally. There also microphones installed at each table that allow the students and the instructor to communicate verbally. In addition to audio considerations there would be no windows in the classroom in order to prevent natural light from interfering with recording camera's quality.

4.6.3 Instrumentation Lab



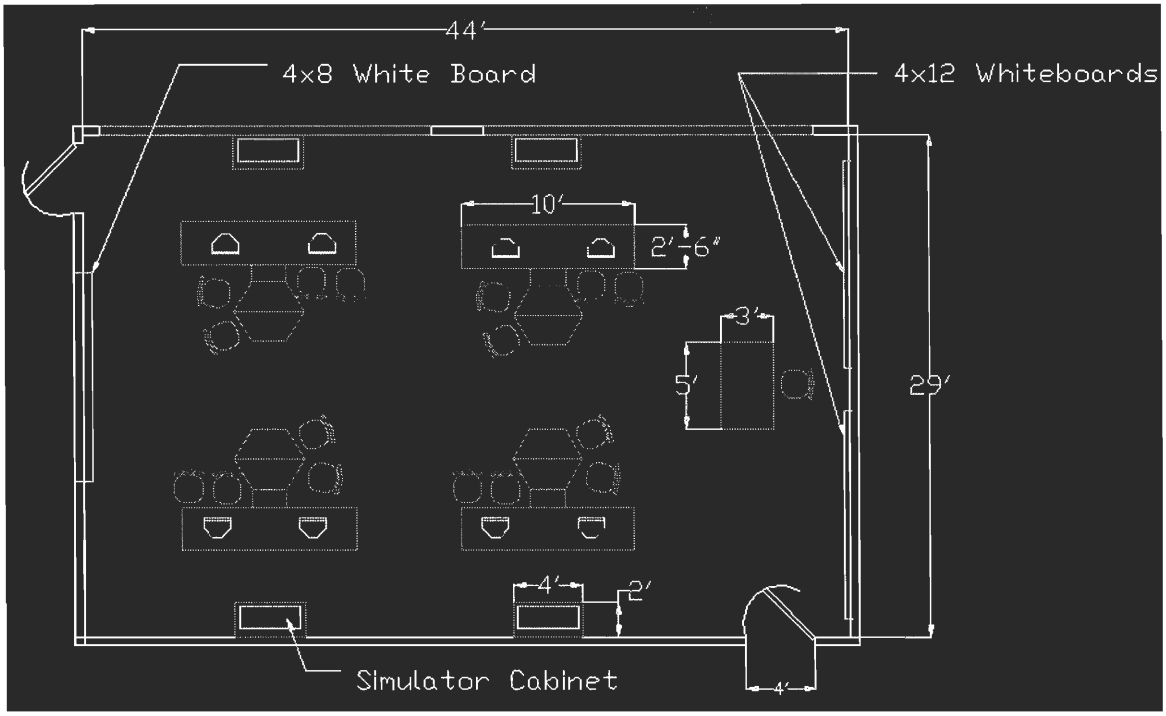
Instrumentation Lab – Top View



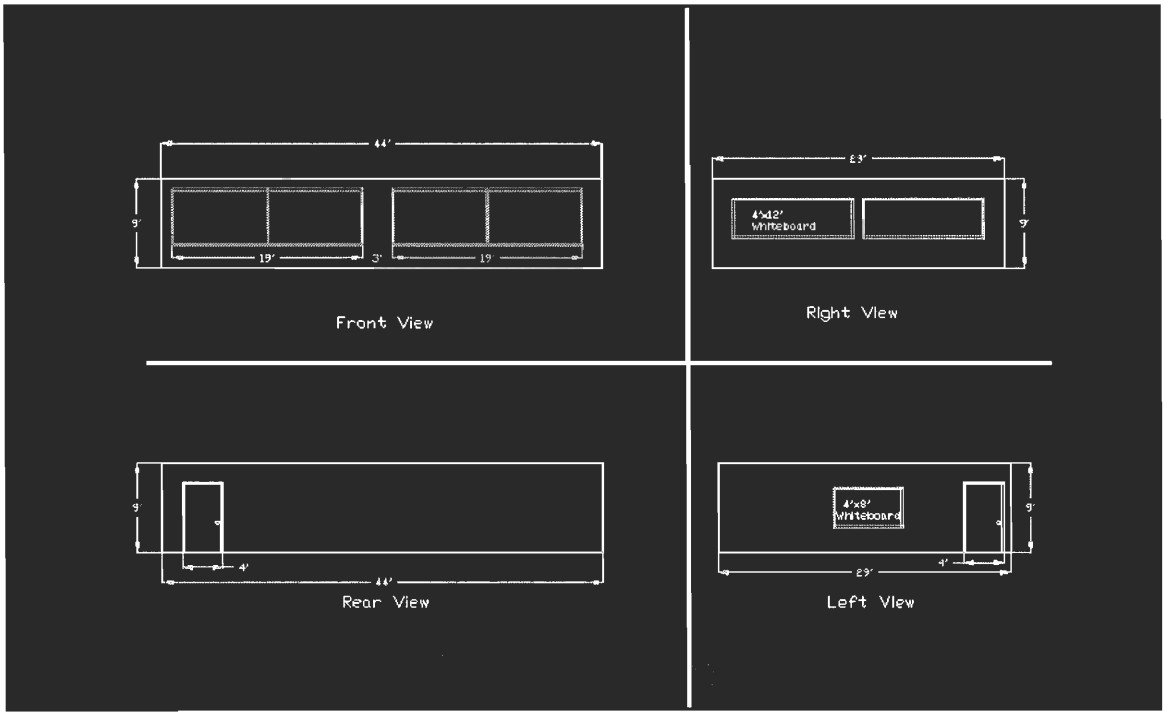
Instrumentation Lab – Front, Rear, and Side Views

This lab also has many of the same considerations as the general lecture classroom, but the student workspace needs to be larger and should provide students with enough room not only for course material and notes, but also room to calibrate instruments and other such hands on activities. We chose tables that seat four students and have a hexagonal table attached. This gives them additional workspace to work on lab equipment. These tables allow students to work in groups of two or four on lab equipment, but also be instructed in a general lecture setting. The current room dimensions for the labs are 44 by 29 feet and we kept with these dimensions. The student tables are spaced well apart to eliminate students feeling crowded, handicap accessibility and to allow the instructor access to all students and provide assistance. The instructor, situated against one of the sidewalls of the classroom, is provided with a demonstration table and whiteboard for instructional purposes. Around two of the walls are storage shelves for lab instruments and equipment. Additional AV equipment can easily be installed if deemed necessary for instruction.

4.6.4 Control Process Simulation Lab



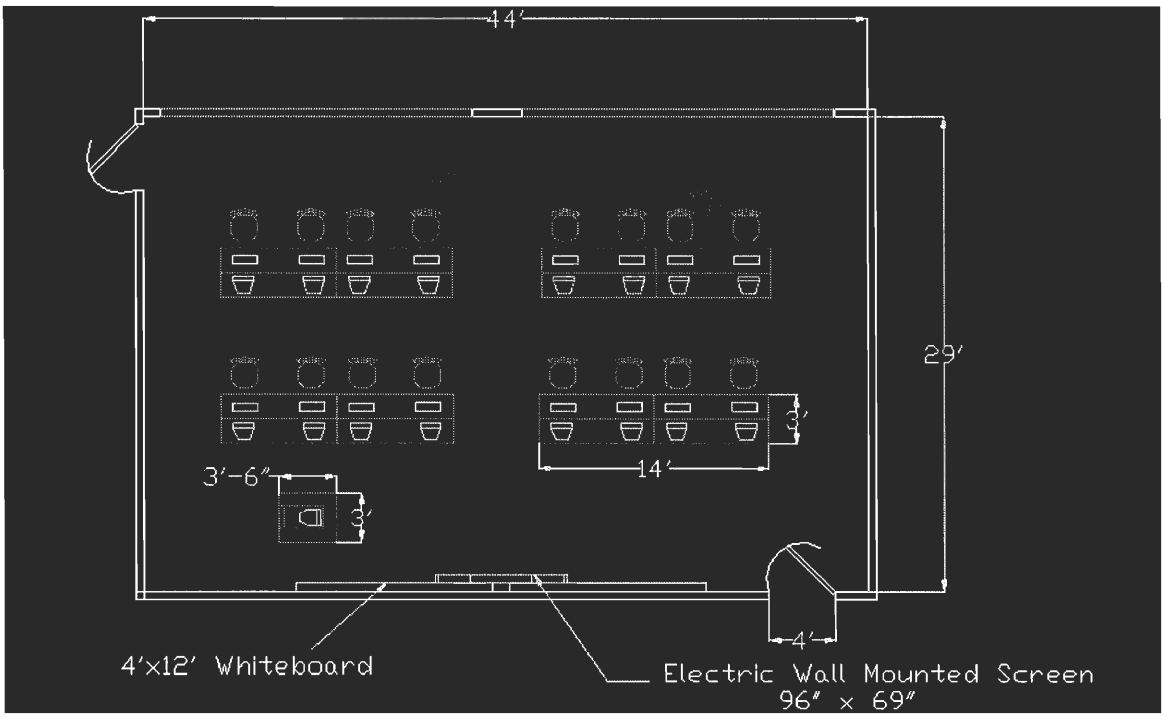
Control System Simulation Lab – Top View



Control System Simulation Lab – Front, Rear, and Side Views

This lab is very similar to the instrumentation lab; it has the same considerations as the instrumentation lab as well as the general classroom. The key difference in this classroom is that it requires computers at the student workstations. On each desk are two computers for four students that control the hardware; according to The Foxboro Company students usually work in groups of two on these systems. These computers manage the control process simulation hardware that is housed in cabinets located directly in front of the students. This allows students to see the direct correlation between their input on the computers and the reactions in the hardware. The instructor is situated against one side of the classroom and is provided with whiteboard space and demonstrations space for instructional purposes.

4.6.5 Computer Lab



Computer Lab – Top View

This lab, although very similar in room characteristics to the other labs, is a little different because unlike the other rooms provides every student with a computer workstation that runs simulation software. This room can be used as a lab, where students work on their own with teacher assistance, and as a lecture room with computers. This allows the instructor to clearly display and demonstrate programs on the computer. Most of the same considerations in the other classrooms still apply to this room.

Students are seated in groups of two at the tables. These tables recess the monitor with the purpose of providing the students a clear line of sight to the instructor and display areas of the classrooms, but also a good view of the computer's monitor. These desks provide the necessary workspace for notes, course material as well as computer operation. The desks are arranged so that students are arranged in groups of four for collaboration purposes. These groups of tables are spaced evenly apart so that instructors can easily reach any student and provide assistance.

The instructor positioned at the front of the class has access to whiteboards and a front screen projector. This allows him to lecture while providing visual information. He can also guide students through computer software, by displaying the program from his computer through the Projector. This allows all students to be taught using the actual software. The instructor also has all the necessary tools to conduct normal lecture instruction.

4.7 Cost Analysis

To ultimately make the new learner-centered learning environment possible, it is necessary to have the monetary resources. There are general considerations that apply to every room, and these will be discussed. Not included in any of these price estimates is the cost of labor, lighting, flooring, or constructions cost.

4.7.1 Cost Considerations

A few important points are to be noted when examining the cost estimates of these classrooms. These prices include all the furniture and A/V equipment in each room, but do not include the labor costs involved in getting them installed. The costs of delivery of these items are also excluded from prices. When these rooms were designed, only the factors that can significantly affect learning were considered; therefore carpeting, a standard item, was not part of the cost consideration, nor was wall paint jobs, and lighting. Therefore, it was recommended that the Foxboro Company seek a lighting expert service to better suit there needs.

4.7.2 General-Purpose Classroom

The total cost of this room comes to $15,540.00. This price includes all the furniture such as tables, chairs, and the demo table. Also included are the audio/visual equipment such as whiteboards and the projector.

Equipment Type	Specifications and Description	Company	Individual Prices	Price per Room
General Classroom				
Student Tables	7' L; 30" W; 30" H, trapezoidal shape	**Computer Comforts** http://www.computercomforts.com	$500.00	$3,000.00
Chairs	395 Series Chairs	**Steelcase** http://www.steelcase.com	$300.00	$5,400.00
Projector	MP8635, Multimedia Projector	**3M** http://www.3M.com	$5,195.00	$5,195.00
Screen	69"Hx92"W Viewing Area Matte White Surface Electric Wall or Ceiling Projection Screen	Da-Lite http://www.da-lite.com/	$895.00	$895.00
Instructor's Station	Recessed Monitor Table	Bretford Company http://www.bretford.com	$300.00	$300.00
Whiteboard	two 4x12 whiteboards		$250.00	$500.00
Lighting	Apex55: reflective lighting	**Ledalite** (781) 272-2301 http://www.ledalite.com/issues/edu-clas.htm	TBD	
Small Table	2'x5' teacher table		$250.00	$250.00
			Total:	**$15,540.00**

4.7.3 Distance Learning Classroom

The total cost of this room is $30,000.00. This room is more expensive than the General-Purpose Classroom. The reasons become clear when the types of equipment are examined. Due to the extra technology necessary to suit the distance learning needs, slightly more expensive items were used. These are the rear-projector, the rear-projection

screen, and the mirror system used to reduce the throw distance of the projector, the Mimio whiteboard scanner, and other audio equipment.

Equipment Type	Specifications and Description	Company	Individual Prices	Price per Room
Distance-Learning Classroom				
Student Tables	7' L; 30" W; 30" H, trapezoidal shape	Computer Comforts www.computercomforts.com	$500.00	$2,500.00
Display Stand	2'x2'x30"		$200.00	$200.00
Chairs	395 Series Chairs	Steelcase www.steelcase.com	$300.00	$4,500.00
Projector	InFocus LitePro 425: 800x600 resolution	InFocus LitePro 425	$5,999.00	$5,999.00
Screen	Da-Lite Rear Projection Graphics Screen	Da-Lite	$5,400.00	$5,400.00
Suggested Rear Projection Mirror 2	Rear Projection space reducing mirrors	Mirrorlite	$3,795.00	$3,795.00
Instructor's Station	Recessed Monitor Table	Bretford Company http://www.bretford.com	$300.00	$300.00
Object Display Camera	3M DC1000 Object Display Camera	**3M** http://www.3M.com	$2,528.85	$2,528.85
Electronic Whiteboard	Whiteboard converter: 4' by 4'	Mimio	$2,000.00	$2,000.00
Audio Output	5x full bandwidth satellites	Kinyo Dolby Digital Home Theater System	$224.25	$224.25
Whiteboard	two 4x12 boards		$250.00	$500.00
Lighting	Apex55: reflective lighting	**Ledalite** (781) 272-2301 http://www.ledalite.com/issues/edu-clas.htm	TBD	
microphones	PCC-160 boundary microphones	**Crown International**	$309.00	$1,854.00
	Miniature Condenser Lavalier Microphone	**Electro-Voice, Inc**	$210.00	$210.00
			Total:	**$30,011.10**

4.7.4 Control System Simulation Laboratory

This is the laboratory where the students, in the new design, will sit in pairs of two and in teams of four directly in front of the controls equipment. It should be noted that the fluid controls simulation panels are the property of the Foxboro Co., and therefore not considered in the costs. All in all, the work stations, chairs, demo table, and whiteboards totaled to $11,188.00. Computers weren't included in the cost.

Equipment Type	Specifications and Description	Company	Individual Prices	Price per Room
Control System Simulation Laboratory				
Chairs	395 Series Chairs	Steelcase www.steelcase.com	$300.00	$5,100.00
Small Table	2'x5'x30" teacher table		$250.00	$250.00
Student Workstations (trapezoidal tables)	Trapezoid Table 24x24x24x48 34"	Howe Furniture Corporation (order through E&I)	$312.00	$2,496.00
Student Workstations (rectangular tables)	Rectangle Table 30x120 34 "	Howe Furniture Corporation (order through E&I)	$648.00	$2,592.00
Whiteboard	three 4x12		$250.00	$750.00
Lighting	Apex55: reflective lighting	**Ledalite** (781) 272-2301 http://www.ledalite.com/issues/edu-clas.htm	TBD	
			Total:	**$11,188.00**

4.7.5 Instrumentation Laboratory

The instrumentation laboratory is where the students work solely with hands-on modules, such as repairing a device. The estimate includes the tables, chairs, the demo table, and the whiteboard. The estimated total for this classroom is $10,688.00.

Equipment Type	Specifications and Description	Company	Individual Prices	Price per Room
Instrumentation Lab				
Chairs	395 Series Chairs	Steelcase www.steelcase.com	$300.00	$5,100.00
Student Workstations (trapezoidal tables)	Trapezoid Table 24x24x24x48 34" high	Howe Furniture Corporation (order through E&I)	$312.00	$2,496.00
Student Workstations (rectangular tables)	Rectangle Table 30x120 34 " high	Howe Furniture Corporation (order through E&I)	$648.00	$2,592.00
Whiteboard	4x12		$250.00	$250.00
teacher table	3 x 6 ft		$250.00	$250.00
Lighting	Apex55: reflective lighting	**Ledalite** (781) 272-2301 http://www.ledalite.com/issues/edu-clas.htm	TBD	
			Total:	**$10,688.00**

4.7.6 Computer Laboratory

The cost of this classroom comes down to $12,000.00, and includes the recessed-monitor tables, chairs, and A/V equipment such as the whiteboards and projection screen. Again to be noted is the exclusion of computer costs.

Equipment Type	Specifications and Description	Company	Individual Prices	Price per Room
Computer Lab				
Chairs	395 Series Chairs	Steelcase www.steelcase.com	$300.00	$5,100.00
Whiteboard	two 4x12		$250.00	$500.00
student stations	eight lowered monitor table workstations	computercomforts.com	$650.00	$5,200.00
Screen	69"Hx92"W Viewing Area Matte White Surface Electric Wall or Ceiling Projection Screen	Da-Lite http://www.da-lite.com/	$895.00	$895.00
Instructor's Station	Recessed Monitor Table	Bretford Company http://www.bretford.com	$300.00	$300.00
Lighting	Apex55: reflective lighting	**Ledalite** (781) 272-2301 http://www.ledalite.com/issues/edu-clas.htm	TBD	
			Total:	**$11,995.00**

4.8 Presentation Analysis

Another aspect of the project was giving a presentation to The Foxboro Company. It was discussed between group members and with the advisors and Michael Bleyhl, our liaison with The Foxboro Company. From there, we all agreed that it would be a step in the right direction to conduct a presentation with the instructors at the Lifetime Learning Center, followed by a presentation with some of the executives at The Foxboro Company involved in the redesign process.

Our first step in the process of putting together our presentation was to decide which aspects of our project we would like to involve in the presentation. After some deliberation, we agreed that the main topic of our presentation should be our classroom designs. Our reasoning was that the instructor staff at the Lifetime Learning Center

would probably be most interested in what might directly affect their jobs, and that would be the new classrooms. Outside of our designs, we felt it would be helpful to our presentation to focus on the reasoning behind the choices that we made, so we also incorporated information on adult learners and learning styles.

After piecing all of our information together, we began practicing giving our presentation to each other in order to relieve some of the nervousness that we all would feel standing in front of a group of 10 to 15 people. Using note cards with our presentation material on them to practice, we made some dry runs of the presentation. After these, we found it best to critique ourselves on the little problems before we presented in front of the instructors. We were told ahead of time that the desired presentation would last about 20 to 30 minutes, so we also kept track of time as we presented to make sure we kept within the desired length.

When setting up the presentation with the instructors, we had decided between the group and Mr. Bleyhl that it would smooth out our presentation to the instructors if we were to present to Mr. Bleyhl alone beforehand. Mr. Bleyhl came down to WPI 2 days before the scheduled instructor presentation, and we presented to him as we would in front of the instructors. This meeting proved to be very helpful, as Mr. Bleyhl had constructive criticism for each of us, as well as a couple of suggestions about how to make the PowerPoint aspect of our presentation better. We came away from the meeting with a much better idea of exactly what it would take to give the instructors a n informative presentation.

The next step in the process was to make revisions to our PowerPoint as well as to our presentation. We decided to not continue using note cards, as per suggestion by Mr.

Bleyhl, and to speak from memory. We knew that we knew what we wanted to talk about during our presentation, so there was no point to using note cards outside of as a crutch if we happened to falter during the presentation. After the revisions, we ran through the presentation as a group again and, from there, were ready for our presentation with the instructors.

Foxboro's production manager taped the presentation in front of the instructors for the project group so that we would be able to show it to our advisors for feedback before our presentation in front of Foxboro's executives. We felt that the presentation came off very well. The instructors had lots of positive feedback and many questions to ask us, proving that we were able to keep them interested in our material. Overall, the group feels that the presentation was a success, and the feedback from the instructors helped us to mold our final presentation into what we feel is the best it can be.

5.0 Conclusions and Recommendations

This section presents the culmination of our work for the LifeTime Learning Center. It includes the conclusions that we were able to make from the research and recommendations that we were able to draw from the analysis that we did.

5.1 Conclusions

As we started this project, we were initially unclear of what exactly needed to be done. After meeting with Mr. Bleyhl at the LifeTime Learning Center, we were able to establish the major objectives of our project but we were still unsure of how far we would take it. After some time and certain changes to the plans by The Foxboro Company, we finally established that we would design prototypes of classrooms for each type of classroom that already existed. This way, no matter what building they used or how many classrooms they decided to have, The Foxboro Company would have a set of designs that they could apply to any situation.

After collecting research through various means such as books, online resources, interviews, questionnaires, and visits to the LifeTime Learning Center, we took some time to analyze what we needed to do and how we were going to go about designing it. We decided to start out with the general-purpose classroom. In designing this classroom, we took into account the general considerations we found to be vital to each classroom. The general-purpose classroom became the basis of all our designs, especially the distance learning classroom, which had the same general layout but incorporated technology to allow for the transfer of information. For the laboratories, we also

considered many of the same aspects that went into the design of the classrooms. However, with the laboratories, we knew that there were certain features that needed to remain in those rooms such as equipment used in training. We focused in on designing around the permanent equipment in the laboratories. Once we finished our designs, we compiled a cost estimate that we hope can give The Foxboro Company an idea of how much they can expect to spend on the interior design of each room. We were also fortunate enough to present our designs to Mr. Bleyhl and his staff. We received some constructive suggestions and took them into account during our own evaluation of the designs. We then finalized the designs that are submitted in this report.

5.2 Recommendations

We recommend that The Foxboro Company use our designs in redesigning the LifeTime Learning Center. We have primarily focused on the interior design of the classroom and the elements that pertain to enhancing learner-centric and distance learning environments. All construction concerns should be taken up by the contractor that takes on this project. For aspects such as acoustics and lighting, we highly recommend that The Foxboro Company seek out consultants that we have referenced. Included in the cost estimate we have included the companies that make the products that we have suggested for them to use. We have also included the contact information for these companies.

Throughout the length of this project there were many considerations that we took into account. There were also many revisions between the initial designs and the final

designs that we presented in this report. We also realize that The Foxboro Company may not use all of our ideas, however we feel that we have provided them with the best solutions to suit their needs.

Appendices

Appendix A – Questionnaires

Appendix A-1: Questionnaire for Foxboro Instructors

The Foxboro Company is currently assessing its Lifetime Learning Center. We would appreciate it if you could fill out this questionnaire to help us decide what improvements can be made. Please explain each answer as thoroughly as possible.

1) **Which of these two teaching styles described below do you use in class more, or do you combine both methods? Explain briefly**.

Active – A "hands-on" approach to things. You interact with the students during class time.

Passive – Straight lecturing, you do most of the talking during class time.

2) Do you think it is more beneficial to teach the class information in a separate classroom and then move to the lab?

-OR-

Do you favor a room that can be used as both a lab and a classroom?

Which do you prefer and explain why.

3) Do you use audio/visual equipment (i.e. Over-head projectors, VCR's, etc…)?

And if so how often do you use them and do you feel that you spend too much time on setting up this equipment?

4) How often do you have the students move into groups?

5) How long is an average class? Does it seem that the students stay focused during this time span?

Appendix A-2: Questionnaire for Foxboro Students

The Foxboro Company is currently assessing its Lifetime Learning Center. We would appreciate it if you could fill out this questionnaire to help us decide what improvements can be made. Please explain each answer as thoroughly as possible.

1) Do you think that the equipment being used in labs fulfills the class requirements?
2) Do you find it hard to see the instructor from any seat in the classrooms? If so, in what classrooms did this occur?
3) Can you hear the instructors well enough in the classrooms?
4) Do you think there is ample lighting in the classrooms and laboratories? Does the glare from the windows affect your vision?
5) Does the room provide a good "comfort" level for the students? (A/C in summer; heat in winter)
6) Do the professors use enough audio/visual equipment? When it is used is it used effectively and efficiently? Can you see it well enough when it is used? Explain briefly.
7) Is the classroom furniture conducive to a learning environment?
8) What kinds of relaxation facilities do you think would be beneficial to this facility?
9) Would you rather learn the relevant information first and then conduct laboratory exercises or learn the information and perform the lab simultaneously?
10) Are Computers used effectively in this course?

Appendix A-3: Statistics of Student Questionnaire

1) 60 responses
   - Yes – 52
   - No – 2
   - Other – 6

   Comments: 1 workstation per student; would rather work with real equipment; do labs separate; prefer equipment to PC; some PCs were old; could use newer equipment; could use more data ports; hide electrical wires for computers; equipment was faulty and out of date

2) 60 responses
   - Yes – 0
   - No – 60

   Comments: Would like more workspace

3) 60 responses
   - Yes – 60
   - No – 0

4) 60 responses
   - Yes – 46
   - No – 13
   - Other – 1

   Comments: 2 lights burnt out; want variable light control (dimmer); lights at workstations for when room lights are out.

5) 60 responses
   - Yes/ok – 54
   - No – 0
   - Other – 6

   Comments: Could be a little warmer in early winter; when thermostat was properly set; a little hot some days; instructor turned it down too low; some days a bit too cool; more padding on chairs; colder nearer windows

6) 59 responses
   - Yes – 50
   - No – 3
   - N/A – 4
   - Other – 2

   Comments: dimmer switches; hard to see from back of room; not used enough; some content too small; hard to see small content; projector is loud.

7) 60 responses
   - Yes – 49
   - No – 0
   - Other – 11

   Comments: chairs with wheels (x3); a little crowded; chairs too stiff; more workspace (x3); larger chairs; chairs uncomfortable; need better chairs (x2)

8) 34 responses
   - No Suggestions – 10
   - Suggestions – 24

   Comments: Health facility (x3); soft music; Internet access (x6); TV; Concessions (x3); FM radio; Lounge<chairs, couches> (x5); walking path (x2); larger bathroom; movies; current relevant periodicals; place of worship; massage parlor

9) 54 responses
   - Separate – 29
   - Simultaneous – 25

10) 57 responses
   - Yes – 56
   - No – 1

   Comments: Prefer 2 to a computer

Appendix B – Interview Questions

Appendix B-1: Questions for Professor Kildahl

1) What is the most important aspect of any learning environment?

2) What is the best arrangement or layout for the students and professor in both a teacher-oriented classroom and a student-oriented classroom?

3) How large should classrooms be for a 25 to 30-person class and what shape should the room be?

4) Are ergonomics a deciding factor in furnishing a classroom?

5) How much workspace is appropriate for a student in a classroom? How much workspace does a professor need?

6) Are there any certain room lighting considerations that are important for either the professor of the students? How should rooms be illuminated?

7) What types of AV equipment is important to most classrooms. Any preferred types

8) If computers are used in classrooms, how should they be arranged so that they are not distractions?

9) Are there any types of acoustic situations that need to be avoided in classrooms and what type of room layouts allows for the best classroom acoustics? Are there any additions to classrooms that dampen ambient noise?

10) Are there any certain color schemes that you find beneficial to classrooms, or any schemes that need to be avoided?

11) Of the following, which do you prefer? Chalk Board, White Board, or Electronic Whiteboard (any other).

12) Give an example of both a well-designed and poorly designed classroom on campus.

Appendix B-2: Questions for Professor Miller

1) How can the knowledge of adult learning habits and psychology be applied into the design of classrooms?

2) How is the more theoretical information from the research useful to this project?

3) What do you know about M. S. Knowles and D. D. Pratt?

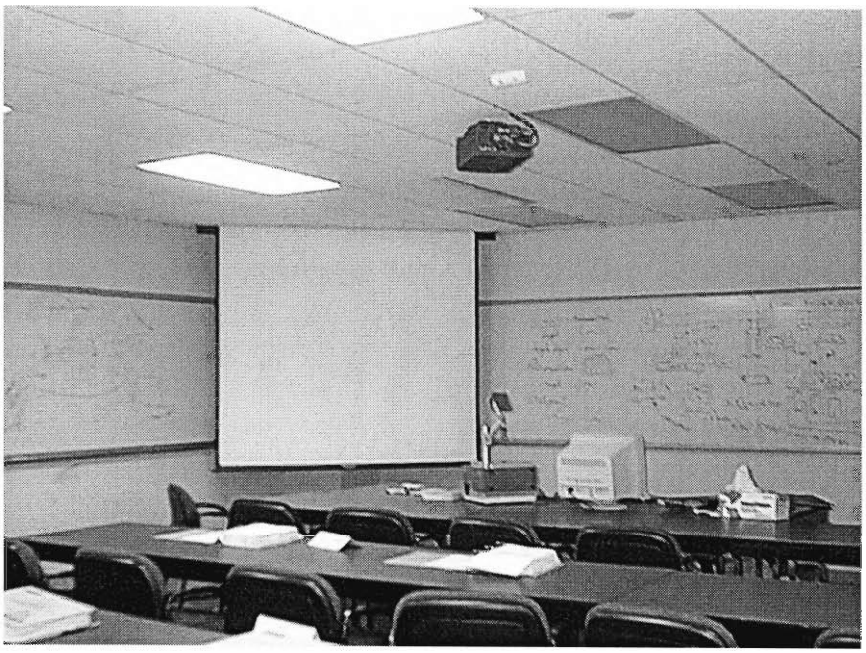
4) Can you suggest any sources on the psychology of physical learning environments?

5) What and how do physical attributes factor into the motivation and mentality of the adult learners?

Appendix B-3: Questions for Pennie Turgeon, Director of the WPI IMC

1) Does WPI offer distance education?
2) Is there a distance education classroom on campus?
3) Is it more effective to have the instructor lead an on-site class while leading the distance student(s), or to have the instructor focus solely on distance students?
4) In most cases, students and instructors who have never been involved in distance education before feel uncomfortable with the idea. What methods could be used to alleviate some of their anxiety before starting the course?
5) The Foxboro Company would like to convert a large percentage of their courses from instructor-led to learner-centric. What might be some effective ways to allow the students to control their learning process?
6) Are there any specific methods of delivery of information that you feel are better or worse than most others?
7) Are secondary methods of communication necessary to create an effective environment?
8) What are some advantages and disadvantages to synchronous delivery?
9) What are some advantages and disadvantages to asynchronous delivery?
10) Outside of lighting and acoustical concerns, are there any other important considerations to take into account when designing a distance learning environment?
11) Are there any other sources of information on distance learning that we could benefit from that you can refer us to?

Appendix C: Current Pictures of the LifeTime Learning Center

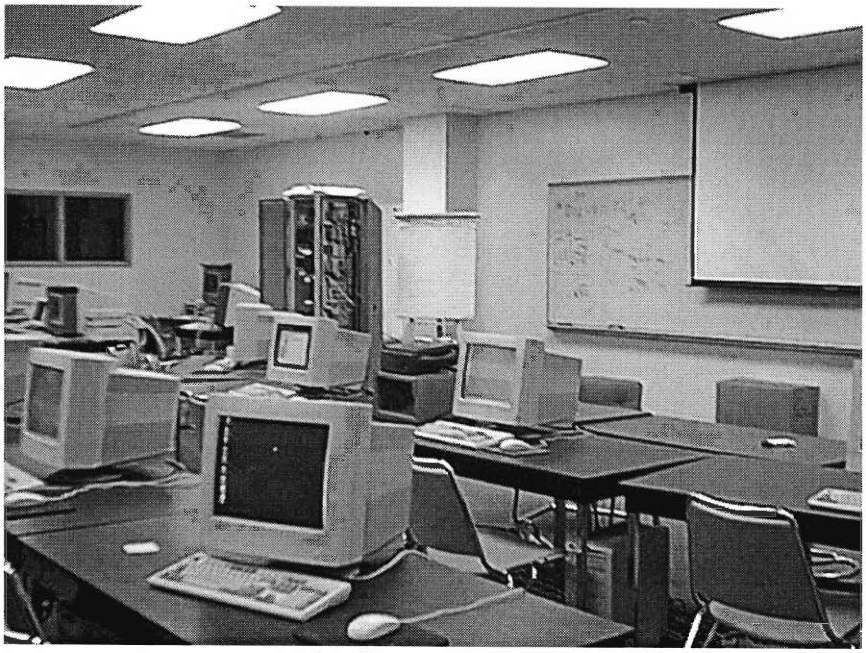


The General-Purpose Classroom

The Distance-Learning Classroom

The Instrumentation Lab

Control System Simulation Lab



The Computer Lab

Appendix D – Classroom Specifications

Appendix D-1: General Classroom Specifications

- **Tables**
  - 7' L; 30" W; 30" H
  - Trapezoidal Shape
  - Provide each student with 36" by 30" workspace
  - 29"-30" off the floor to allow wheel chair accessibility
  - All tables are positioned 4' from each other to allow wheel chair accessibility
  - Positioned so that all students have a good view of Instructor and AV equipment
  - Facilitate group work and collaboration, but also provide each student with adequate space and good line of sight to the Instructor
  - Of neutral color (match color scheme TBD)
  - Tables do not have glossy finishes that reflect light

(See blueprint of table)

- **Chairs**
  - Have wheels, 5 point wheel base to maximize stability to allow mobility
  - Are ergonomic and provide adequate back support
  - Seat back are 19" wide to and have adjustable heights and tilts
  - Seating made of high strength fabric
  - Of neutral color (match color scheme TBD)
  - Example

Steelcase Company395 Series
www.steelcase.com

Features

- Adjustable back height
- Adjustable seat depth
- Forward seat tilt
- Knee-tilt mechanism
- Pneumatic height adjustment
- Posture-tilt mechanism
- Swivel mechanism
- Swivel-tilt mechanism
- Tilt tension
- Variable back lock

Options

- Height and width adjustable T-arms
- Width adjustable loop arms

- **AV equipment**
    - 3 White boards 1 - 4'x8' and 2 - 4'x12'
    - Possibly "Wall Talker" material
    - Front Screen Projector

3M Company - Visual Systems Div.
MP8780
Multimedia Projector
$12,999.00
http://www.markeys.com/markeysECATALOG.html

Now there is a projector that can deliver high XGA (1024 x 768) resolution and a stunning 2,300 ANSI lumens of brightness for a true multimedia experience. Offering the latest in presentation technology, the MP8780 has picture-in-picture feature for displaying video or digital images simultaneous with data. Five input channels allow the simultaneous connection of two computers and three video signals for true plug-and-play flexibility. Ideal for large-venue presentations, convention centers and corporate environments, the MP8780 is the perfect business partner for your strategic presentations.

- Screen:

Da-Lite Screen Company, Inc. - Electric Wall/Ceiling Screens
http://www.markeys.com/markeysECATALOG.html

8'Hx8'W Matte White Surface Electric Ceiling Projection Screen - Front Projection

- Electric motor oiled for life, automatic thermal overload cut-out, integral gears, capacitor and electric brake to prevent coasting
- Black masking borders standard
- Preset but adjustable limit switches to automatically stop screen surface in the up and down positions
- Wood case with primer coat
- Offers unlimited viewing angles and perfect uniformity while giving precise definition and reproduction of color or black and white

- Matte White screen surface is seamless and ideal for front projection when ambient light is controllable
- Screen surface is washable with mild soap and water
    - Instructor has a low profile computer stand in order to control AV Equipment

    Bretford Company

    http://www.bretford.com/new_products/individual_products/frameset/pres_recessed.htm

Features

- Provides excellent sightlines in a classroom environment allowing students and instructors to easily see over the monitor.
- Ergonomic design eliminates glare on computer screens.
- Helpful for users with bifocals and prevents neck strain.
- Holds up to a 21" computer monitor.
- Users can choose up to six settings to customize the angle of the screen without removing the monitor.
- Built-in safety feature prevents monitor from dropping.
- Options can include a CPU holder and a raceway that can be hard wired.

- **Flooring**
    - High impact carpeting
    - Polyurethane padding under carpets to reduce echoing and ambient noise
    - Of neutral color (match color scheme TBD)
    - 2" Drop Flooring if possible
    - Possible Company: Interface Flooring Systems
      http://www.interfaceinc.com/us/

- **Ceiling**
    - Acoustic tiling to reduce ambient noises
    - 9' ceilings
    - Drop Ceiling Tiles

- **Walls**
  - Off white coloring
    - White with a hint of beige should produce the appropriate color
  - 8" chair rails 25" from flooring to protect walls from damage by furniture
  - Rough in texture to facilitate front to back sound movement

- **Doors**
  - All door ways at least 36" in width to provide handicap accessibility
  - 2 doors per classroom to fulfill fire codes.

- **Lighting**
  - Both indirect and direct lighting
  - Soft luminance
  - Possible windows with coverings
  - Zoned Lightings parallel to front of classroom
  - Easy and Effective lighting controls near Instructor
  - Check out Ledalite lighting solutions
    - **http://www.ledalite.com/issues/edu-clas.htm**

Check out especially the APEX 55 lighting system fulfills all classroom requirements.

Appendix D-2: Distance Learning Specifications (15-person audience)

Furniture (same as general classroom)

Tables
7'-3" L; 30" W; 30" H
Trapezoidal Shape
Provide each student with 36" by 30" workspace
29"-30" off the floor to allow wheel chair accessibility
All tables are positioned 4' from each other to allow wheel chair accessibility
Positioned so that all students have a good view of Instructor and AV equipment
Facilitate group work and collaboration, but also provide each student with adequate space and good line of sight to the Instructor
Of neutral color (match color scheme TBD)
Tables do not have glossy finishes that reflect light

2' x 2' 29" height table for document projector

Chairs
Have wheels, 5-point wheelbase to maximize stability to allow mobility
Are ergonomic and provide adequate back support
Seat back is 19" wide and has adjustable heights and tilts
Seating made of high strength fabric

Of neutral color (match color scheme TBD)

Instructor AV stand
Lighting
Same as General Classroom
No Windows in this room if possible
Opaque screens necessary

AV equipment
- **Rear Projector** This projector was chosen as it has high quality resolution, computer and video input, short throw distance, and low cost (comparatively).

IMPORTANT FEATURES AND CAPABILITIES
Manufacturer/Model InFocus LitePro 425
MSRP (List Price) $5,999
Warranty 2 Years 1st with overnight replacement
Extended Warranties Yes, up to 3 years
PERFORMANCE
Brightness 700 Lumens
Max Diagonal Image size:
Darkened Room 25 Feet
Moderate Lighting 16 Feet
Zoom Lens, Power No / No
Min/Max Distance to 10 FT Diagonal Screen 8.4 Feet
True Resolution SVGA (800x600)
Compressed Resolution XGA (1024x768)
Auto-Resize Yes
Rear Screen Yes
Ceiling Mount No
Type of Projection 2nd Generation DLP™
Number of Colors 16.7 Million
Lamp Type Metal Halide, 150 Watts
Lamp Life 1000 Hours half-life
Contrast Ratio 200:1
Inputs 1 Computer, 2 Video, Audio
CONTROLS
Built-in Remote Mouse Optional
Type of Pointing Device Disc Pad Microsoft mouse compatible.
Remote Control/Backlit Optional
Full Control Panel Yes
Backlit Optional
Menu Driven Yes, Multilingual
Remote Zoom/Focus No/No
Built-In Laser Pointer No
PORTABILITY
Weight 6.8 LBS
Dimensions HxWxL 3.9"x12"x9"

Power Supply 100-240 VAC 50/60 Hz

- **Rear Projection Screen** Chosen due to graphical capabilities, low cost…

Da-Lite Rear Projection Graphics Screen

This screen is designed especially for high-resolution graphics and data projection. Its patented double-element construction concentrates light being projected to the audience with added contrast yet allows the true colors of the image to show through.

Highest gain available 3.5.

Excellent resolution, brightness and uniformity.

Non-glare surface with high contrast gray optical tint.

Diagonal sizes from 60" to 84".

Available in both video and widescreen formats.

Screens can be cleaned with any ammonia based cleaning agent.

Diagonal size – 84”

Price - $5400 (through Grant Enterprises)

- **Overhead Document Camera** - Chosen due to low cost while capable of performing all necessary tasks, and can interact directly with a projector, or through a computer, via the S-Video output.

3M DC1000 Object Display Camera
The 3M DC1000 gives you high-end performance at a smart price. Powerful, portable and priced right, the DC1000 represents one of the best values in the industry. With the DC1000, you can transform your existing projector into a high-performance presentation system. The DC1000 works with most multimedia projectors. The DC1000 delivers outstanding resolution with 450 TV lines. Using a video conferencing system, the DC1000 enables many people in many places to view one object. Its 16x powered zoom gives you the flexibility to zoom in on small objects and zoom out on large ones. Best of all, the DC1000 delivers all this power and weighs only eight pounds, so it is ideal for prototype displays for business meetings, live demos for classroom instruction, and 3D diagrams or documents for law offices or courtrooms. **$2,528.85**

Horizontal resolution: 450 TV lines
Sensitivity: 3 Lux
Weight: 8 lbs
Output: S-video/Composite

Interface: 9-pin mini-DIN/S-Video/2X Line Audio (stereo)
Image pick-up device: 0.25" CCD
Dimensions: 8"(20.3cm)x11"(27.9cm)
Aspect ratio: 4:3
Lens (horizontal angle): fl.4(w)-f2.8(t)[47(w)-3(t)]
Iris: Auto
Shutter: Auto exposure
Operating temperature: 32F (0C) to XXF (40C)
Storage temperature: -4F (-20C) to 140F (60C)
Power consumption: 300mA w/o FlexLites
Regulatory approvals: FCC Part 15 Class A, UL, cUL
Warranty: One-year limited warranty on parts and labor
Order number: 78-9236-6499-5

-Mimio Whiteboard converter - Chosen mostly based on price. An electronic whiteboard, of size 4'x4', goes for ~ $2000, which is 4x the price of this tool, which can cover a larger area, and is more user friendly.

VIRTUAL INK MIMIO
Mimio uses infrared and ultrasound sensors to capture pen strokes with pinpoint precision, essentially transforming any flat surface into an electronic whiteboard. It stores everything directly to your PC. $499.00

Mimio is an entirely new approach to collaborative meeting technology. Mimio essentially transforms any flat surface into an electronic whiteboard, to make capturing, managing and sharing ideas easy and affordable. The slim 24" *Mimio* unit attaches to the upper left side of your whiteboard or easel pad and plugs into your PC. Once a sensing unit is slipped over a common dry-erase marker, *Mimio* uses infrared and ultrasound sensors to capture pen strokes with pinpoint precision, storing and displaying data in the PC. *Mimio* software allows users to review, edit, and export captured data directly into a variety of PC applications for projection, review, and transfer anywhere via the Web, fax or e-mail.
Mimio includes everything you need to get started:
MIMIO CAPTURE BAR
24" bar with infrared detectors, microprocessor, serial and interface and five function switches (New Board; Tag Board; Print Board; Maximize Board; Locate Control Panel)
Connects to PC via 10' RS-232 serial cable
SOFTWARE
Record and playback everything you write on your whiteboard or flipchart in 4 colors
Collaborate in real time over the Internet with Microsoft NetMeeting
Data exchange to and from other applications through the Windows clipboard
Supports mimio.INK file format and BMP, JPEG, and HTML file export
Variable standard and custom size boards
Projection display support as a mouse input with Mimio Mouse Software (included)
CONTROL PANEL DECAL

Allows access and control of the function switches from anywhere on the whiteboard or flipchart and includes a calculator function

MARKER JACKETS

4 marker jackets that use stylus tracking technology based on ultrasonic and infrared transmitters
4 standard dry-erase markers
1.5V AAA batteries included

ERASER

Combines 4" and 1" circular eraser that uses Stylus tracking technology (battery included)

Minimum System Requirements:

Windows 95 or 98 or NT; 9-pin DB-p serial port; 16 MB of RAM (32 MB recommended); 10 MB of available hard drive space; use of Mimio and Netmeeting requires 166 Mhz Pentium and 32 Mb of RAM and TCP/IP network with support for 32-bit applications

- **Audio Output** Based on the decision to control as much of the process as possible with a personal computer, a computer based surround sound speaker system for the classroom is optimal. One cheap and effective suggestion is this:

Kinyo Dolby Digital Home Theater System
Experience the vivid Dolby Digital theater sound effect with the Kinyo Home Theater System. This compact and powerful system produces the same level of performance as other expensive home theater systems, but at a fraction of the cost.

$224.25

Features:
5.1 Dolby Digital home theater system.
Five full bandwidth satellite speakers plus a dedicated subwoofer.
Signal process unit - Dolby Digital 5.1 (AC-3) decoder with LCD display.
Auto detected encoded mode for Dolby Digital, Pro-Logic and Analog.
Wooden woofer enclosure to enhance solid bass performance.
Magnetically shielded to protect monitor and magnetic media.
One-year product warranty
Audio Input:
SPDIF Coaxial
Optical (Cable not included)
RCA jack
Slim line credit card size remote control
Power On/Off, six point volume level
Control mute
Amplified power output:
Five satellites - 5Watts (RMS) per channel
Subwoofer - 40Watts (RMS)
Drivers:
Five satellite - 3" cone type

Subwoofer - 6 1/2" long throw woofer
Frequency Response:
Satellite - 80 Hz to 20kHz
Subwoofer - 40 Hz to 120 Hz L.F.E
Dimensions:
Satellite - 3 ½" x 5" x 3 ¼"
Subwoofer - 14" x 7 ½" x 12 ¾"
Signal Processing Unit - 2 ¼" x 5 ¼" x 7"

Microphones

Electro-Voice, Inc.
CO2
Miniature Condenser Lavalier Microphone
Price: $210.00

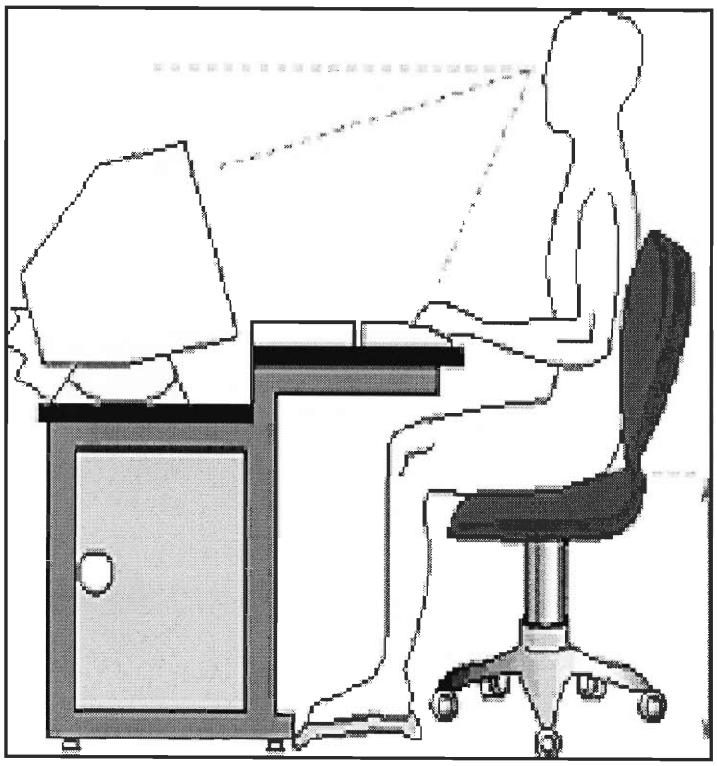
Product Description:
The CO2 is a miniature condenser lavalier microphone. It is designed for broadcast and sound reinforcement applications where acoustic feedback problems are minimal. It provides a full range, well balanced sound character for clean, accurate sound reproduction.

Appendix E – Charts and Figures

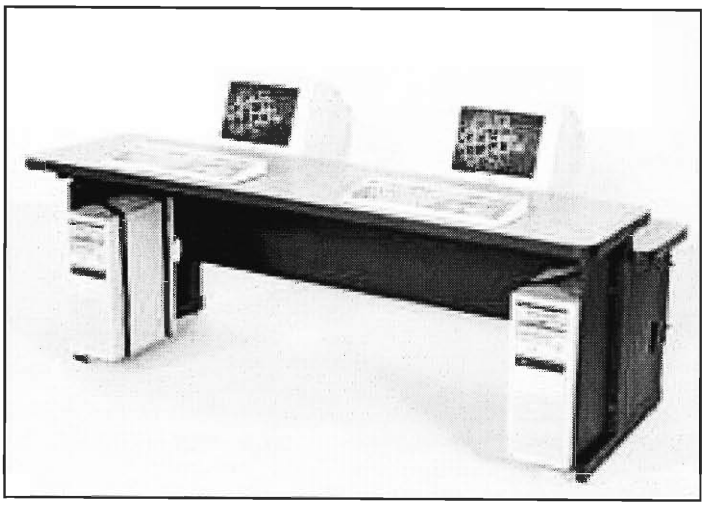
Appendix E-1: Chair Chart

Key Features	Ergonomics, Durability and Safety Issues	Classroom Chair Requirements
Seat Height Adjusts	Ideal upright seating position is achieved with feet flat on the floor and both the angle between back and thigh and the angle at the knee slightly more than 90 degrees.	Lever/Button activated pneumatic cylinder preferred. Quicker adjustment and shock absorption from multiple seating impacts.
Seat Tilt Adjusts	For long periods of use, certain close tasks (WP, DTP, CAD and graphics, etc.) require forward-tilt capabilities to protect the back and neck from undue stress.	Seat-Tilt function is unnecessary for the classroom. For all day seminars, however, the tilt function may be helpful.
Seat Depth Adjusts	Long-term sitting can cut off the circulation to the lower legs if the seat front is too close to the back of the knee. On the other hand, taller users need support under the thighs to relieve some of the pressure on the buttocks.	Back tilts - lever adjustment preferred. It is the most durable and, with proper seat and back design, is adequate to meet the shorter-term needs of the student.
Seat Shape Design	Supports buttocks and thighs. Saddle seat offers support in tilt-forward mode, split seat meets special needs.	Flat, extra-wide (19") seat with waterfall front edge fits the widest variety of body shapes and provides adequate support for classroom applications.
Back Angle Adjusts	Reduces stress on the abdomen and lower back depending on the users preference and needs.	Back tilts with lever adjustment. The hand wheel is not as durable as the lever.
Back Height Adjusts	Supports shoulders and upper middle back as required by certain tasks.	The relatively short duration of the typical class does not require any adjustment.
Back Shape Design	Supports upper torso.	Medium height back slightly concave vertically. Fits the largest number of users and requires no height adjustment.
Seat & Back Tilt	Allows reach-back and leg flex. Rocking motion and tilt enhance blood flow.	Not necessary for computer classroom applications unless training sessions are to last 4 hours or more.
Swivel	Ease of positioning. Reduces twist stress on lower back.	Generally standard on all chairs.
Mobility	Ease of positioning encourages correct posture and posture changes for varying tasks.	Very important that chairs roll smoothly and that casters are correct for floor surface. Caster durability is an issue. Purchase extra casters for repairs.
Stability	Adequate floor contact prevents tipping and injury.	Five-point configuration uses least floor space, prevents tipping even when chair is not occupied but with heavy coat draped over back.
Frame Construction	Prevent structural failure and injury.	Check welds for consistency, plastic components for durability, and total unit for ease of maintenance.
Controls: Construction/ Configuration	Ease of use and access encourages proper adjustment of the task chair and encourages healthy sitting.	Lever/Push Button preferred. Lever tucked under the seat surface to prevent snagging on clothes, book bag, etc. Lever of sufficient strength to endure many daily adjustments. Springs, gaskets, etc. concealed. Control paddle(s) labeled.
Back Construction	Back should give firm support without applying undue pressure to any single area. Back panel should be protected if chair will chafe against furniture behind it.	Plywood substrate with multi-density foam padding and PVC back shell. Plywood permits ease of reupholstery. PVC shell protects back and provides a snag-free surface.
Back Attachment To Frame	Should provide stable support with little or no wobble. Some flex, however, is desirable.	Angled metal support in PVC sleeve. No protrusions to snag or injure anything or anyone to the rear of user.
Seat Construction	Seat pan should give firm support without applying undue pressure to any single area. Seat edges should be protected if chair will chafe against furniture behind it. Pan under seat should be easy to maintain and protect mechanism.	Plywood substrate with multi-density foam padding and PVC shell under seat pad. PVC protects the mechanism from vandalism and provides an easier surface from which to remove gum.
Seat Attachment To Frame	Should provide stable support with little or no wobble.	Durability is a major issue. BIFMA Standards are only a minimum requirement, not a gauge of strength.
Arm Rests	Supports shoulders, arms, and wrists. Encourages correct posture.	Adjustable height armrests should be provided if sessions last longer than 2 hours. Should be removable or offer seat width adjustment.

Appendix E-2: Pictures of Products in the Classroom

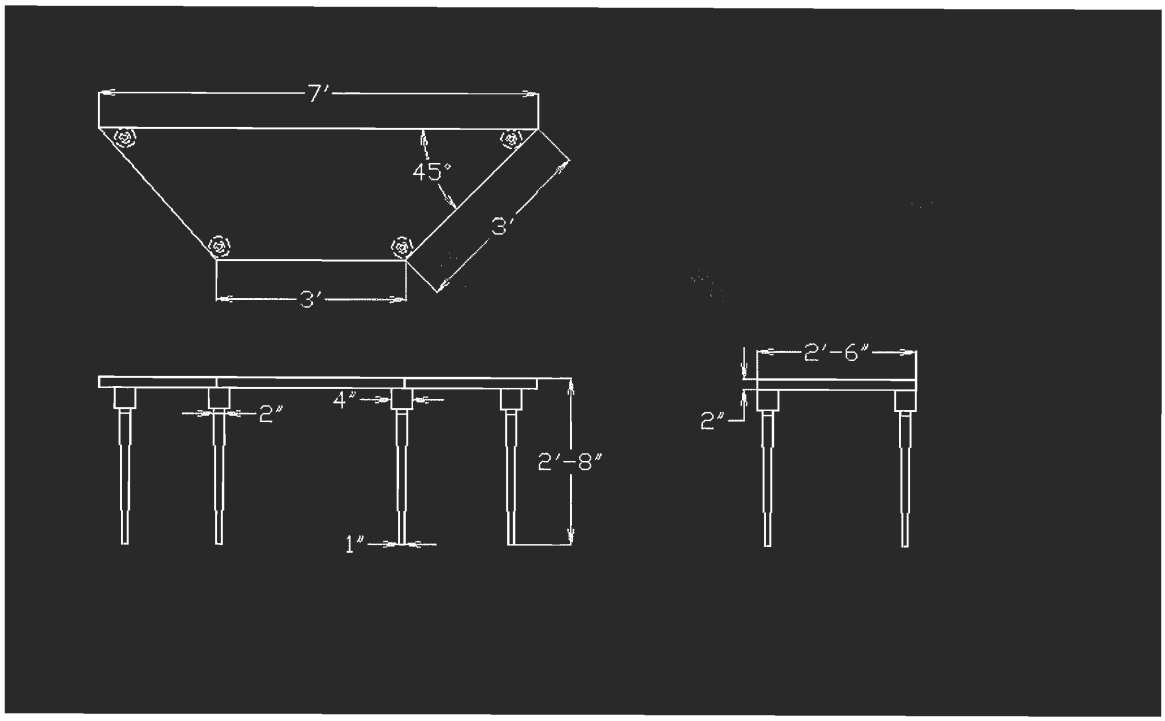


Viewpoint of Split Level Desk



Split Level Desk

Instructor Computer Desk



Layout of Trapezoidal Table

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