Innovative Engineering Learning Center: Design Concepts and Outcomes

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ABSTRACT

A new learning center has been designed and implemented based on extensive benchmarking and innovative design concepts. The design focused on computer-facilitated active learning and team-based pedagogies. The design criteria are reviewed and the preliminary outcomes are presented based on student feedback and faculty assessments.

1. INTRODUCTION

The Chemical and Petroleum Engineering Department at the University of Pittsburgh had a need to improve the existing classroom space and established the following design and operational goals for a new learning center:

- Facilitate and promote team-based classroom activities;
- Support computer facilitated classroom exercises consistent with active or collaborative learning pedagogies;
- Ensure good visibility and interactivity between students and the professor, as well as between students;
- Provide a central "hub" for all classes offered by the Department, and;
- Be distinctive so that the students and the faculty would be proud of this unique asset.

The path to achieving these goals started with extensive benchmarking of other universities who were using advanced classroom facilities. While many institutions helped form the database of "best practices", a special thank you is due to Rensselaer Polytechnic Institute (RPI) [5], the Chemical Engineering Department-University of Massachusetts at Amherst [6], and Arizona State University [1]. The willingness of these institutions to share concepts, designs and their experiences was most helpful in the superb outcome for the Learning Center that is described in this paper. The implementation of this unique learning center was made possible through the generous support of Frank L. Mosier, an alumnus of the Department. In appreciation of Mr. Mosier's support and leadership, the Center has been named the Frank Mosier Learning Center.

In addition to the facility design experiences of the other institutions, the positive results from team-based and active learning assessments that were emerging from the National Science Foundation sponsored trials with the Foundation Collation [2, 3] and the experience at RPI [4] dictated that the learning center layout, and the audio/visual & computer systems support these pedagogical strategies.

In the course of benchmarking, several issues became clear "must do" priorities for the new learning center. These included:

- Many computer-facilitated classrooms have become "burdened" with computer monitors. The need for large screens and quality graphics, can quickly lead to the inclusion of large monitors sitting on the top of tables. These monitors become major impediments to good visibility and interactivity in the room. Means to achieve the quality graphic needs and meet the visibility goals was a high priority;
- Many computers in a room can result in substantial background noise from CPU fans. Methods to reduce room background noise needed to be explored;
- Hardware and software maintenance could be substantial for a facility with 30 or more PCs. Means to minimize the level of maintenance effort must be fully explored;
- While the preliminary list of software that the faculty requested was large (around 24 different packages), the software for any class was small (1 to 5 packages). The ability to have customized desktops for each class would be a desirable feature of the computer system;
- Since this was to be a classroom, and not a computer lab, we should minimize the distractions of email, and the Internet (except where desired by the instructor for a specific class).
- The operational needs of the Department dictated that the learning center accommodate 75 students.

Keywords:
team-based activities, collaborative learning, active learning, networking.

2. DESIGN

There were four major components of the learning center implementation: room, furniture, computer systems, and audio/visual equipment. The essential aspects of each component is addressed below:

2.1 THE ROOM

The available space to construct the learning center was dictated by the availability of existing classrooms. Part of the strategy to make the space unique and distinctive was to use tinted glass window walls adjacent to the entrances as shown in Figure 1.

Figure 1: Tinted window wall between the learning center and the hall (used at both entrances)

Other elements of the redesigned room included a raised floor to accommodate the power and computer cabling to the desks and the podium, and reconfiguring the HVAC to meet the aesthetic and operational needs of the learning center. Acoustic panels were added to the ceiling to minimize reverberations.

2.2 FURNITURE

Some of the early decisions in the design of the learning center involved what type of computers to use, how many, what size monitors and how to place the monitors to meet the visibility requirement listed above. While the overall computer system is discussed below, the aspects that relate to the layout of the learning center and the design of the furniture are discussed here, as these considerations had substantial impact on the room layout and the furniture design.

The requirement for good visibility, and specifically no obstructions caused by computer monitors led the design team to consider monitors built into the student tables, with a non-glare glass top. While this approach has been used successfully elsewhere, the additional requirement in the learning center of promoting teamwork made the "monitor in the table" approach unsatisfactory. This was due to the difficulty of having multiple team members peering into the "hole" in the table. Thin screen LCD monitors were considered, and deemed unsatisfactory due to the image and/or color distortion when viewing the monitors at an angle, as in team-based activities. This limitation was overcome when one vendor (AcerView) offered a LCD monitor that has a 160-degree viewing range.

The availability of a thin screen LCD monitor permitted the final design of the student desks, as shown in Figures 2. The desk requirements included:

- Accommodate 5 students (based on the room size and the need to have 2 or 3 person teams);

Figure 2: Student Desk with LCD Monitors

- Host 2 PC Monitors as well as the CPU and peripherals (keyboard, and mouse) and meet the visibility (no obstructed view) requirements;
- Provide writing space, and storage space for the PC peripherals when not in use.

It should be noted that a decision was made to use a commercially available telemetry system from Cybex so that the student CPUs could be remotely located. The Cybex telemetry unit was installed under the student desk. One Cybex unit is required for each PC. This telemetry unit permits the remote location of the CPU and avoided having to find a place for two CPUs at each desk. This remote location approach is discussed fully in the Computer Systems section below. The resultant student desk design fully meets the requirements for visibility, low noise (from computer fans), as well as the facilitation of teamwork and active learning via the PCs. The use of the Cybex system also reduces the space requirements of accommodating 30 PCs in the Learning Center.

The podium had aesthetic and functional requirements. It was designed to compliment the decor of the learning center and to house electronic equipment and the instructors PC; see Figure 3.

Figure 3: Podium Showing Control Stations

The controls on the podium are addressed in the Computer Systems section below.

The finished learning center is shown in Figures 4. Note the effort to "decorate" the room with technical photography highlighting Departmental activities.

Figure 4:Overall view of the Learning Center

2.3   COMPUTER SYSTEMS

The basic computer system consists of 30 student PCs and an instructor PC. All of the PCs use the AcerView F51 LCD monitor as discussed above. All PCs run under the Windows NT operating system. The overall configuration of the student PCs, the instructors PC, the server and the network switch are shown in Figure 5.

The faculty was surveyed for software needs and a suite of software was selected to meet the Department's requirements. There are 24 different software user packages available in the Learning Center. While the full compliment of software is always available on the Instructor's PC, the system was designed to have the desktop of the student PCs customized for each class. This ensures that the software needed by an instructor is available for that class, but other installed software is not on the desktop as a distraction to the students. The desktop can be modified by the system administrator to add, or remove software for all 30 PCs in less than 5 minutes through the Novel Netware on the server.

Management of the customized desktops for each class, as well as logins to the system for students and for faculty are provided through a server that operates under Novell Netware. The following are the major functions provided through Netware:

- Login administration for individual classes, instructor and the system administrator. Note, for most classes there is a generic login for each class. File storage is via individual folders on the server, but not password protected by individual students. For selected classes, where deemed appropriate, each student has an individual login.
- Desktop management by class. Through Netware the system administrator can create an account for a class. Then using ZenWorks, the administrator can add or delete any of the software packages available to the students in that class.

- File accessibility. The full description of the file structure on the PCs and the server is provided below.
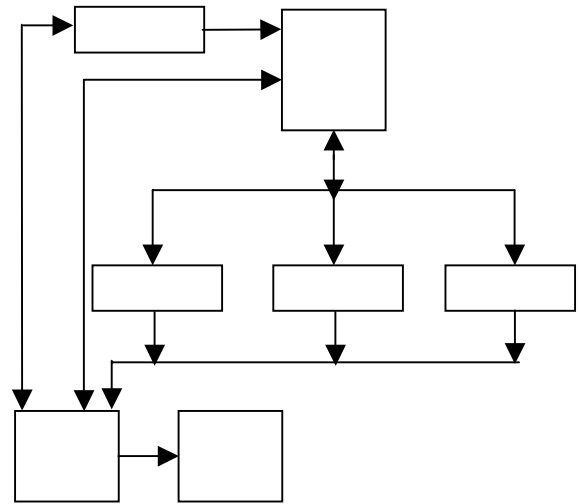- File backups

Figure 5: Configuration of Learning Center PCs and Server

3.   FILE MANAGEMENT SYSTEM

Students can access "template" files that have been placed on the network by the instructor, then save those files to a class account space on the learning center network, then transfer files from the learning center network to their own personal file space on the University of Pittsburgh Unix timesharing system.

3.1   OPENING FILES FROM THE NETWORK

The instructor can install files that are available to students on a read only basis from a class-specific file folder on the server.
The student can load the applicable file into the application (like Excel). Since the file is "Read Only" the students do not have the ability to save files to the location from which the file was opened. If a student tries to save their work to the source file folder, the application will display a "Read Only" designation in the application's title bar.

3.2   SAVING FILES TO THE CLASS ACCOUNT HOME DIRECTORY

After a student has worked with and modified the file provided by the instructor, he or she may want the student to save the file for future use. To do so, the file must be saved to the class account network home directory.

3.3   TRANSFERRING FILES TO YOUR UNIX FILE SPACE

Because the users in a class share the same network home directory, the instructor may want students to transfer their files from the learning center network to their own personal file storage space on the University's Unix timesharing system for safekeeping and/or subsequent work.

Since there are no floppy disk drives in the learning center for the students, these file transfers are done with Ipswitch WS_FTP application through the University LAN. A similar procedure can be used to transfer files into the learning center (homework, etc).

4. REMOTELY POSITIONED COMPUTERS

As noted above, the student computers are not physically located in the learning center. Using the Cybex telemetry, the CPUs are in a separate room, as shown in Figure 6. The decision to use the remote placement of the PCs was based on the concern about fan noise, and to ensure adequate seating and work space for five students at each desk. This approach has also minimized the abuse of the PCs by the multitude of students who use the PCs. The file transfer protocol to the students UINX accounts (discussed above) has worked well.

Figure 6: Overall view of PC Room

5. COMPUTER INTERACTIVITY

From the podium, the instructor can set four modes of display and control of the PCs from the Tech Electronics touch screen panel on the podium as shown in Figure 7:
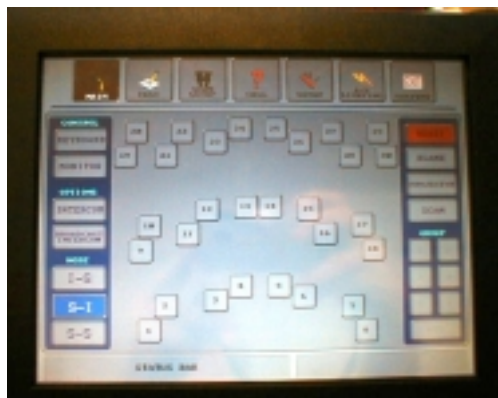

Figure 7: Tech Electronics Touch Screen Controller

- "Stand-Alone", where each PC functions independently through the server and network switch as shown in Figure 5;
- "Instructor-to-Student" where the student's monitors see what is on the instructors PC, and the students have no control of their PC via the keyboard or mouse (Figure 8);

- "Student-to-Instructor" where a student PC is also displayed on the instructors PC (Figure 9). The instructor can optionally take control of that students PC to demonstrate the proper methodology on an assignment;
- "Student-to-Student" where the work on a student's PC is broadcast to the other students' monitors by the instructor's selection of this mode of operation (Figure 10).
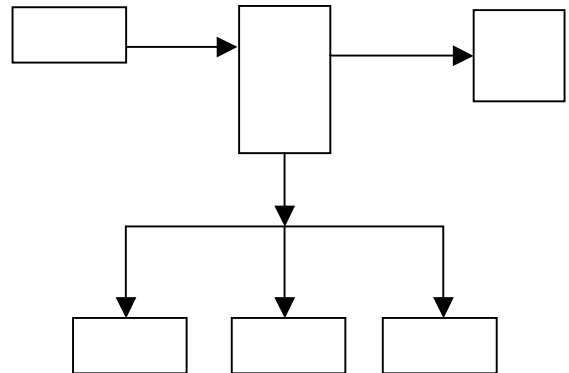

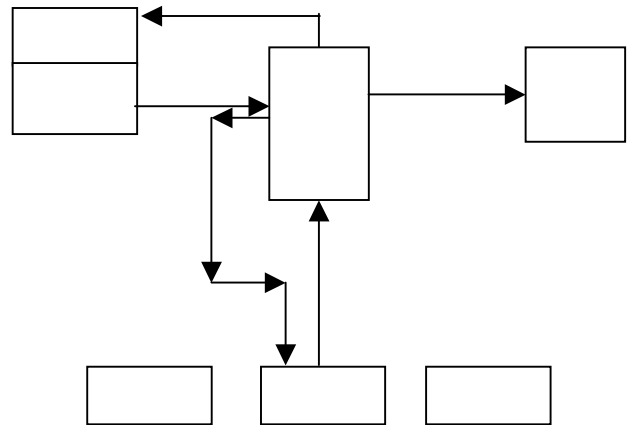Figure 8: Tech Electronics in "Instructor-to-Student" Mode

Figure 9: Tech Electronics in the "Student-to-Instructor" Mode, With Optional Control of Student PC from the Instructors PC
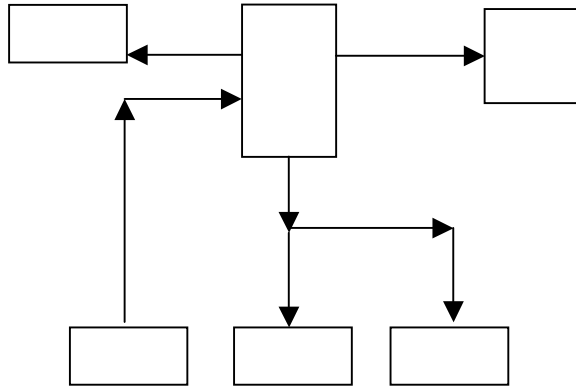
Figure 10: Tech Electronics in the "Student-to-Student" Mode

6. AUDIO/VISUAL SYSTEM:

The control aspects of the audio/visual system are built around a Crestron controller. Using the touch panel controller, the following functions are available to the instructor:

- System Power
- Main Power
- Video Projector
- Lights
- Six lighting circuits are individually controlled for room illumination
- Video Source
- Document Camera
- VCR
- Video Camera
- Computer
- Podium PC
- Portable PC
- Slide Controller
- 35 mm slide controller
- Audio System
- Microphone Volume
- Program Volume (VCR, etc.)

These are state-of-the-art devices and have served the needs of the faculty and students well.

7. IMPLEMENTATION, UTILIZATION AND RECEPTION

Both the students and the faculty have embraced the functional and the aesthetic aspects of the learning center. As note earlier, one of the "cultural" outcomes that we strove for was an improved sense of community and better networking amongst students in the Department. This has clearly been achieved based on the behavior and the feedback of the students.

The faculty have adapted to the new instructional tools and opportunities for modified pedagogies. The learning center has been operational for two semesters. While the rate of change in instructional techniques varies depending on the individual instructor and the nature of the course, essentially all have gone from the old overheads to Power Point for visuals. Examples beyond that mode of conversion include:

- The use of web based lecture notes, which are delivered to each LCD monitor in the learning center, and;
- Full implementation of active learning, such as short lectures, in-class work on a PC based problem that is accessed by the students from the server, and group discussion of the assignment.

The faculty continues to modify and adapt class format to make full use of the capabilities available. Formal assessment of changes in learning and retention will be made based on pre and post-learning center student assessments, but the preliminary qualitative feedback is very positive. Likewise, the faculty feedback has been most positive.

The level of effort to support the advanced technology in the learning center has been minimal. A computer specialist is on contract for one day a week to make upgrades and changes to the computer system. Beyond several minor start-up problems, the overall system has been essentially maintenance free.

8. EARLY OUTCOMES

We have completed two semesters with essentially all of the Departments' classes held in the learning center. While the database is relatively small in terms of quantitative assessment, there are some significant observations and trends that we can report:

1.   The have faculty applied the new computer and audio-visual facilities in the learning center in varying degrees. In classes where there was a substantial transition to cooperative or collaborative learning pedagogy, a review of student evaluations of the instructor showed that on average, the "overall" rating of the instructor increased on average by 15 percent as compared to the prior class without the learning center capabilities. The most dramatic change was in the evaluation category "ability to solve engineering problems" where the average increase was nearly 20 percent. Such a changes are significant when the change was realized in two adjacent semesters. A review of the ratings of the other instructors during this same time interval showed that there was no substantial change in the ratings of the other instructors who used the audio-visual capabilities of the learning center, but did not include cooperative and collaborative learning in their classes.

2.   We have requested student evaluations of the learning center, and these narrative assessments have been positive as well. They also identified some minor adjustments that need to be made, and they have been, or are in process.

9. RECOMMENDATIONS FOR NEW LEARNING CENTER DEVELOPMENTS

Based on the extensive and successful pre-design benchmarking, and the coordination of the design team with the faculty, the learning center has fulfilled all of the identified needs and expectations. If one had the luxury of selecting the dimensions of the room to be used, our preference would be to have a room that was not as wide and deeper, so that the aspect ration would be closer to unity. The learning center is 30 feet deep x 65 feet wide.

Document cameras come in a wide range of resolutions. For optimal performance in an engineering environment, the highest resolution, 3-chip camera might be beneficial, but the cost of approximately $14,000 needs to be carefully considered.

The ability to "broadcast" the instructors notes or slides to all of the student flat-screen monitors with the Tech Electronics system has been so successful that in the design of an additional learning center for the School of Engineering, the design team has eliminated the large screen, high intensity video projectors, so the only "projection screens" will be the student monitors. Also in the new room, the document camera has been replaced with a scanner and an electronic white board.

10. CONCLUSIONS

Each institution will have different functional requirements and budgets that will dictate variations in the approaches outlined herein. However, the authors believe that it is clear that:

1. Cooperative and collaborative learning does improve students' reception to materials presented. Other studies [2,3,4] have clearly shown that these pedagogical techniques also enhance student performance and their ability to apply newly learned skills.

2. The available technology facilitates "active learning", however to realize the benefits, it is necessary that the faculty not be intimidated by new technology, and overcome any reluctance to break typical engineering problems into 10-15 minute "bits"

3. While it is clear that the design of similar facilities at different institutions will vary based on the intended applications and budgets, the underlying design concepts followed here need to be seriously considered for any new classroom that is intended to meet the needs and expectations of today's students and faculty.

REFERENCES:

[1] Bruce Doaks, Arizona State University. Personal communications on the design and application of advanced technology classrooms

[2] R.M Felder. A Longitudinal Study Of Engineering Student Performance and Retention IV. Instructional Methods And Student Responses To Them. Journal of Engineering Education, 84(4),361-367(1995).

[3] R.M. Felder and R. Brent. Cooperative Learning in Technical Courses: Procedures, Pitfalls, and Payoffs. ERIC Document Reproduction Service, ED 377038 (1994).

[4] Maby, E.W. et al. A Studio Format for Innovative Pedagogy in Circuits and Electronics. ASEE/IEEE Frontiers in Education Conference. 4 pp; 1997

[5] Ed Maby, Oliver Holmes, B. Wayne Bequette and Bruce Laplante, Rensselaer Polytechnic Institute. Personal communications on the design and application of advanced technology classrooms.

[6] Michael F. Malone, Chemical Engineering Department-University of Massachusetts at Amherst. Personal communications on the design and application of advanced technology classrooms.