This Isn’t Your Father’s Computer Lab: Computer Labs Redefined

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ABSTRACT
The College of Engineering at Colorado State University supports 20 computer labs, but only three qualify as the “traditional computer lab” model, with the number of available seats as the selling point. Our computer lab offerings have primarily shifted to electronic classrooms, meeting rooms, virtual labs, and collaborative design spaces based on evolving feedback from students and faculty. We promote group work spaces such as our Engineering Design Studios, a diverse offering of meeting rooms, multi-purpose spaces and electronic classrooms with a computer at each desk for interactive coursework. The curriculum emphasizes group work, and our technology services team works to support the curriculum by providing students with spaces that facilitate collaboration. Web-based virtual computer labs allow students to connect from virtually anywhere. Smart cards, thin clients and virtual desktops allow portable sessions. Audiovisual technology is prevalent and accessible. Our instructional needs require these types of evolving spaces, which blend instruction, course work and social interactions.

Categories and Subject Descriptors
K.3.1 [Computers and Education]: Computer Uses in Education – Computer-assisted instruction (CAI), Collaborative learning, Distance learning.
K.4.3 [Computers and Society]: Organizational Impacts – Computer-supported collaborative work.

General Terms
Design, Human Factors

Keywords
Computer Lab, Computer Laboratory, Computer Classroom, Electronic Classroom, Design Studio, Studio Classroom, Internet Café, Technology Suite, Virtual Lab, Collaboration

1. INTRODUCTION

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The focus on computer labs in higher education has shifted from a traditional, well-understood model to more flexible models to accommodate diverse needs from all users. Students and faculty need flexibility of physical spaces and technical capabilities. All users of the computer lab environment can be accommodated with foresight of design and flexible operating tactics.

1.1 Institutional Background
The IT environment, including the computer labs, at Colorado State University (CSU) operates under a highly decentralized model. Central IT groups serve the university’s basic and overarching academic IT needs, such as Internet backbone and course management software, while each college, department and administrative unit provides more detailed IT needs as appropriate to its constituency.

The College of Engineering at CSU has 2348 enrolled students and 109 faculty, approximately 10% of CSU’s student population. Engineering Network Services (ENS) supplies academic and business IT services to the College of Engineering only. ENS has 9 permanent full-time staff and about 25-30 part-time student employees. The ENS Labs Team includes one staff Computer Lab Manager and 10 student employees.

Even within the College of Engineering, some departments support their own computer labs. There are 20 facilities directly managed by the ENS Labs Team and under the oversight of the Computer Lab Manager. There are 7 other departmental computer labs managed by individual departments, or jointly managed by the department and by ENS. Altogether, there are about 425 computer seats in all of these labs.

Other computer labs exist at CSU, but we focus here on the computer labs within the College of Engineering.

2. WHAT IS A COMPUTER LAB?
The widest definition of a computer lab is a room which contains many networked computers for public use [1]. (The “public”, in this case, are the students and faculty of the Engineering College.) For a university, a better definition would be “at least two similar computers located in an area primarily used by many students to complete course work” [2]. Characteristics of computer labs include computers shared by many users, the availability of academic software packages to each user, and the philosophy of providing a general computing resource to university students.

For our college, the definition has evolved over time just as the physical spaces and the uses they have been put to have evolved. We now consider our computer labs to include what has typically been regarded as classrooms, meeting rooms, video conference rooms, hands-on instructional labs, and even virtual computing resources. This expanded definition can be summed up as this: A computer lab is a space whose primary purpose is to support the
In our environment, unlike many, we have deliberately chosen not to segregate this type of higher-end technology, and instead have it integrated with the other computer labs. Plotters are located in one of our largest lab spaces, the Lockheed Martin Magellan Design Studio, and one of our computer classrooms. Color printers and scanners are distributed evenly through our highest-use labs.

2.2.3 Computer Classrooms

A computer classroom, also called an “electronic classroom” or “smart classroom”, is set up as a typical instructor-led presentation room and has a personal computer at each desk. One more projection systems are available in this room, along with white or chalk boards, or electronic interactive white boards.

A classroom with a single computer, or computers that are only for instructor use, is not considered a computer classroom.

A distinct sub-type of the computer classroom is the instructional or teaching lab. Instructional labs are organized so that instructors can maneuver easily about the room to direct or observe student activity at the computers. The room is used primarily for hands-on instruction, such as “lab” course sections that coincide with lecture sections, and are often smaller than a normal computer classroom. Frequently these labs are available for general purpose use when not reserved for a class section.

Computer classrooms provide a level of student engagement far beyond a simple classroom, with the addition of audio/video technology, classroom response systems (“clickers”), video conferencing, and computers at each desk. These technologies make students interact in real time with the instructor, providing valuable feedback to the instructor and enriching the students’ learning experience.

The Engineering faculty, and the students, have expressed a pedagogical need for classrooms specifically equipped with computers for instruction. Computer classrooms of this nature are not generally available at CSU, and software licensing issues would prevent them from having all of the necessary software. While computer-based classroom instruction has been available in the College since the 1980s, both with mainframe terminals and UNIX workstations, the first desktop computer-based Engineering computer classroom opened in 1999. As of 2011, there are five computer classrooms in Engineering, and two more planned for 2012, demonstrating their success.

2.2.4 Design Studio

The design for the College of Engineering’s main Design Studio computer lab comes from Lockheed Martin’s Spacecraft Technology Center [5]. Essentially, an individual design studio consists of six computer seats around the periphery of the room or cubicle, a central conference table, a projector and a projection screen or interactive white board. The computers are set on large desks which have a large amount of surface area for study materials, and typically have large wide screen or dual monitors.

The individual design studios are modular and one room can hold several Design Studios. In the College of Engineering, the Lockheed Martin Magellan Design Studios contains six design studios, and the Lockheed Martin Orion Design Studios contains four. Each design studio is available to be reserved by a group or small class.

The design studios are immensely popular with the students. They are versatile: Design teams or study groups can use the space, and without any special setup, it is ready for the next group or
individuals. Individuals can use the computers while study groups use the table and/or the projection system. One disadvantage of the design studios is that they are less space efficient than a traditional computer lab.

2.2.5 Studio Classroom
The studio classroom is a specialized type of computer lab within the College of Engineering. Larger than a design studio but smaller than a computer classroom, it is a hybrid between the two concepts. Six or more (typically up to 20) computer seats are available at the periphery of the room, while a large conference table is in the center of the room. A projection system and optionally an audio system are present in the room. Other specialized audio/visual equipment, such as teleconference or video conference equipment may be present as well.

The studio classroom model lends well to smaller classes (such as graduate-level classes), lab sections of a course, or large study groups.

2.2.6 Meeting Room and Lounge
Computer-enabled meeting rooms are often placed inside or adjacent to a general purpose computer lab, and serviced by the same staff that support the computer lab. In our situation, there are three meeting rooms and one large study lounge, all of which contain at least one computer of the same configuration as the others in the nearby computer labs.

The meeting rooms can be reserved for group work or study, and contain a projection system. They provide a quiet work space in the midst of the computer lab environment. Meeting rooms can be a separate room or as simple as a separate space within a computer lab defined by fabric partitions.

Lounges are popular with students, and we have one lounge populated with a small number of thin client computers, and furniture that can be easily arranged into a configuration comfortable for a group of any size. This provides a transitional environment from a full computer lab to a non-computer recreational space. Other lounges across campus frequently feature a computer kiosk so that students and visitors alike can use a computer for brief tasks.

There are fewer lounges and study rooms in Engineering now. Thanks to the more versatile and social nature of the other lab spaces, there is a reduced need for dedicated casual spaces like lounges. Also, most other lab spaces (design studios, studio classrooms and computer classrooms) can be used as meeting rooms.

2.2.7 Virtual Computer Lab
A virtual computer lab is a computing resource which is connected via another computing device, and which has the same or similar software resources as a physical computer lab. The virtual computing resource may be a physical machine in a remote location, such as a server in a server room, or a true virtual appliance which runs software. It may be accessed via a web browser, via a specialized connection program, or by a remote communications protocol such as RDP.

The advantages of a virtual computer lab are that it does not take up a physical facility, and it can be accessed from a variety of computing devices (including mobile computing devices). In some cases, a virtual computer lab may be used as a supplement to a physical computer lab, but in general it is used in place of the same.

The Engineering “Virtual Lab” came online in 2002, providing remote access via a web interface to servers which had lab software installed. This student-funded initiative was intended to supplement access to lab software to off-campus students. The Virtual Lab uses technology from Citrix to provide a remote desktop experience to web users, or to “publish” an application [6]. Users may also connect from a desktop application rather than through a web interface. On the back end, a “farm” of servers, identically provisioned with software, provide the desktop, software and computing power for the users. The Citrix technology works to balance the load between servers, so that users requesting a connection are routed to the server with the least load.

The Virtual Lab continues today, and is used widely: by off-campus from their own computers, by students on campus from their laptops, and even from graduate students working from their on-campus office computers. Use of the Virtual Lab drastically changes where, when and how a student can access their course software, providing students much more control over their computer lab experience.

Although very successful, some significant challenges remain for the Virtual Lab. Because many graduate students are provided computers with insufficient computing power by their home department, they use the Virtual Lab as a means to gain that computing power. This puts a strain on the computing infrastructure of the Virtual Lab. Also, faculty have seen the Virtual Lab as a resource to be put to use for distance learning, presenting some logistical and support challenges for ENS staff, as well as unfunded capacity on this student-funded computing resource.

3. OPERATIONS

3.1 Purpose
Quite clearly, the primary purpose of a computer lab is to provide general computing resources for students. More specifically, the purpose of a computer lab is defined by its type and roles (see above). A design studio’s purposes, for example, include providing a space for group work combined with computers to access their course work software. A key philosophy of the Engineering computer labs is that each lab provides more than one purpose. For example, a computer classroom’s primary purpose may be for classes mediated by an instructor, but when classes are not in session, the room may be used as group work space, meeting space, or individual computer work space.

The Engineering course curriculum is typically very technical, requiring the use of technology, especially computer software, for maximum instructional impact and to complete assignments. The curriculum also heavily emphasizes group project work, and in their senior year, each Engineering student is part of a Senior Design Team, which completes and presents a unique final project. The Senior Design Teams especially use the design studios extensively for their group work.

3.2 Funding
The college administration provides minimal funding for the computer labs. The college’s funding contribution is limited to the physical space the lab occupies and non-computing features such as furniture. The Computer Lab Manager’s salary is paid for out of central college funding.

All technology within the computer labs is funded by the Engineering Charge for Technology. This charge is separate from
the University Technology Fee (which is applied to all CSU students) and is applied only to Engineering majors. As a result, the Engineering computer labs have a disproportionately high level of technology when compared to many other university colleges or departments, which the curriculum requires. The Engineering Student Technology Committee (ESTC), comprised of 75% students and 25% faculty, administers the funds raised from this charge. Approximately 40% of these funds are used to fund the computer lab equipment and wages for student computer lab support personnel.

3.3 Level of Technical Service
Another key philosophy of the Engineering computer labs is that of self-service or self-sufficiency. It is accepted by faculty that Engineering students already have a familiarity with the computing systems in place in the computer labs, and basic computer training is not offered by the college. Instruction in individual engineering discipline software is given in classroom sessions (either lecture or lab) by faculty or graduate teaching assistants, not by ENS. Indeed, ENS employees most often know little about the operation of the software they support. (See section 4.2, Software.)

Audio/visual equipment in the computer classrooms is matched as closely as possible with university-standard “smart” classrooms, in terms of both equipment and operation. Written instructions are posted at each lectern or specialized audio/visual device in each computer lab, and operation of this equipment is offered to instructors on an individual basis as needed.

Signage is an important part of providing self-service to the computer labs. The contact information for the ENS Help Desk is posted prominently in key locations in each lab. Operating instructions for audio/visual and specialized equipment is posted clearly. Lab policies and alternate lab locations and hours are posted in each lab. Care must be taken to maintain the balance of providing enough important information via signs without contributing to visual clutter.

The ENS web site [7] includes a wealth of knowledge about operating the computer lab equipment, the computers and the software. The web site URL is posted prominently in all major signage. An ENS staff member presents an overview of the college’s computing resources annually to some Engineering Freshmen orientation classes. (Unfortunately, this is inconsistent as it has not been incorporated into the Engineering curriculum.) ENS staff also offer a graduate computing seminar twice per year.

3.3.1 Personnel
Notably absent from the Engineering computer labs is a help desk located in the labs themselves. Instead, ENS has a central Help Desk at its main office. An auxiliary Help Desk is located in the Academic Village residence hall (inside the program space which includes computer labs) but is staffed only at peak hours by Help Desk workers. The rationale for not staffing computer labs with personnel is twofold: The number of computer labs supported by ENS (20) and the widespread distribution of the computer labs across campus would necessitate several help desks and result in mostly idle student workers. This distributed help desk model was used in the Engineering computer labs until 2006, when the central ENS Help Desk was created.

Since there is no help desk or consultant station in the labs, when an ENS worker is in the lab, he or she wears a clearly identifiable name tag, so that a user can approach him or her with problems or questions. Otherwise, users call, email or walk to the ENS Help Desk for support with the computer lab equipment.

3.3.2 Faculty Involvement
Faculty are highly involved with the computer labs in Engineering. It is the faculty who decide what software will be installed each year to the lab computers. The ESTC, which is composed of about 25% faculty, determines how student Charges for Technology funds are spent, in the computer labs and elsewhere in the college. Engineering faculty drive the computer lab pedagogical needs, such as the design studios and group project work.

The college administration even uses the technology in the computer labs as recruitment tools for students and faculty.

3.4 Reservations
Most of the computer lab spaces, from meeting rooms to classrooms, can be reserved at any time for any reason (with some limitations, described below) by any Engineering student, faculty or staff member. The reservations are accomplished by a self-service web-based system. Reservations do not have to be approved, but are monitored by ENS for conflicts or other special needs. It is not necessary to provide a rationale for a room reservation; however, class sessions are given first priority. The university’s classroom scheduling office does not schedule classes for the Engineering computer classrooms, so it is up to the individual departments or instructors to ensure that their classes are scheduled appropriately.

Limits to computer lab reservations have been imposed by the ESTC to ensure that no one group can unfairly dominate the times for the labs. Classrooms may only be reserved for up to 15 weeks at a time, to ensure that study groups do not take up class time slots for a subsequent semester, and the other labs may be reserved for up to 6 weeks at a time, to allow each group an equal chance at access in popular labs and time slots.

4. TECHNICAL FEATURES

4.1 Computers
Three types of computers are present in the computer labs: Workstation computers, personal computers, and thin clients. In addition, the labs are available for other computing resources.

Approximately half of the computer seats throughout the Engineering computer labs are workstation computers. These are personal computers which have advanced computing power and graphics, similar to what would be found in a technology suite [see section 2.2.2, Technology Suite]. Unlike a university computer lab which serves a broad audience, the Engineering curriculum requires a large number of computationally expensive software packages (see section 4.2, Software), which in turn require more advanced hardware.

A small number of computers, termed “projection PCs”, are present in some of the classroom lecterns, when required to interface with specialized presentation equipment such as interactive white boards. These projection PCs are connected to remote computing resources (see below).

Approximately the other half of the computer seats are thin clients [3]. Thin clients provide a portable, server-based desktop session via a combination of smart cards and Citrix technology to users. The Academic Village residence hall provides thin clients in each residence, which means a user can initiate a desktop session on the thin client in their room, and take that same session (with
applications that continue to run uninterrupted) to any other thin client at CSU. It’s even possible to connect to that session from any computer with a web browser. This ultimate session portability provides students with great flexibility: Wherever they choose to reconnect to their session becomes their computer lab.

Instructors particularly like thin clients in a classroom setting. Whereas 30 personal computers in a computer classroom may have inconsistently installed or configured software, 30 thin client seats are guaranteed to have identical software. Also, the zero noise factor associated with thin clients allows for less audible distraction in a classroom setting.

A common feature of all computers in the labs is the accessibility of external ports for users, such as USB ports for USB flash drives and headphone jacks. While providing this type of feature has long been viewed as optional, more and more students consider this an essential feature of a computer lab, due to the ubiquity of portable file storage.

The computer labs are mobile device-friendly. Video cables are provided at each lectern, in meeting rooms and at other projection sites so that users may use their own device on the room’s video (and if available, audio) system. Wireless Internet access is provided in each computer lab, so that users with laptops and other mobile devices have connectivity. Wired data ports and electrical outlets are provided in the classrooms, for students with laptops. It is not uncommon to see students using their own laptop in a computer lab and connecting to the Engineering Virtual Lab.

### 4.2 Software

A normal university computer lab serves a broad audience and has limited specialized software, instead staying to the basic software such as office productivity software, a graphics manipulation package, and web authoring tools. The Engineering curriculum requires a broad array of discipline-specific software packages, and many computationally expensive software packages.

One of the characteristics of the Engineering computer labs is that the same software packages are available on every computer in every lab. Thus, it is not necessary to go to a particular lab to use a specific software package. This results in tremendous advantages for students, in that they can use a computer in any lab and be guaranteed a consistent software experience. Faculty benefit for the same reason, plus it allows instructors to teach from the most convenient location for them, and in some cases, present the same computer-supported class to two different locations with assistance from video conference technologies in the computer classrooms (see section 4.4, Video Conferencing).

### 4.3 Projection Systems

As a method to show information to a group, projectors are heavily utilized in the computer labs. In many labs, a user has the choice of projection from the supplied computer, or their own laptop or mobile device.

Projection surfaces are either electric screens which drop in front of white boards, or interactive white boards which are permanently mounted. Interactive white boards are used in 15 computer labs, and because they require special software, are directly connected to a Windows computer.

Interactive white boards are very popular with instructors and students. These devices are used in many schools as replacements for white boards, and display a computer desktop, often paired with presentation software such as Microsoft PowerPoint [8]. The white boards in use in the Engineering computer labs have productivity software which allow, among other features, taking notes directly into PowerPoint presentations and annotating presentations, drawings and screen capture.

### 4.4 Video Conferencing

Several Engineering computer classrooms and studio classrooms support video conference technologies. The primary supported video conference technology is the Access Grid [9], an open source project. The Engineering computer classrooms have dedicated equipment to manage the Access Grid software, which supports group-to-group interactions only. Three of the Engineering classrooms are equipped with Access Grid technology, which allows for triple the number of students that could potentially interact in one combined virtual classroom.

The Access Grid, and other video conference solutions of this scale, requires a dedicated, trained operator during the video conference or class. Due to staffing limitations, ENS does not provide the operator for each class or conference, but will train an operator. This coincides with the spirit of self-service for the Engineering computer labs.

Personal video conference technologies used by computer lab users, such as Skype, Google Talk and Apple iChat, are unrestricted but not specifically supported by ENS staff. No lecture recording capability exists in the Engineering computer labs at this time, but the computer classrooms have the potential for this.

### 4.5 “Smart” Lecterns

Following the Colorado State University classroom standard, Engineering computer classrooms are equipped with “smart” lecterns, in which all of the audio/visual equipment is routed through an audio/visual control system and video switcher. The interface is accomplished via a programmable touch panel, which is located on the top of the lectern. The programming conforms to the university standard, so that instructors can feel comfortable moving from an Engineering computer classroom to a university general assignment classroom. Use of the touch panel for universal equipment control prevents confusion with multiple controls for multiple equipment systems, and there are no remote controls to become misplaced.

Wireless microphone systems are used in the computer classrooms, with the control systems inside the lectern.

### 4.6 Printers and Peripherals

In feedback from students, printers have been one of the most desired features of the labs. The distribution and feature sets of the printers are key. Printers are dispersed throughout the computer labs, at a minimum one to each lab or adjacent lab area, with 24 printers and plotters total. Printer models range from high-volume, large workgroup printers to small workgroup printers, depending on their recorded usage. All computer lab printers are networked and tied into the college’s print quota system. Lab printers are monitored by the HP Web Jetadmin software [10], and alerts are sent via email so that the labs team can respond quickly to printer issues. Printers are maintained by the Student Lab Assistants, part of whose core functions are to stock and ensure the smooth operation of the printers.

Large format plotters are located in two major areas and are used much less frequently than the other printers. Because plotting can be technically challenging and each plot uses up a large amount of a user’s print quota, users are asked to consult with one of the ENS employees before attempting to plot, but are not restricted
from plotting on their own. Written instructions for plotting are provided on the ENS web site, as well.

Scanners are provided in two distinct types: Network scanners and computer-connected desktop scanners. Network scanners in use are the HP Digital Sender models [11]. Users can scan documents on the digital sender’s flatbed or ADF feeder, and scanned documents are sent to a user’s email address in PDF format. The network scanners do not require a connected computer to operate, which makes them extremely advantageous particularly in labs which contain only thin client devices, which cannot support a scanner natively.

A small number of desktop scanners are available, located in the larger computer labs. Previously, a larger number of desktop scanners had been dispersed throughout the labs, but were ineffective for the casual scanner user because other users would “park” on a scanner-enabled computer for hours at a time. As a result, a limited number of “scanning stations” are now present in the labs. The scanners are connected to a basic personal computer, which contains only scanning software and is not connected to a network, which discourages a user from using it for any purpose than scanning and image manipulation.

5. CHALLENGES

5.1 Funding for Non-Computing Features

As mentioned previously, funding for the technology in the computer labs is provided by a charge for technology. However, by charter this charge cannot be used to fund items or projects which are outside the definition of technology equipment (and the labor to support it). As a result, features such as furniture and chairs, fabric partitions, carpet and associated cleaning, lighting, heating and cooling, and other facility-related features must be funded elsewhere. In every survey of college computer labs, “ergonomic chairs” are cited by students as one of the most desired features not currently seen in the computer labs.

In these times of leaner funding for higher education, such features are viewed as “luxuries” and are not funded. Even in better times, these features have been funded by either gift funds or special projects rather than central college funding. A limited amount of charge for Technology funds are allowed to be used for furniture to support the computing equipment -- certainly not enough to keep these items on a regular replacement cycle. It is unlikely that this situation will change.

5.2 Food and Drink

One of the most universal signs posted in computer labs is noticeably lacking in the Engineering computer labs: “Food and Drink Prohibited”. In fact, a “No Food or Drink” policy was in place in the Engineering computer labs until 2010. Before this time, this was the most enforced policy and the one that created the most friction between users and lab support staff. The college had been too successful in its goal of creating a computer lab space that students desired to spend time in, and Engineering students spent a disproportionate amount of the time in the computer labs, and naturally desired to refresh themselves. Because the labs were open 24/7, and the computer labs were not staffed outside normal business hours, the policy was impossible to enforce at most times of the day. Adding to the problem was that certain labs did allow food and drink consumption (and in fact encouraged it, in the case of the Internet Café), while others disallowed it.

The compromise for allowing food and drink in the computer labs was to provide more funding for Student Lab Assistant wages, so that they could devote more time to cleaning. Signage was changed to inform users that food and drink was allowed, and to exert them to clean up after themselves. In the time since the policy was changed to allow food and drink, no complaints have been received about the cleanliness of the computer labs. The students are noticeably responsible with their food and drink consumption, and the Student Lab Assistants are diligent in their cleaning.

5.3 Vandalism and Misuse

Very few acts of vandalism, or breakage of equipment, have taken place in the history of the Engineering computer labs. In part, this is due to diligent security efforts (including security cameras), but credit also goes to the users of the computer labs themselves, who maintain a stewardship mentality of the computer labs and typically treat the facilities with respect. Notably, the number of anti-ENS sign defacing has decreased to almost zero since the food and drink policy was changed (see section 5.2., Food and Drink).

Misuse of the computer lab equipment is always going to be a factor when serving students, no matter how responsible the majority are. In most cases, the misuse amounts to students unplugging audio/visual equipment or changing it to a different configuration. Normally the reason for this is unknown, but it’s suspected that when help desk support is unavailable after hours and a projection system operation is not working (or not perceived as working) correctly, the user ingeniously devises a temporary solution which involves changing the cabling. This of course prevents correct operation for the next user. The solution for this, in most cases, is to hide or lock down the cabling so it is not accessible to the user.

5.4 Visiting Faculty

It is especially challenging to provide support for visiting faculty such as a guest lecturer or an instructor from another college. Because the visiting faculty member generally does not have an Engineering computer account, which is used for all computing access, one must be obtained for them and other access issues, such as swipe card access to the facilities, initiated. These operations may take extra time because they must be coordinated with other support entities. Typically, the visiting faculty do not seek this access before their first class, because they are unfamiliar with the Engineering computer labs and IT systems and do not realize there is a need for Engineering-specific access. This challenges the labs support staff, which are staffed primarily with regard to regular maintenance rather than immediate response.

6. HIGHLIGHTED LAB FACILITIES

6.1 Magellan Design Studios

The Lockheed Martin Magellan Design Studios consists of a 3700 square feet room subdivided by fabric partitions into six design studios. Each studio contains six workstation computers with wide screen or dual monitors, a conference table, a projector and an interactive white board. A wide central corridor opens into entrances to most of the studios, and houses the printers and plotters. There are three entrances to the room: The main entrance opens to the building hallway, another connects to the Lockheed Martin Stardust Studio Classroom, and another connects to the Lockheed Martin Viking Electronic Classroom.
6.1.1 Purpose and Layout

The original purpose for the creation of the Magellan Design Studios, created in 1999, was to provide group work space and computing power for inter-disciplinary student design teams [12]. Incorporated into the design were casual meeting areas and lounges, in response to students’ concerns about the intense work and the need for study breaks. This was and remains a room dominated by the student personality: Flexible, containing as much technology as they can consume, and a space that allows for social interactions.

Figure 1. Original layout of Magellan Design Studio.

Originally, the room had seven studios, two lounges, two conference areas, and a help desk. (See Figure 1.) Over time, the needs and desires of the students changed and they were the driving force to split the room, carving out a computer classroom and a studio classroom, and reducing the number of studios from eight (they had previously added one) to six, and removing the casual areas. (See Figure 2.)

Figure 2. Current layout of Magellan Design Studio and Stardust Studio Classroom.

The current use of this lab is the same as the original, mostly design teams. The lab has traditionally been the most popular computer lab: even though computer seats were available in other labs (with the exact same computers), students would be witnessed to wait in line to use a computer in the Magellan lab.

6.2 Viking Electronic Classroom

The Viking classroom is the most popular of its kind. It connects directly to the Magellan Design Studios, but the main entrance is via the building hallway. The classroom consists of 34 computer seats, three projectors, two wide projector screens, an interactive white board, an audio system, hanging microphones, a wireless microphone system, a “smart” lectern, an Access Grid-enabled video conference system, and a printer. The projection system is a dual system: An instructor can project with the thin client in the lectern to one or both side screens, which allow an unobstructed view from any point in the classroom, or to the middle screen (the interactive white board) with the personal computer in the lectern. Other projection sources include an instructor-supplied laptop, a DVD/VCR player, and a digital document projector.

The computers at each seat are thin clients, so there is no noise from 34 workstations interfering with a presentation. The technology in the room is modern, versatile and powerful, accommodating every role that could be desired in a computer lab. Part of the room’s popularity can be attributed to the location; it is next to the Magellan Design Studio, the most popular computer lab, which in turn is located in the main Engineering building, close to most Engineering students’ classes and faculty offices.

The room has its challenges, as well. It was retrofitted from an existing, larger room and contains features such as support pillars that are poor for video conference uses. Because of its prime location next to the popular computer lab, students frequently use it as a “pass-through” location between the hallway and the Magellan lab, sometimes even when an instructor is presenting! Because it is often used by visiting faculty, it incurs more support calls due to the visiting faculty member’s inexperience with thin client technology and the access issues mentioned earlier, which also results in the door being left propped open for convenience of the instructor and not closed properly after class. Because it serves literally every purpose of a computer lab, the technology can be a bit overwhelming to a new user of the instructional portion of the room.

6.3 Internet Café

This very popular computer lab was conceived and designed by Engineering students to provide a social atmosphere for food and drink with casual computer use and meeting space [12]. The room has several design elements, including a computer “bar” complete with bar stools, a computer bench and tables with recessed computer monitors, and a separate meeting room with a projection system. (See Figure 3 for the layout.) This lab houses 25 thin clients and one personal computer (in the meeting room), two printers, and a network scanner.

Figure 3. Internet Café layout.

It was originally conceived to be the one food-friendly computer lab in the college, and so contains vending machines and a food vendor area. While the need for a separate computer lab where food and drink is allowed has disappeared with the new food-
friendly policy, this remains a popular computer lab. Its popularity can be attributed to its casual atmosphere, flexible seating (it’s one of the three “generic” computer labs in our classification), and prime location on the first floor of the Engineering building. The room was designed with a 1950s theme, complete with neon clocks, bar stools and a working 1950s-era telephone.

The food vendor area has rarely been utilized to its full extent. Originally, an outside vendor was contracted to provide a coffee bar, but the vendor did not realize financial success. Small wonder, as it was in a restricted access room, competing with the Student Center’s several similar venues next door! Since it was built, the Internet Café was only able to sustain a vendor for a few months, despite active recruiting efforts. The vendor area is used occasionally for special events held in the Café, but largely sits unused.

The Internet Café has proved to be one of the most popular computer labs, and remains virtually unchanged from its original design in 2002.

6.4 Academic Village
The Academic Village is a “living and learning community” residence hall concept which opened in Fall 2007. The College of Engineering partnered with CSU Housing and Dining Services to provide classroom and programming space in the Academic Village residence hall. Currently, the Engineering College maintains two classrooms, two meeting rooms, four design studios, a server room and an auxiliary help desk at the Academic Village. All computer seats in the Academic Village are thin clients, with the exception of some personal computers to support interactive white boards where they are available.

The computer lab facilities at the Academic Village have been very popular with the residents, thanks to their proximity and the fact that each resident has a thin client in their room, which allows a resident to carry a portable computer session from one thin client to another, anywhere on campus. Despite the high level of technology in the Academic Village, these computer labs have not been a draw for other Engineering students, likely due to the location across campus from the other Engineering resources.

7. FUTURE DIRECTIONS
7.1 Pervasive Computing
Weiser spoke in 1988 [13] of an era of ubiquitous computing, also called pervasive computing, which has yet to come to pass. The core idea of pervasive computing is that the actual computer is invisible to the user and yet the user can use its technologies everywhere. Portable desktop sessions, application publishing and virtualization, and the ubiquity of mobile devices (and the fantastic growth of their computing capabilities) seem to indicate that this era is close. The next generation of university students will have grown up, figuratively speaking, with a smart phone in hand and an interactive screen in every room. They will expect to have computing resources delivered to them at any time, without delay. The traditional computer lab model is as antiquated to them as the mainframe model is to computer users today.

7.1.1 Accommodating Mobile Devices
Mobile devices, mentioned above, are becoming more powerful and extensible. One limiting factor of laptops and other mobile devices is the graphics capability; software specific to the engineering disciplines, such as 3-D Computer Aided Design, Geographic Information Systems, and fluid or mechanical simulation software all require enhanced graphics capabilities that even low- to mid-range personal computers struggle to properly render. At some point mobile device graphics capability may catch up to the point where the graphics are at least “good enough” for students to use.

Even now, students use mobile devices to accomplish everyday computing tasks, and there is little reason to differentiate a laptop, a tablet or a smart phone, when providing access to a server-based software resource. It makes sense to accommodate these mobile devices because it reduces the demand for physical seats in a computer lab, which are always at a premium. ENS supports expanding access to the Virtual Lab to users of mobile devices (while acknowledging a dependence on vendor-supported tools to enable this use).

7.1.2 Continue Thin Clients
The use of thin clients in the Engineering College has expanded to six times its initial deployment from 2000. Given the low cost factor[cite Mark’s paper] of thin clients versus desktop computers, it is likely that further expansion of computer labs will feature thin clients. ENS is in the process of evaluating a replacement thin client infrastructure. Depending on the results of the evaluation, in particular the cost effectiveness of providing the same level of service and the ability to transport a session between a thin client and a user’s own mobile device, existing workstation computer seats may even be replaced by thin clients.

7.1.3 Virtualization
The Engineering College has been slow to embrace virtualization, for practical reasons. (The benefits of server virtualization have been evaluated and found mostly lacking for this specific environment.) However, the college has reached a turning point where it makes practical sense to migrate many server-based services to virtual machines. Desktop virtualization has been utilized in the college’s computer labs to a limited degree, and further use may be pursued, though for lab computers dependent on compute power it may not make practical sense.

7.2 New Facility
The Engineering College plans to open a new 122,000 square foot building, planned to open in 2013, which will include computer and non-computer classrooms, design studios, teaching laboratories, and research laboratories. It is expected that the lines between computer labs and classrooms, and between computer labs and teaching labs will continue to blur. The roles of the computer labs will be seen throughout diverse facilities and the challenge will be to help provide the services to students and faculty that computer labs have traditionally filled.

8. REFERENCES
[5] [http://www. engr.colostate.edu/news/index.cfm?id=111](http://www. engr.colostate.edu/news/index.cfm?id=111)


