External University Facilities Survey

How to do what we do better based upon the best practices at other institutions.

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In my travels to other universities, I have discovered that, while other schools may possess innovative and creative ways to create, run and maintain their labs, they likewise share some of the same problems. This report is intended to outline some of the areas in which other schools excel at being at the forefront as well as demonstrating where there may be hidden opportunities for our own excellence. While my list of candidate schools is certainly not comprehensive, I believe they represent some of the best that we compete against. Over the years, I feel it would be beneficial to continue to survey other institutions as a way of not only gauging our own progress, but also as a way of of builindg goodwill and recognition between universities. In the end, the real winners through this whole process will ultimately be the students.

The two schools I visited were Carnegie Mellon in Pittsburgh, Pennsylvania and Rensselaer Polytechnic Institute in Troy, New York. Both schools are peers of CWRU in the area of electrical engineering and computer science and it may be argued that, in some areas at least, they are slightly superior. Like CWRU, both schools have unique advantages. As my visits determined, though, we share many of the same problems. These problems, though, are not insurmountable, provided that there is enough attention, enthusiasm and institutional support. For example, CMU as a whole manages a robust and comprehensive set of computing clusters and is able to attract a lot of corporate attention and donations. RPI, on the other hand, has innovative "studio" teaching labs. CWRU, I believe, has a great diversity in lab resources considering the program sizes and provides comparable levels of technical support. What we all share to some degree is a lack of funding resources to keep these labs and facilities operational and relevant.

Another fact learned from this investigation was that there exist no concrete methodologies or set of best practices, whether it is from school to school or even from department to department within the same school. In many ways, we all both benefit and suffer through our independence from any central computing authority. What one department finds works for them is often completely different from any other. However, in every regard, each department made things work and always tried to provide some level of support and maintenance. However, each department's experience did allow me to gather a few "general guidelines" that I believe may be useful in helping to make our own facilities better.

Finally, in the area of facilities support, I believe that this is one area in which we in EECS benefit from our merger . Possessing one cohesive technical staff upon which all facilities are created and maintained helps a lot to both reduce costs and provide to better levels of continuity and support.

Carnegie Mellon University: Department of Electrical and Computer Engineering

Highlights:

- Significant lab donations or price breaks in the past from Intel, AMD, Sun, and HP/Agilent
- Maintain network and computer services for 2200 machines in different buildings with a full-time technical staff of only 13.
- Excellent customer service and support with turnaround times often less than 24 hours.
- Technical staff with experience and knowledge rivaling most others.
- Computers replaced on a 3 to 5 year period.
- Email based help system is the same one we use (RT2)
- Research machines (including faculty and staff office machines) are supported through a "pay as you go" system.

Carnegie Mellon's ECE department creates and maintains their facilities in an enviable manner. They manage to provide excellent customer service while at the same time managing thousands of machines.

The main computing facilities consist of at seven main laboratories as well as smaller laboratories designed to support courses that are more specialized. The main computing facility is open to all students and consists of 30 Sun Sunblade 100 workstations with 256 MB of RAM, most with LCD flat panel displays. These run software to support many of the architecture based courses in the department. This software includes programs such as Matlab, Verilog and Cadence. The lab is also reservable for classes. There is also a lab monitor workstation available where a student laboratory assistant may help manage the lab.

Other labs in the department are used primarily to teach introductory circuits based courses. As with all of the other major teaching labs, each lab is meant to handle 30 workstations. All of these PCs are Intel/AMD based. Each workstation is set up to allow for two persons per group. These workstations also include a complement of HP / Agilent test equipment. More specialized labs support topics such as introductory MEMS courses and FGPA design.

The technical staff tries to maintain a 3-year computing cycle. By doing this, they attempt to make sure the computing hardware is useful and relevant. Test equipment is used until it becomes obsolete, which takes significantly longer. The prevailing estimate is anywhere from 7 to 10 years, which is in line with our own numbers.

The source funding for these labs comes primarily via line item in the department's budget. However, a significant amount of deals and donations help to defray the much of the cost of the equipment. For example, Intel has been a primary supporter of many of the labs. However, since Sun also wants to have a visible presence, they play Intel off on Sun, causing Sun to cut drastically their prices. Fortunately for them, AMD has now gotten into the fray and realizes that Intel is largely represented and that they are not. Hence, AMD has started donating hardware as well. Finally, in the past, HP and Agilent were major supporters of the lab in the are of test equipment. However the technical staff is not counting on any future equipment donations from in the near to mid-term future due to the economic uncertainty within the company. We are also in the same situation.

Therefore, in many cases, the department will be facing some of the same problems we are in terms of expensive test equipment. On the other hand, they seem fortunate to have the lines of communication necessary to help fund the computing side of the laboratories, which are just as expensive since equipment needs to be replaced more often. However, even still, they maintain a budget to maintain their central networking services (which they run autonomously), servers (mail, print, file storage, Active Directory) and other lab workstations.

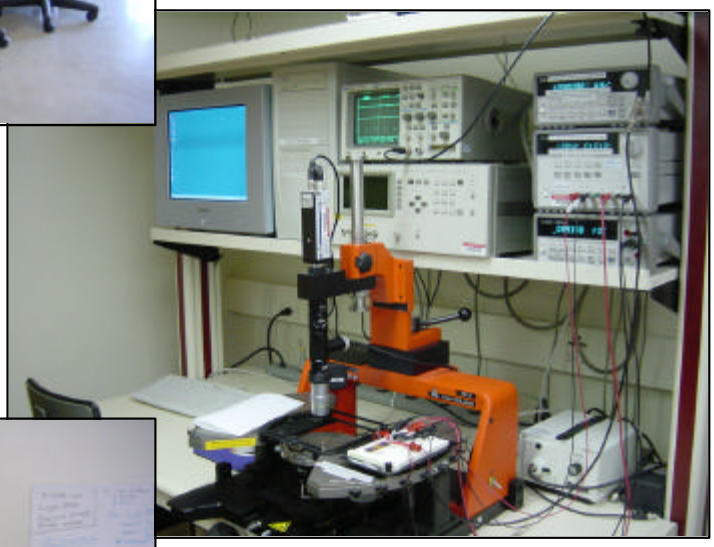
In all, there are 13 full-time technical staff members maintaining 2200 machines amongst approximately eight buildings. While this works out to a staff to computer ration of approximately 1 to 170, one could argue that they can not only take advantage of vast quantities of scale, but are also fortunate to have an extremely skilled and experienced staff (one of whom actually helped deploy much of the fiber running CWRUnet today). This skill and experience level among technical staff is something that we ourselves are slowly developing over time.

One final point of interest involves their website. Formerly they, like us, had students and graduate students working on it in a piece-meal fashion. However, recently they created a staff of three web developers whom not only take care of the web page, but also take care of a lot of the other public relations and marketing activities for the department. Their website contains such features as online graduate applications, their own course evaluation system, and undergraduate primer. Their goal was stated as trying to make the system, "as paperless as possible."

In all, while it recognized that CMU ECE is the exception instead of the rule, it is certainly a situation in which we should at least strive for. While we do not have quite the same number of students as they do, we can at least take into consideration the trying to foster a sense of competition between vendors as well as having a line item budget to cover core services, servers and networking hardware.

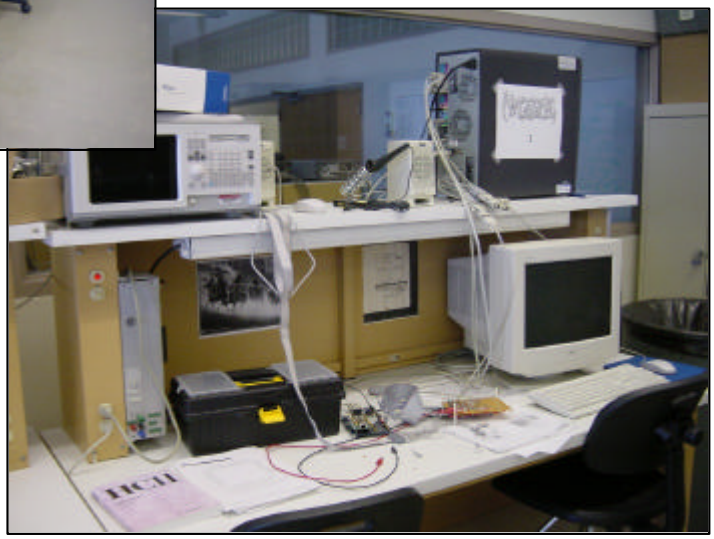
A view of some of the introductory circuits lab workstations.

The undergraduate MEMS lab has four workstations include high power microscopes and test equipment



Another circuits based lab contains similar equipment, but also includes other more advanced test equipment.

Embedded design and FPGA work is done with the help of Agilent logic analyzers and a Dell PCs



Carnegie Mellon University: Department of Computer Science

Highlights:

- Most computing clusters in the department are actually run and maintained by the university's central computing services group.
- They maintain four department computing classrooms each with 25 Apple workstations running OSX. Two of these rooms can be turned into two larger classrooms, if needed.
- Computers replaced every 3 years
- Graduate students are given a computer upon acceptance and attendance to the University
- A full-time staff of 47 supports 1400 to 1500 research, faculty and graduate student PCs. This equates to an approximate ratio of 1 person to each 32 computers.
- Research machines (including faculty and staff office machines) are supported through a "pay as you go" system.

The CMU Computer Science department is in many regards quite different from the ECE department. First and foremost, there are few department-supported facilities. In all, the department supports four classrooms each with 25 new iMacs running OSX. These can be combined to create two 50 computer classrooms should the need arise. These machines are maintained and purchased by the department. Curiously enough, these classrooms somewhat resemble the RPI studios I mention later on. The layout of these classrooms allow for a more intimate teaching environment and more in class hands-on student-teacher interaction.

All of the other computing clusters in the department, totaling another 100 computers or so, are fully maintained by a central campus computing service that is supported by the Provost's office. There is no direct expenditure by the department for the purchase, support or maintenance of these labs. The university supported cluster machines are maintained by one individual, which is reasonable since there is a great deal of homogeneity between computers in the cluster. The cluster includes both high-end Windows based PCs running Windows and Sun based Unix workstations.

All clusters and teaching labs are reservable should an instructor need one for his or her class. During off hours, they are open labs and students may come in to use them. When I was there, all of the labs and facilities were in heavy use.

One of the more unique concepts the computer science department supports is making

sure that each incoming graduate student has his or own workstation. This workstation is a standard commodity PC with standard software. This then becomes "their" workstation to do with as they please throughout their graduate career. The rationale behind this is that they are not dependent upon the availability of any particular computer in a cluster and can have more freedom in their studies and how they use the PC. These PCs are purchased through department funds.

I cannot address the computer science department at CMU without also mentioning their impressive support infrastructures. A faculty member may opt to have their computer or computers (including their graduate student/researcher machines) supported either by a central computing services group or through the department for a low monthly per computer fee. Central campus computing support is general in nature and intended to support mostly undergraduates and large scale computing clusters. The departmental support infrastructure exists to provide more specialized support and faster turnaround times. The system is designed to be self-supportive in that the amount of money brought in by subscription fees covers all of the costs. This allows the group the ability to expand and contract staff and resources as necessary to fill demand.

The cost per month per machine is currently $91. This figure changes depending upon overall support costs and is billed on a quarterly basis against a faculty member's accounts. The entire account system is a complex process, but there are simpler ways to do something similar here at CWRU. This supports grants users the following privileges:

- Hardware and software repair and problem resolution
- Software licensing for site-licensed software
- Full network backups if desired
- Networking

The group supports Windows, Linux and many flavors of Unix. If a faculty member has a problem with a machine and it is due to a fault in some software or hardware problem and that problem could be traced to an application or piece of hardware supported by the group, then it is taken care. However, if a problem arises from a piece of software that is user-installed, support for that application is limited. Obviously, the list of available and supported software is quite lengthy in order to provide a meaningful set of tools to work with. The technical staff also maintains administrative ownership of the machines in the event that they need to work on it.

Support is <u>not</u> mandated. Faculty members may opt out of support if they wish. However, should a problem arise, they are solely responisble for addressing the problem. The intent of the system is to improve overall the quality and availability of computing systems to faculty.

One final topic I discussed involved a laptop program they they piloted for undergraduate students. Each student was required to have a laptop and asked to bring it to their various CS classes. Instructors were then supposed to incorporate this new capability into their courses. After one year, though, they regarded the program a failure. They attributed this to three interrelated factors. The first was that students rarely brought the laptops to classes using them. The second was simply that, when they did, the laptop was not very necessary in enabling them to helping them get work done during class. Finally, the laptops were not integrated well enough into existing classes and were not used by enough classes to create a "critical mass" necessary to make it mandatory that all students actually brought their laptops. If found this an interesting situation which can be contrasted against RPI's laptop program which I will discuss later.

The availability of electronic learning classrooms as well as the outstanding and differing level of support provided makes the CMU CS department something to work towards, even if it is on a smaller scale. The increased support for research machines of both faculty and graduate students an especially intriguing idea, provided that the necessary resources are available to support such an endeavor.

Rensselaer Polytechnic Institute: Department of Electrical, Computer and Systems Engineering

Highlights:

- Many courses taught in "studio" classrooms, complete with computers, test equipment and laptop hookups that has benefits to both education and support, as necessary.
- Maintain many other computer and engineering labs in non-studio format
- Computers replaced when needed, most often on a 3 year cycle
- All incoming students are required to have laptops.

I traveled to Rensselaer at the suggestion of Frank Merat. In retrospect, it was an excellent idea. One specific reason I decided to examine it was because of a teaching classroom concept he called "theater in the round". This involves arranging students and lab equipment in a manner that allows instructors to present material at the beginning of class and allow students to perform the requisite lab portion in the same class period with the instructor and TAs present. After the labs are done, students can then talk about the results with the instructor and do a wrap-up.

While the studio classroom concept is intriguing, other qualities about the ECSE program at RPI are also interesting. Aside from the studio labs, there are other, more specialized labs catering to the more diverse interests of engineering. Many of them do not have appropriate counterparts here in EECS due to the differences in curriculum and scope. However, in all of these labs, funding is almost always an issue. The department works towards finding creative solutions to manage their funding difficulties. However, when something needs to get done in a lab, a faculty member usually takes initiative to see that the lab is outfitted properly.

While the focus of my work was on aspects relating to facilities management and user support, I did pose questions regarding the studio labs that in some ways transcend these goals in an effort to get a picture of the "why" in addition to the "what" and "how". Studio labs at RPI are structured the way they are for one clear reason: students are able to learn in them better because there is more course continuity and fewer interruptions to the learning process. Material is expressed faster and more clearly and at the same time allows students to retain the materail better. However, the other component usually found in this "better and faster," triad is "cheaper". Unfortunately, there is nothing cheap about implementing such a classroom, but it is worth considering that the potential benefits may outweigh the downsides and deserve discussion.

In the example photograph on the next page, the structure of one of these studio type classrooms becomes clearer. In this particular studio, which happens to be the largest, there are room for about 35 workstations, each able to accommodate 2 students per station. The class calls adding sensors to a robotic car and programming it to move autonomously around a track, akin to what is done in the autonomous robotics lab on the 8th floor of Olin (although I believe they have less complicated goals). The instructor stands at the podium towards the center of one end of the classroom. From there, he or she is able to talk to the entire class and present prepared PowerPoint presentations or overheads to LCD panels located near each student workstation. The tiered structure of the room as well as its ovular shape helps to make sure that when the presenter is at the center of the room, they are no further than 20 feet from any student.

Other, smaller, studio labs contain 20 computer workstations complete with a complement of test equipment and are use to teach introductory electrical engineering concepts, including circuits. Each workstation, again, is designed for 2 students per group. The instructor workstations include the same equipment, but also include multiple laptop hookups, two digital overhead projectors, and four LCD projectors with screens. Since the rooms are much wider than they are deep, it is necessary and beneficial to have presentations sometimes "simulcast" to an LCD screen on each side of the lab.

Most of the technical design work for the construction of the labs was done in house. Since RPI benefits from strong industrial and lighting engineering departments, they were fortunate enough to be able to make use of those resources. However, the general contracting was done by outside sources.

One thing struck me regarding each of the studio labs that I felt remarkable enough to mention to ECSE chair Ken Connor: lighting. The lighting in each of the studios was different, but I felt a sense of calm when sitting in each them. Ken mentioned that it was curious I should mention it, since all of the lighting designs for the lab were done by the lighting engineers at RPI. I commented on how I found it interesting that something as simple as the right type of lighting could have such a profound impact. When one looks back at the lighting situations in our labs here at CWRU, industrial fluorescent lighting is the norm. While creative lighting in and of itself is certainly not a panacea to better learning, it is something that ought to be considered in future laboratory and classroom designs. A photo montage of some of the studio labs is located on the next page.

In my final thoughts regarding the studio labs I feel compelled to mention that the studios in general felt aesthetically "right", whatever that may mean. They seemed well laid out, accessible and conducive to learning. Students I spoke too gave a lot of positive feedback about them. Faculty, too, generally approved of the design. Obviously not all courses are best taught in this type of environment, but many do lend themselves to this approach.

In terms of support, a small but dedicated technical staff tries to maintain not only all lab machines, but also faculty and staff machines. The technical staff also makes heavy use of student assistants but, like us, other technicians assist in the support of other studio and non-studio facilities. I could not, unfortunately, find a way to determine an accurate computer to support technician count. However, I estimate that there is approximately the same number of technicians to computers as we have here at CWRU.

In general, most of the computers in the studio labs tend to be changed out on a three-year cycle. However, there are some exceptions where the computers are much older. In one particular lab, the computers were very old first generation Pentiums. However, as the instructor

told me, since they do not connect the test equipment to the computers, there is not any real need for computing power. From what I could tell, this is something that he felt would be nice, but something he did not feel was a requirement for his specific class.

Support of the labs in the ECSE department is done primarily through donations and begging. Since faculty work directly with students in the studios, they have first hand knowledge of the quality of the equipment in the room as well as its age, a huge benefit that most other schools cannot claim to that degree. When a faculty member notices that the equipment in the lab is not fulfilling its duty, the general process is that they will then write a proposal to address the situation. This may include soliciting donations from outside organizations or asking for departmental support. When examining the labs, though, I saw that, for the most part, up-to-date and well-kept. Certain faculty and staff members seem to be champions of particular facilities, seeing to it that they are well maintained and equipped.

It should be mentioned that the set up of studios and labs may change in the near future at RPI as more and more incoming students have laptops. For many classes already, they are required to bring them into classes. In certain classes, desktop computers at each station will be removed in favor of wired ports where students can plug in their laptops.

Also of note are the some of the interactive demos devised to help students with their introductory circuits courses. These are often weaved into these classes, which are taught in the studio. Students can work through the demos with the instructor and may also work on them at their individual workstations. Finally, students are given toolboxes and breadboards during this first circuits class which they can then take with them and use throughout the rest of their education.

Therefore, while the RPI ECSE department is strapped financially as well, they manage to maintain and build new facilities that perform well and look good. The studio concept is not new, as they have been doing it at RPI for almost 15 years. Likewise, other schools seem to be implementing, to some degree, this same concept in their own facilities.

One-half of the larger studio lab shows student workstations complete with LCD panels for present materials to appear on

A smaller studio lab holds 20 workstations complete with test equipment

In the front of the room is the instructor's station, complete with four LCD projectors and screens

This instructor station includes a TV to a remote lab, room for multiple laptop hookups, two digital overhead projectors (not shown), as well as touch screen control panel.

Rensselaer Polytechnic Institute: Department of Computer Science

The department of computer science at RPI is certainly a different situation from the ECSE department. While I did not have the opportunity to talk with nearly as many people in CS as I did with ECSE, I did manage to talk to some students and a couple of faculty members that are heavily involved with the department. Overall, the department has basic computing facilities and teaching laboratories. Most of those appear to be funded by private research and grants. This is a situation they indicate should be rectified. I do not anticipate that this would be considered a "best practice" at any institution, as grant rules often prohibit this kind of activity.

Support for computing facilities in the computer science department did not seem to have much rhyme or reason. Likewise, support for machines outside of the scope of the research lab seemed to come from the University level. This is not too surprising considering that many faculty buy into the laptop program as well and are then able to get support for their laptop through the on campus service representatives.

The computing environments in the RPI CS department are almost exclusively Unix based and are supported by both Intel and Sun based hardware. The Unix lab I visited had approximately one dozen Sun Ultra 10 workstations. The PC based lab had a little over 20 workstations in it.

The comment was made that, overall, students do not use labs as much due to the laptop program. However, since the laptops generally run the Windows operating system, the Unix machines are required to enable them to get their coursework done.

Rensselaer Polytechnic Institute in Review

As a whole, the school is an interesting case study. We have a lot to learn from them, and in return, we will have a lot to share in return. Some unique aspects of the university, including the laptop requirement program and the studio classroom, have been latent interests among some CWRU EECS faculty for quite some time. Contrasting this with CMU's laptop experience sheds some light on what direction we should take if we were to consider for such a program.

Conclusion

It feels good to know that the CWRU EECS department is headed in the right direction in regards to not only facilities and teaching labs manager, but also in terms of user support. While we have some definite choices to make regarding equipment maintenance, lab structure and support systems, it is somewhat comforting to know that other schools are facing some of the same challenges as us.

There are three areas, though, that I believe we could really work hard at excelling in to not only provide for better labs and support, but to also increase the overall "high tech" appearance of the department. First, I believe it is imperative that we implement a three-year computer replacement cycle for all teaching laboratories. Second, I think it is important to look at finding ways to share lab costs and responsibilities with either other engineering departments or the school of engineering as a whole. Finally, I think that we should explore further the concept of a studio classroom as a possibility to support some of the courses that are currently taught in the Glennan 308 circuits laboratory.

In order to support these endeavors, I believe we must look at cost sharing between departments for our current facilities. I also believe that we must find the funds within the school to support an overall lab budget. This budget should demonstrate in clear, honest and accurate terms the amount of support needed to sustain the facility. Finally and most importantly, I recommend that we rethink seriously the vital role faculty have in terms of providing contacts that will enable us to solicit donations and/or bargain for better prices on equipment. This is only natural, seeing as they are more likely to have the contacts and relationship networks necessary. Without faculty support and interest, it will be difficult to ensure that the labs stay current. We must also leverage our current corporate relationships and cultivate new ones.

In closing, I think we can look ahead knowing that we have not fallen far behind other "peer" institutions. In fact, in some areas I feel can call ourselves equals and, in a few instances, perhaps superiors. These areas include our technical support infrastructure as well as our ability to offer, on a 24/7 basis, access to many undergraduates using our lab facilities, something these two schools, surprisingly, do not offer largely. I also firmly believe that our diversity in lab content and equipment is impressive relative to our size.

Only through continued hard work and a sensible expectation of yearly funding and donations can we continue to work towards an EECS department that not only looks cutting edge, but delivers on that exciting premise to its' students. My next project is to finalize a working budget for the department lab facilities. Once this has been accomplished, Mehran, our chair will have a solid foundation upon which to facilitate any change necessary to support these goals.

Summary

My survey of these universities shed light on some important aspects of their operations that would be valuable to CWRU to attempt to implement. While not all of them may be immediately feasible or inexpensive, they certainly have merit and deserve careful review and consideration.

- High quality and attractive labs will add to the overall appeal of the lab and support an atmosphere of being "high tech".
- Faculty need to continue working towards finding outside donations, sponsorships and grants essential to complement to these ends. Ongoing maintenance of the facilities is everyone's responsibity. Faculty have the connections and the technical staff does the dirty work!
- While hardware donations may be hard to come by, soliciting software donations may be easier. Again, faculty are critical in this endeavor.
- A consistent policy of replacing computers every 3 years helps to maintain a stable baseline for computing labs needs to be adopted.
- "Recycling" computers from more demanding labs to less demanding labs can cut computer costs by approximately 15% to 20%.
- Providing standard computer configurations for faculty and research computers may allow them to do what they each do best while at the same time providing increased levels of support.
- Restructuring some teaching labs into a more studio like manner may benefit not only the quality of the class, but may also help to identify quality control problems with equipment and software.

References and Resources

http://www.csd.cs.cmu.edu/	CS department at CMU
http://www.ece.cmu.edu/	ECE department at CMU
http://www.ecse.rpi.edu/	ECSE department at RPI
http://www.cieem.rpi.edu/	Interactive circuits demos (URL may be bad)