AC 2008-1440: CASE STUDY: A SPACE DESIGNED FOR COOPERATIVE LEARNING WITH MULTIPLE PROCESSES

S. Scott Moor, Indiana University-Purdue University-Fort Wayne

Scott Moor is an Assistant Professor of Engineering and Coordinator of First-Year Engineering at Indiana University Purdue University – Fort Wayne. He received a B.S. and M.S. in Chemical Engineering from M.I.T. After over a decade in industry he returned to academia at the University of California at Berkeley where he received a Ph.D. in Chemical Engineering and an M.A. in Statistics. He is a registered Professional Chemical Engineer in California. His research interests include engineering education with an emphasis on developing and testing educational materials and learning spaces that stimulate serious play.

Case Study: A Space Designed for Cooperative Learning with Multiple Processes

Abstract

The importance of cooperative and active approaches to classroom learning has long been recognized. However most of our resources, textbooks, curriculum structures and learning spaces are not designed with these pedagogies in mind. Many instructors have developed their own materials and figured out how to conduct an engaged, active and cooperative class in any setting.

While these approaches can be used in any classroom, there are distinct advantages to having learning spaces designed with these pedagogies in mind. From their first entrance into the room, such spaces help students know that rather than sitting back and listening, they will be actively engaged in learning. Such spaces can help faculty who use cooperative learning to work more easily and efficiently with a wide range of processes. In addition, specially designed spaces may encourage some faculty to try cooperative learning for the first time. Buckminster Fuller once noted “Reform the environment; stop trying to reform the people. They will reform themselves if the environment is right.”

This case study describes such a space designed for collaborative classes. The space was designed for using multiple modes of instruction and for moving a class quickly from one mode of learning to another. The facility allows for quick small group activities, simple laboratory experiments, computer work and simulation, and mini-lectures. It was particularly designed with the needs of our first-year program in mind.

The space was renovated from a 30 by 24 foot Computer Engineering laboratory. The renovated space consists of four clusters designed to seat six students each. One wall of the room has a laboratory bench and storage. Each cluster consists of a fixed trapezoidal center for computers and services. On three sides of this central core are three trapezoidal tables where students work. Two computers are included in each core with their monitors on support arms allowing easy movement. Computer connections are accessible at the desktop. In addition, each cluster includes electric power, water and compressed air. Students break into groups of three for computer work, and can break into groups of two, three, four or six for other activities. When not in use for formal classes, students use it as an informal learning space.

Use of the room for classes has just begun. We are currently assessing the basic configuration of this space. Student surveys, room observation and instructor interviews are planned as components of this assessment.

Initial indications are that the room is well liked in spite of some early technical glitches. Students, particularly groups, regularly choose this room for study. They often choose this facility over the computer laboratory next door. Learning spaces, like this one, that facilitate alternative pedagogies are greatly needed. The basic configuration and concepts used in this

design could easily be extended to other facilities. The design could be scaled up to a larger room with more clusters.

Introduction

A wide range of education literature discusses the importance of inductive, cooperative and active learning approaches in the classroom. In the review article, "The Future of Engineering Education Part 2. Teaching Methods that Work," Felder, et al. present seven methods that engineering instructors should use. Three of these are 1) Establish the relevance of course material and teach inductively, 2) Promote Active Learning in the Classroom and 3) Use Cooperative Learning.[1] Repeatedly studies have encouraged and shown the benefits of these basic approaches. Inductive learning, where the instruction works from a particular problem to build up to the generalities as opposed to the traditional approach of working the other way around, includes various problem based learning approaches and learning cycles such as the Kolb cycle or VANITH's legacy cycle.[2-4] The benefits of various forms of active learning, where students become engaged in the material beyond simply taking notes, have shown many positive benefits.[5] Cooperative learning where students work together on structured activities as teams either in class or out of class has been shown by a range of literature to be quite effective.[6]

These approaches can all be used in a traditional classroom to increase the effectiveness of instruction. However, in many cases the classroom can make such approaches harder or easier. Some classrooms separate students and can make cooperative approaches difficult. Other classrooms have limited desk space for activities that might require such room. Often the classrooms have been designed for a purpose completely different from the current use.[7] North[8] describes a case, all to common in higher education, where the quality classrooms versus the quality of meeting rooms indicates we value meetings more than classes. A classroom designed with active and cooperative learning approaches in mind can encourage and facilitate their use and display our commitment to the educational process.

In 1986, Chickering and Gamson, with support from a range of colleagues and organizations published the "Seven Principles for Good Practice in Undergraduate Education".[9] They stated that

Good practice in undergraduate education:

1. *encourages contact between students and faculty,*
2. *develops reciprocity and cooperation among students,*
3. *encourages active learning,*
4. *gives prompt feed back,*
5. *emphasizes time on task,*
6. *encourages high expectations, and,*
7. *respects diverse talents and ways of learning.*

Theses principles encourage a classroom that is more interactive than a traditional lecture. Such a a classroom would include cooperative learning exercises that have students working together, includes interaction between the faculty and the student and uses diverse approaches to learning. In addition, setting up a classroom capable of handling varied modes of instruction can help instructors address the issue that our students come with varied learning styles and need variation in how we present material to cover all the students we see.[10-12]

Often students and/or faculty resist the change to something other than traditional lecture. When students enter a traditional classroom with rows of chairs often they are most prepared to sit back and passively listen to a lecture. In such an environment students may resist active and cooperative approaches in the classroom. A redesigned learning space can communicate to students from the onset that this class is going to be active.

Traditional lectures were the way many faculty learned and is a comfortable mode that does not demand too much of the students. Buckminster Fuller noted "Reform the environment; stop trying to reform the people. They will reform themselves if the environment is right."[13] One option for encouraging greater use of the seven principles is to transform our classrooms so that they more easily accommodate these approaches. Ten years after the Seven Principles were published Chickering and Ehrmann[14] noted that we could use "technology as a lever" to help implement these principles. The large-scale technology of the learning space itself can be one such lever.

Examples of Alternative Learning Spaces

Different groups are starting to transform some learning spaces to accommodate more cooperative and active learning approaches.[15]

A prime example of using redesigned space to enhance learning is the SCALE-UP project (Student Centered Activities for Large Enrolment Undergraduate Programs).[16] While this project has broader interests, its initial focus has been introductory physics. It is a joint project of a number of universities. They have combined the traditional introductory physics lecture and laboratory into a single setting. The setting is a large room with no "front", nine-foot diameter tables that accommodate three teams of three students each. This approach makes use of laptop computers and simple portable experiments. There are projection screens on all walls so students in any position can see a screen. The instructor's base station is in the middle of the room. They have found "In comparisons to traditional instruction we have seen significantly increased conceptual understanding, improved attitudes, successful problem solving, and higher success rates, particularly for females and minorities." [17]

Wallenberg Hall at Stanford University is an example of a more general purpose classroom design. Wallenberg has several different classrooms and informal learning spaces that are used by a wide range of disciplines. The classrooms emphasize the availability of flexible furniture, flexible computer facilities including student laptops, multiple projection computers, write-on computer screens and software for allowing collaboration on the computer. Each classroom has several Huddleboards™, lightweight portable white boards, for student activities[18]. In addition there are informal learning spaces available in the building.[19]

The Flyspaces at the North Carolina State University are an interesting example of a cooperative out-of-class learning space. These are small spaces for student groups to work. They include large flat surface to work on, lots of whiteboard space, two computers, a large shared screen, and laptop network connections. They are designed to allow student groups a place to collaborate and can be scheduled by any group through a web based reservation system. They are meant to be flexible rooms where students decide their use.[20, 21]

The Studio in the Learning-Teaching Center at the University of Dayton is a flexible teaching space designed for cooperative learning. The 30 foot by 30 foot space is designed for 24 students. It features flexible furniture, and a pleasant environment. Particularly notable is the use of portable whiteboards that can be hung from a ceiling grid throughout the room. These boards provide writing space for working student groups and a means for providing some separation between groups.[22, 23]

For many years Rensselear Polytechnic Institute (RPI) has experimented with several variations on the studio classroom for cooperative learning. In one recent version, two to six students sit at "tulip-shaped" cluster (the table has two pedals like a side view of a couple of petals of a tulip blossom). The room contains eight such clusters. The clusters have two monitors under a glassed top table that are connected to the same computer. Students can easily interact with each other and also have good sight lines to the front and to the rest of the classroom.[23]

Goals of the Learning Space

The facility described here was designed

- to provide for multiple modes of education in the same space with a particular emphasis on active and cooperative modes,
- to encourage students to identify with our program and develop an attachment to the engineering department space,
- to be a showcase for our program, and
- to provide a 24/7 informal learning space when not being used by classes. (The room access control to accomplish this 24/7 goal is not yet implemented.)

Multimodal Education: This room was designed to provide a space which allows seamless movement between lecture, problem-based learning, simple laboratory work, simulation and group exercises. We were seeking a physical environment that would:

a. encourage and facilitate the greater use of hands-on/minds-on and collaborative forms of learning by instructors.
b. encourage interaction between students and the faculty
c. encourage reciprocity and cooperation between students
d. prepare students for a different type of leaning by the look of the room when they first enter.

The first item in this list is the key goal of this room design, a room that was designed from the ground up with active and cooperative learning approaches in mind. The next two are directly from the Chickering and Gamson's "Good Practices in Undergraduate Education" and are related to the first. It was hoped that the room would allow this greater engagement by students with each other, with the instructor and with the material.

The likely function of a space is suggested by the "substances (glass, steel, wood) and surfaces (tables, walls, floors)" present when the student enters the room.[22] This suggestion effects student preparation by informing their attitudes and expectations of what they will be doing. It is desired that this room, by its look, would prepare students for an active and cooperative classroom experience.

Attachment: This room is part of an effort to increase students' sense of identification with the engineering program via experiencing some attachment to the place and by having a place where they come in regular contact with students and faculty in the engineering program. Graetz and Goliber[22] note "As people live and work in physical settings, they may develop a strong connection to a particular location that goes beyond simple preference." As a largely commuter campus students do not easily connect to the college or program. We wanted to aid their connection to the program through the places where they study engineering.

This classroom and a renovated computer workshop classroom[24], located next door to it, are the location for all first-year engineering classes and they are adjacent to the faculty office suite for engineering. Both rooms are available as open compute laboratories when not being used by a class. We attempt to schedule classes so it is rare that both rooms are booked at the same time.

Showcase: An additional goal is that this facility would be a showcase that would display some of the strength of our program. As a regional branch campus of a large state university it is easy for our program to be viewed as a derivative of the main campus program. It was desired that visiting students (tours, outreach …) will have a positive impression of the strength and uniqueness of our program and that continuing students will have pride in their program.

The Learning Space Design

An existing 24 x 30 foot room was converted into this new learning space. Figure 1 shows the floor plan for this new facility and Figure 2 shows two picture of the room. The central feature of the room are four work clusters designed to accommodate six students each with the possibility of squeezing one extra student in each cluster if needed. Each cluster has a center trapezoidal service island surrounded by three standard trapezoidal tables for student work. The trapezoidal tables are generally in the configuration show in Figure 1 but can be rearranged as needed for different classroom activities.

Each cluster has two computers in the central service island. The computer monitors are on articulated arms so that they can be easily repositioned. Computer USB, sound and serial ports are brought up to a patch panel at the desk top for easy use. Standard 110 volt power is also available at the desktop. On the front side of the clusters are hot water, cold water, compressed air and drainage available for conducting simple experiments. The center trapezoid is necessarily fixed to accommodate these services. In the front of the classroom are master shut-off switches for the water and compressed air.

The electrical circuits are all GFCI protected and the USB connections at the desk top go through a USB hub external to the computer as a protection against shorting out the computers internal

USB circuitry. Low-power computer-based electrical instrumentation (voltmeter, oscilloscope, signal analyzer, and power supply/waveform generator) are currently being developed for use in this facility. The water and drain were included in part to make the classroom work with classroom process control kits that have been developed.[25] These are flow systems where the water would flow from the sink to the small scale self-contained kit and then back to the drain. The kits were developed for process control but also have the possibility of being used for a number of fluid mechanics experiments.

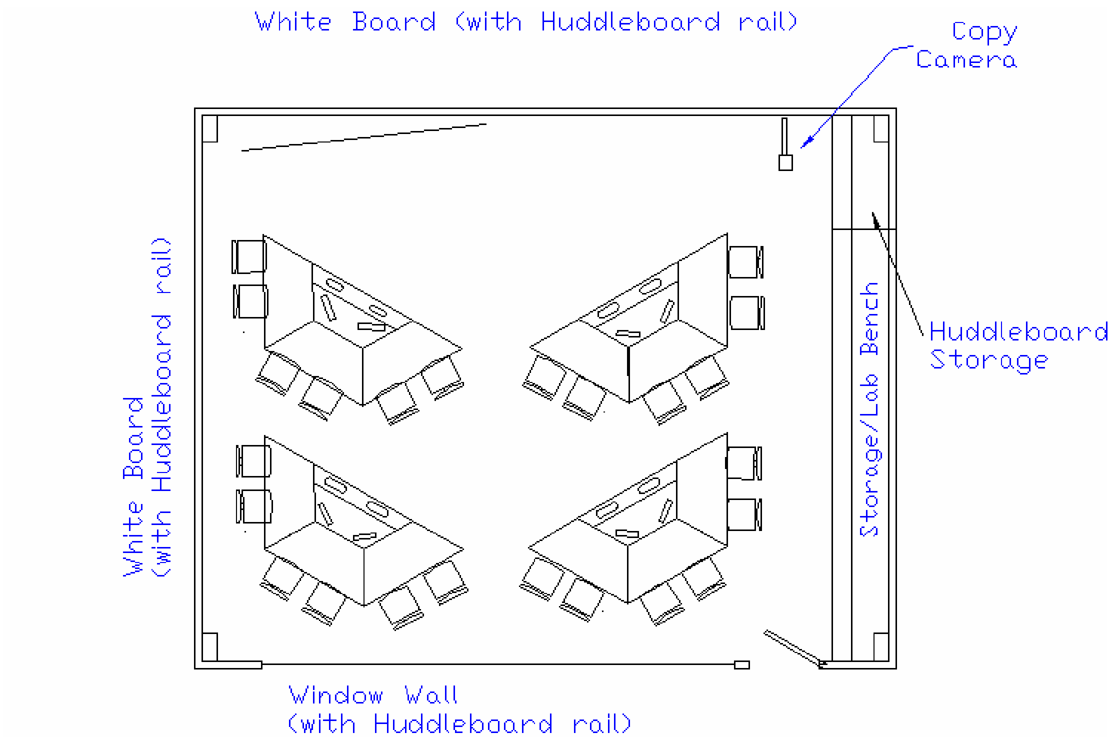


Figure 1: Floor plan for new classroom consisting of four student work clusters for six students each.

Figure 2: Two views of the new learning space. The picture on the left is from the doorway and the picture on the right is from the front of the classroom.

All four walls are designed to be useful parts of this environment. The front and left side wall are covered in white board to allow ample space for instructor or students use. Also twelve Huddleboards, lightweight portable white boards, are available and used primarily by student groups. These boards can be hung along any of the walls in the room. The right wall is a storage and preparation bench. The back of the classroom is a window wall open to the hall which both opens up the environment inside the room and displays this facility to visitors.

There is a tablet computer for the instructor to use for presentations. The tablet links wirelessly to a classroom server that is connected to the internet and to the classroom projector. All computing happens on the server computer with the tablet acting as a terminal. The tablet allows instructors to present from anywhere in the room and to also to annotate their presentations as they go. All monitors and the classroom projector are wide (16:9) screens. The projection screen is to one side of the room (see Figure 1) allowing instructors to use both projection and the whiteboard at the same time. The room was designed so that the lights can remain on during projection to enhance the interaction in the class. This is accomplished by having a separate switch to turn off the light directly in front of the screen and by having a suitability bright projector.

This set up easily adapts to a variety of instructional approaches and is particularly suited to cooperative learning. Students are grouped in clusters of six that are turned in toward each other by the use of trapezoidal tables. They can be easily broken into groups of two, three or six. Groups of three are natural for computer work. With a slight rearrangement of the tables groups of four can also be used. The Huddleboards are a nice option for group brainstorming or problem solving activities. When gathering students back together after they have been in small groups, the Huddleboards can be hung up and students can directly observe each others work.

In addition to handling laboratories, group processes, and computer/simulation activities this classroom also easily accommodates presentation. Students all have good sightlines to the front of the classroom and the instructor has both projection and white board space available. This makes the room less threatening to faculty new to cooperative and active learning approaches. In addition an instructor can move from mini-lecture, to laboratory to group exercise with minimal time for change over. This facility is experimental so we are still developing many of its features.

Table 1 summarizes the capacity of this space versus the design standards of the University of Colorado Bolder.[26] This space has an ideal capacity of 24 students and an overload capacity of 28. The overload capacity is only used for classes where students tend to withdraw over the course of the term. This space has lower capacity than a high density traditional classroom with fixed seating or with tablet desks. However, it has a larger capacity than an equivalent computer laboratory.

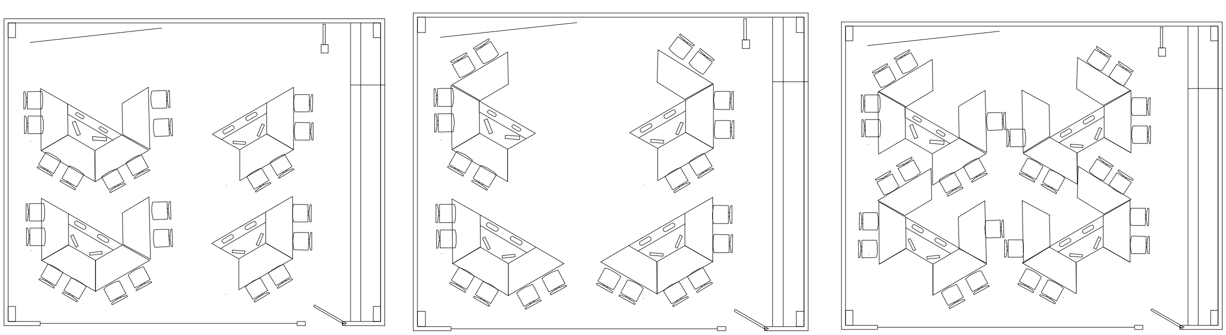
This 24 student capacity is an ideal size for keeping a high level of interaction between the students and the instructor. It also can allow for interaction between individual students and the class as a whole. The classroom could be scaled up by increasing the number of clusters. Widening the classroom by two more clusters could be accomplished with few other changes in the design necessary.   For adding more clusters it would likely be necessary to increase the screen size or include multiple screens.

Table 1: The Capacity of this Design versus Design Standards for Traditional Classrooms[26]

Capacity type		Calculation Basis	Capacity
This classroom	Design	(6 students/ cluster x 4 clusters)	24
	Overload	(7 students/cluster x 4 clusters)	28
U. of Colorado Design Standard	Fixed Seating	(100 sq ft common + ~12 ft^2/student)	51
	Tablet Desks	(100 sq ft. common + ~15 ft^2/student)	41
	Computer Classroom	(100 sq ft. common + ~30 ft^2/student)	21

Unique aspects

While this classroom shares many characteristics with some of collaborative and studio classrooms discussed earlier, it has a unique combination of features. The base configuration in Figure 1 allows for collaborative learning, lecture presentation and discussion to happen in a single setting. This has similar advantages to the tulip-shaped table set up at RPI. This space also allows for simple experiments to be conducted in this base configuration. In addition, the trapezoidal work tables to be rearranged if desired making it a very flexible setup. Figure 3 shows three possible rearrangements that allow for 1) six teams of four students each (instead of the eight groups of three in the base arrangement), 2) the whole class turned in to discuss and/or follow a demonstration in the center of the class 3) a focused laboratory setup for 3 or 4 students per group to carry out more extensive laboratory experiments. The first two reconfigurations require that only two tables be moved. The last setup uses four additional tables and is shown with 28 chairs.



(1) Groups of four   (2) Whole class activity   (3) Special Laboratory Setup

Figure 3: Three alternative arrangements of the trapezoidal tables – (1) Allows for groups of four students each, (2) faces the entire class in for full class activities and (3) is a set up for classes that are completely laboratory in nature.

The fixed center trapezoid in the clusters provides facilities for a range of laboratory experiences in this classroom. Experiments can be done in the base arrangement for quick integration of experiments into a regular course setting. The rearranged setup shown in Figure 3 can be used for a more laboratory oriented session. The fixed desktop computers with a connection panel used in this facility allow for quicker set up and transition to simulation or computer based experiments than is possible with a laptop setup. While this is not as flexible as laptops the long reach monitor arms make this difference practically small in normal use.

Taking down the wall between the classroom and the laboratory has some distinct advantages.[27] Learning does not get more active than in a good experiment. Having experiments in the classroom allows the teaching activity to be chosen based on the needs of the topic rather than the constraints of the space. Experiments are also an excellent tool for inductive or problem-based learning.

A key unique aspect is that this classroom was designed for engineering classes and is "owned" by the engineering department. In addition to allowing the customization of the classroom for engineering needs, this ownership helps to build the sense of attachment in both engineering students and in the faculty.

Assessment

Final development and IRB approval of the formal assessment of this space is underway. A key element of that assessment is an assessment of student engagement. Student engagement has been shown to be an appropriate target for assessment of learning spaces which reflects learning quality.[28] Student engagement is also a direct reflection of our goal of seeing student-to-student interaction and student-to-faculty interactions increase.

A survey instrument building on the Student Course Engagement Questionnaire (SCEQ)[29] is being finalized. This instrument divides questions into four factors: skills engagement, emotional engagement, participation/interaction engagement, and performance engagement. This instrument will be supplemented with questions directly on the space.

In addition, an observational study is planned that focuses on simply how the room is used. In this portion of the assessment the number of people in the room will be observed and possibly photographed every hour over a two-week period.[27]

Finally faculty interviews are planned. These interviews will focus on how each faculty member is using the space and how the space has affected how they teach their class. The first round of these assessments is planned for spring term 2008.

Initial Lessons

Response of both students and faculty to this room has been quite positive. Both want their classes in this room. Many students preferentially choose this room over other computer laboratories in the building (including one next door). Students like the pleasant environment, the widescreen monitors, the ability to move the monitors around, and the ease of working together with a group in this facility. It is often used by student project groups. This past fall one group of students regularly met in the classroom for their distance education class – turning an internet class back into a classroom experience.

Before the classroom was up and running there was some concern that the window wall at the back of the classroom might be a distraction. This has not turned out to be the case. The windows that open into a hall make the room feel more open and inviting. However because the window wall is at the back of the classroom it has not been a distraction. If anything, the fact that someone could walk by and see what they are doing may deter students from activities unrelated to class.

The Huddleboard portable white boards are available in two sizes: 23" x 32" (600mm x 800mm) and 32" x 42" (800mm x1000mm). For this space the larger size was purchased. This size is a bit too wide easily place on the tables, which is often how students want to use them. In the future a few of the smaller size will be available for students to use.

The base cluster with three trapezoidal tables is perfect for most classes and activities. However we have found that it is sometimes helpful to add an additional table to a cluster. The purchase of two to four additional trapezoidal tables is planned. They will be stored in the front corner, under the screen, when not being used in a cluster.

The additional cost of upgrading to widescreen monitors and projector was less than expected. The cost differential was approximately $3000 to upgrade to widescreen projection, eight widescreen student monitors and a widescreen instructor tablet computer.

Conclusions

While active and cooperative learning can be done in almost any space, some spaces are more conducive to these approaches for both the student and the faculty. Our educational spaces need to be tuned more to these pedagogies rather than being optimized for lecture. The cluster design presented here allows for a range of educational approaches to be used in a single space with out transition delay.

The space is pleasant and well liked by both students and faculty and is working well for teaching a range of classes. Students regularly choose it as their study space. The basic cluster design is quite flexible making use of standard trapezoidal tables. This design could be scaled up by increasing the number of clusters with attention to sight lines and screen size.

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