LEARNING ENVIRONMENT ASSESSMENT

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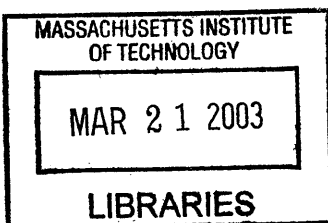February 2003

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1

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Submitted to the Department of Architecture on January 17th, 2003 in Partial Fulfillment of the Requirement for the Degrees of Master of Architecture and Master of Science of Architecture Studies.

Abstract This thesis introduces a rationale and a set of methods for assessing the performance of learning environments. The vehicle of this study is the assessment project of the new teaching laboratory of the MIT Department of Aeronautics and Astronautics.

Learning environments are settings that support teaching and learning activities. The objective of developing and managing learning environments is to achieve a dynamic coherence among space, equipment, tools, and operation of the learning environment so as to maximize the learning outcome. The method of learning environment assessment is to identify latent problems and explore opportunities and processes of improving its performance.

To assess the performance of the learning environment, this thesis proposes that the learning environment should be examined through three lenses: teaching and learning activities, settings, and students' individual lives. Methods of examining learning environments through these three lenses are introduced in this thesis in the context of the MIT Aero/Astro new teaching laboratory assessment.

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TABLE OF CONTENTS

INTRODUCTION

The new teaching laboratory of the MIT Department of Aeronautics and Astronautics is a milestone among the learning environments developed in the past decade. Since 1996, the department has repositioned itself in the field of aerospace engineering education, redefined its mission and vision, created a new undergraduate engineering education model, redesigned its curriculum, reformed its teaching and learning methods, evolved its faculty and staff to take on new roles in learning-based education, and developed a new teaching laboratory to support its reformed education practice. Active assessment processes have been employed to measure student and program progress, faculty performance, teaching and learning methods as well as the assessment methods.

In fall 2001, in collaboration with Beng-Kiang Tan from Harvard Graduate School of Design, the author conducted a preliminary assessment of the new teaching laboratory. In summer 2002, the author was invited by the Department of Aeronautics and Astronautics to conduct a yearlong assessment of the new teaching laboratory. This yearlong assessment is divided into two phases. The first phase of assessment took place in fall 2002. The second phase will take place in spring 2003.

The first chapter of the thesis discusses learning-based education, introduces the conceptual structure of learning environments designed to support learning-based education, and describe the design process and design features of the MIT Aero/Astro new teaching laboratory.

The second chapter introduces a rationale and a set methods for conducting learning environment assessment. Processes and methods employed in conducting the MIT Aero/Astro teaching laboratory assessment in fall 2001 and fall 2002 will be reported. Findings and proposed solutions will be discussed.

The third chapter reflects on issues related to learning environments encountered during the study.

1. BACKGROUND

1.1 From Teaching to Learning – A New Paradigm for Undergraduate Education

Driven by the need for changing learning expectations to prepare learners for rapidly changing roles and responsibilities in work, family and community for the 21st century, more and more colleges undertook efforts re-examining their mission and education practices.

In a widely read and discussed article entitled 'From Teaching to Learning – A New Paradigm for Undergraduate Education', Robert Barr and John Tagg (1995) argued that:" A shift from Instruction paradigm to Learning Paradigm is taking hold in American higher education." In its brief form, the shift is a transformation from a faculty and teaching centered model to a student and learning centered model. This shift affects many issues, including the learning environments in which the teaching and learning activities take place and the manner in which the learning environments are developed and managed.

Change in Mission and Purpose

At the core of this shift in educational paradigm is the redefinition of the colleges' mission. According to Barr and Tagg (1995) colleges under the Instruction Paradigm see providing instruction as their mission. The purpose of the colleges is to offer courses and to deliver knowledge from faculty to students. Under the Learning Paradigm, the mission of the colleges is to produce learning with every student by whatever means work best. The purpose of the colleges is to create learning environment and experience that bring students to discover and construct knowledge for themselves and to make students members of communities of learners that make discoveries and solve problems.

Change in Teaching and Learning Methods

The shift from providing instructions to producing learning requires a re-examination of teaching and learning methods. Under the Instruction Paradigm, the activity of teaching is conceived primarily as delivering 50-minutes lectures (Barr, Tagg, 1995). Colleges under the Learning Paradigm set their mission as producing learning with every student by whatever means work best. Armed with findings from studies on how people learn, colleges under the Learning Paradigm actively explore effective methods for teaching and learning. Realizing that education is only meaningful in the context of each learner's unique interests and abilities, advocates of the
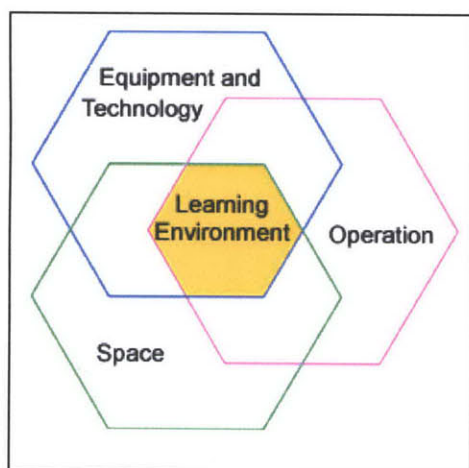
7

Learning Paradigm promote personalized learning instead of standardized learning. The focus of learning shifts from memorization to critical thinking and analysis, supplemented by hands-on project-based learning, formal collaborative learning and informal collaborative learning. The classroom-based and lecture-based learning is redefined as only one of many possible means of producing learning.

Teaching and Learning Practice As Something That Can Be Improved

According to Barr and Tagg (1995):" The Learning Paradigm does not limit institutions to a single means for empowering students to learn; within its framework, effective learning technologies are continually identified, developed, tested, implemented, and assessed against one another... In fact, the Learning Paradigm requires a constant search for new structures and methods that work better for student learning and success, and expects them to be redesigned continuously and to evolve over time." Underlying this continuous improvement is the vision of the institution as a learner in that over time "it continuously learns how to produce more learning with each graduating class, each entering student." (Barr, Tagg, 1995)

1.2 Learning Environment

Learning environments are settings that facilitate teaching and learning activities. The shift in educational paradigm, the change in teaching and learning activities should logically be reflected in learning environments themselves and the manner in which they are developed and managed.

Conceptual Structure of the Learning Environment

Learning environments as settings that facilitate teaching and learning is more than the physical container in which the teaching and learning activities occur. The adequacy of a learning environment depends on the internal compatibility – the active mutual reinforcement – of space, equipment and technology, and operation of the learning environment. This relationship is represented in figure 1.2a. The learning environment at the core of the diagram has three dimensions – space in which teaching and learning activities take place, equipment and technology to support teaching and learning, and operational policies and activities to ensure the smooth operation of the learning environment. These three dimensions are interdependent and in a dynamic relationship with one another. The objective, then, is to achieve a dynamic coherence among the three dimensions so as to maximize the learning outcome.

Conceptual structure of the learning environment
Figure. 1.2 a

Agile learning environment

Under the Learning Paradigm, teaching and learning activities are viewed as something that can be improved. The changing nature of the teaching and learning activities indicates that there is no possible fixed design solution of the learning environment that would meet all the needs of an institution. An adequate learning environment should be an agile learning environment.

In 'The Agile Workplace", Joroff, Porter, Feinberg, and Kukla (2002) define agility as " the ability to respond quickly and effectively to rapid change and high uncertainty". "In the context of the workplace, the agility is achieved through the co-evolution of the workplace and work. The co-evolution is only possible when the work is clearly understood." (Joroff, Porter, Feinberg, and Kukla, 2002)

In the context of learning environment, the agility of a learning environment is achieved through the co-evolution of the learning environment and the teaching and learning activities. This requires a clear understanding of education practice, and continues assessment and adjustment of the learning environment.

1.3 MIT Aero/Astro New Teaching Laboratory

Developing and managing learning environments that can support changing educational practices and can co-evolve with the education practice requires a new model of development and management process. Among the learning environments developed in the past decade, the new teaching laboratory of the MIT Department of Aeronautics and Astronautics has become a milestone. The department created a highly innovative process of developing a learning environment that would meet the department's educational goals.

The rest of this chapter describes the process by which the new teaching laboratory as it was conceived and designed.

1.3.1 Introduction

From fall 1996 to fall 1997, the Department of Aeronautics and Astronautics at MIT undertook a yearlong strategic planning process. The strategic planning involved the department's thirty faculty members and representatives from other MIT departments as well as from other universities and from industry.
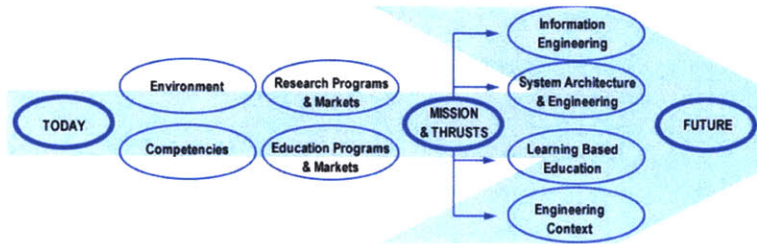
The main tasks of the planning process were to examine the outside environment and internal competencies, to evaluate the current state and future markets and programs for research and education, to reposition and redefine the Department's mission and vision, and to identify and implement the strategic thrusts The result of this yearlong process was a new formal strategic plan.

The examination of the outside environment and the evaluation of the current state and future markets and programs for research and education led the department to believe that graduating engineers should be able to conceive, design, implement, and operate value-added engineering systems in a modern team-based environment. The department believed that the task of academia was to educate students in a broad array of technical, personal, interpersonal and system building knowledge and skills. Based on this belief, the department set its mission as (to quote the department's Strategic Plan) " to prepare engineers for success and leadership in the conception, design, implementation, and operation of aerospace and related engineering systems." The department set its goal as to provide students with a deep working knowledge of the technical fundamentals, to educate engineers to be leaders in the creation and operation of new products and systems, and to instill in students an understanding of the importance and strategic value of their future research."

1.3.2   A learning-based education model

During the strategic planning process, four strategic thrusts that were deemed necessary to achieve the department's mission were identified. One of these thrusts was learning-based education. Another thrust was to conception, design, implementation, and operation of complex aerospace systems as the engineering context of education.

Guided by these two strategic thrusts, a new undergraduate engineering education model called CDIO was created. CDIO stands for conception, design, implementation and operation, which is a vision of the product system life cycle.

The decision of making its education learning-based education suggests a shift from focusing on delivering instruction to

focusing on producing learning.

To determine the learning outcome the department's education practice was to produce, a comprehensive list of abilities required of the contemporary engineers called the CDIO Syllabus was developed. This task was accomplished through the consultation of stakeholder focus groups comprising engineering faculty, students, alumni and senior academicians.

The four primary sections of the CDIO Syllabus are:
1) Technical knowledge and reasoning
2) Personal and professional skills and attributes
3) Interpersonal skills and attributes
4) Ability to conceive, design, implement and operate systems in the enterprise and societal context.

First and second level organization of the CDIO Syllabus
Source: MIT Department of Aeronautics and Astronautics
Figure 1.3.2a

Table ES 1: First and Second Level Organization of the CDIO Syllabus

1 Technical Knowledge and Reasoning:
    1.1 Knowledge of Underlying Sciences
    1.2 Core Engineering Fundamental Knowledge
    1.3 Advanced Engineering Fundamental Knowledge

2 Personal and Professional Skills and Attributes
    2.1 Engineering Reasoning and Problem Solving
    2.2 Experimentation and Knowledge Discovery
    2.3 System Thinking
    2.4 Personal Skills and Attitudes
    2.5 Professional Skills and Attitudes

3 Interpersonal Skills: Teamwork and Communication
    3.1 Teamwork
    3.2 Communications

4 Conceiving, Designing, Implementing and Operating Systems in the Enterprise and Societal Context
    4.1 External and Societal Context
    4.2 Enterprise and Business Context
    4.3 Conceiving and Engineering Systems
    4.4 Designing
    4.5 Implementing
    4.6 Operating

Through various focus groups involved in the strategic planning, the level of proficiency expected of graduating engineers was identified in approximately 90 areas.

A general taxonomy of the proficiency scale as adopted by the department is shown in figure 1.3.2b.

Expert

- Ability to lead and innovate
- Skilled in practice and implementation
- Understand and explain topics
- Ability to participate and contribute
- Exposure to subject material

Novice
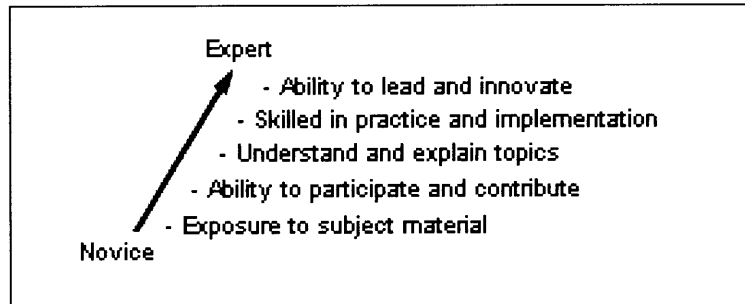
The CDIO syllabus served as the basis for the CDIO education model implementation activities including curriculum reform, teaching and learning reform, the development and management of a new learning environment, and assessment process that measures student and program progress toward consensus goals

1.3.3 Co-invention of Teaching/Learning Practice and the Learning Environment

The design and implementation of the CDIO program at the MIT Department of Aeronautics and Astronautics evolved around four themes:
1) Curriculum
2) Teaching and Learning
3) Learning Environment
4) Faculty and staff

In 1997, four committees were established at the MIT Aero/Astro Department and each committee focused on one of the themes listed above. The four committees worked in close communication and collaboration. In this way, the learning environment development process operated concurrently with the curriculum reformation program, the pedagogical change program, and the faculty development program.

1.3.4 Learning Environments as a Strategic Element

The CDIO program envisions an education that stresses the technical fundamentals within the context of Conceiving-Designing-Implementing-Operating engineering systems and products. Taking learning-based education as one of its strategic thrusts, the department teamed with experts within and outside MIT to help identify and disseminate knowledge and train faculty on running pedagogical experiments. Ultimately the department realized that there is a much broader scope of available techniques for educating students beyond the tradition of "chalk and talk" that would benefit the faculty and the students. The department believes that engineers design and build system products. By providing students with multiple authentic design-build experiences, they develop and

12

reinforce a deep working knowledge of the fundamentals, and learn the skills to design and develop new system products. In the new CDIO program, courses are developed that enhance this theory-to-practice learning. The program is rich with student projects complemented by internships in industry, and feature active, experimental and group learning. Experiences in conceiving, designing, implementing, and operating are woven into curriculum.

The department soon realized that they would need an appropriate learning environment to support its reformed education practice. The learning environment should be able to support the students' hands-on learning, including experimentation, disciplinary laboratory, and social interaction. The learning environment should also be able to facilitate team building and team activities. At the time, the department was operating in a building that was developed to support engineering science/research-based education and not well suited to the entire CDIO context. In the new strategic plan, one of the department's objectives was to" " create the teaching "lab" facility to allow students hands-on experiences in the modern practice of conceiving, designing, implementing, and operating complex aerospace systems"

1.3.5   A New Process For Developing Learning Environment

To ensure that the facility will be developed to meet the department's goals, a former graduate student of the department was hired as the Lead Project Engineer. The mission of the Lead project Engineer was to work within the department to develop a set of rigorous customer requirements informed by the needs of the department, the University, existing literature on the subject, and benchmark data from other locations.

Coordinated by the lead project engineer, a pre-programming process was carried out to define goals, requirements, scope and concept of the new learning environment.

The department viewed the new teaching laboratory as an innovative product that to be developed. A product development process was adopted to ensure that a full understanding of the department's needs could be developed, potential solutions for the needs could be explored, a preferred design could be, implemented, and introduced into service, and the result of its effectiveness could be assessed. An integrated project development team consisting client, architect, and builder was formed to collaboratively develop a learning environment that can facilitate the CDIO program. During the design process, all stakeholders were included in weekly meetings. Major issues were resolved in real time with

13

necessary decision makers present. The Lead Project Engineer served as the interface manager between the various department programs, tracking requirements and identifying incompatibilities and disconnections that needed resolution

1.3.6 How Students Spend Their Time
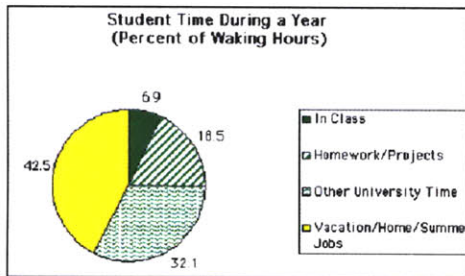
Student time during a year (Percent of Waking Hour)
Source: MIT. Department of Aeronautics and Astronautics
Figure 1.3.5a

To understand how the learning environment can better support students' education, the department did a calculation on how students spent their time. The calculation showed the department that traditional formal classroom teaching only accounted for about 7% of a student's waking hours over a year. Performing work for classes in an informal setting accounted for 20% of a student's waking hours, and students spent on average 50% of their annual waking hours in and around the campus during their semester. To provide students with the most effective education possible, the department decided to design a learning environment to capture and exploit the 20% to 50% of the year when students are learning on their own schedule and via their own means.

1.3.7 Education Modes

To obtain an understanding of the department's teaching and learning activities so as to derive requirements for the new teaching laboratory, the faculty members of the department and the Lead Project Engineer identified 21 educational modes. The 21 educational modes describe how the department foresees itself might operate. The 21 educational modes are:

1) Large Systems Mode (M.Eng, LFM, SDM)
2) Design Project Mode (16.82,.83,.89)[1]
3) 16.62X/UROP Project Mode
4) Large Student Project Mode
5) Class Lab/Experiment Mode
6) Operate Mode
7) Linked Projects Mode
8) Grad Thesis Mode
9) Teaching in Labs Mode
10) Research Design Support Mode
11) Income Generating External Mode
12) Outreach Mode
13) Tinkering Mode
14) Self-Directed Learning Mode
15) Lecture/Presentation Mode
16) Interactive Electronic Class Mode

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[1] Aero/Astro Courses, 16.82-Flight Vehicle Engineering, 16.83-Space Systems Engineering, 16.89-Space Systems Engineering

17) Paper/Conference Mode
18) Paper Design Mode (& competition)
19) Collaborative Project Mode
20) Site Visit Learning/Teaching Mode
21) Distance Learning/Teaching Mode

In order to build up requirements for the new teaching laboratory, each educational mode was described by a set of characteristics: space (dedicated vs. sharable, duration, and contiguous needs); service (communications, power, data, and water); equipment (dedicated vs. sharable, specialized); staff (instruction, supervision, safety); operation (duty cycle, access, number of people, impact on others); money (recurring and occasional expenses).

From education modes to the requirements for the new teaching laboratory
Source: MIT Department of Aeronautics and Astronautics
Figure 1.3.5a:

EDUCATION MODES (6 out of 21 modes) :

| Large Systems Mode (M.Eng, SDM) | Design Project Mode (16.82,83,89) | Tinkering Mode | Class Lab Mode |
| -Year scale -Design intensive -Dedicated space -Product thrust -Close connectivity to outside | -Large scale project -Term length -Virtual design -Dedicated space -Breakout / report-back space | -Occasional -Temporary work space | -Occasional use -Week duration -Storable |

| | | Outreach Mode | 62X/UROP Mode |
| | | -Weekly -Accommodate visits, lectures, presentations | -Desktop project -1 to 2 terms -Student developed |

DESIGN REQUIREMENTS FOR ARCHITECTS :

Learning Science

Pedagogy and Curriculum

Prioritize

Modes	Space	Services	Equipment	Staff	Operations	$
1						
2						
Total						

1.3.8 Viewing Both Teaching and Learning Activities and the Learning Environment As Something That Can Be Improved

The list of educational modes served as a basis for deriving requirements for the learning environments. However, the department was also aware that they would not be able to predict how the modes evolve and what new modes would emerge in the years to come. An education model that stress continuous pedagogical experiments and improvements suggests that there was no possible fixed design solution for the learning environment could meet all the department's needs between the start of the learning environment and the next major renovation of the building decade later. Thus, the design intention was to create a learning environment that could co-evolve with the department's teaching and learning practice. To ensure the sustainable success of the new teaching laboratory, a set of design themes were developed. The themes are:

- The teaching laboratory needs to be flexible by serving many purpose and be being easily reconfigured
- The teaching laboratory should be scaleable to accommodate and to adapt to projects from components to subsystems to complete large-scale systems.
- The teaching laboratory should be sustainable such that the department staff and budget could ensure its continuous successful operation.
- The teaching laboratory should be supportive of large, unique facilities for education, such as the wind tunnel.
- The teaching laboratory should be wired to provide power and data wherever and however it is needed.
- The teaching laboratory should be integrated with other Aero/Astro department labs and coordinated with other MIT facilities to avoid duplication and leverage the capability of others.
- The teaching laboratory should be accessible whenever and however it was needed, versus a traditional 9-5 focus.

1.3.9 Lessons Learned From Benchmarking

Benchmarking was conducted to draw lessons from MIT, other universities, and in industry in large. The lessons learned from the benchmarking are summarized as the following:
- There should be team spaces in the new teaching laboratory to encourage team behavior.
- The learning environment should be an informal learning environment with settings in the new teaching laboratory to facilitate informal learning activities.
- In the new teaching laboratory there should be exhibits that reflect the professional context, content, history, and tradition
- There should be tools in the spaces for students.
- The teaching laboratory should not be over-designed. Let space evolve.
- Let community happen!

1.3.10 Developing Concepts for the Space

Armed with the educational modes and themes and lessons the department intended to incorporate, the department proceeded to identify and describe design concepts for the teaching laboratory.

To reinforce the concept that the role of engineers is to conceive, design, implement and operate systems, the department decided to use this as the organizing principle of the spaces. The department envisioned that there would be different spaces in the teaching laboratory devoted to conceiving, designing, implementing, or operating systems and products.

The following are the definition and requirements of the four types of spaces as defined by the department:

Conceive space would allow students to envision new systems, understand user needs and develop concepts. These spaces would emphasize reflection and reinforce human interaction. They would be linked with library resources, and have sufficient technology only for communications and information retrieval, not for design or computation.

Design space would support the new paradigm of cooperative digitally supported design. They would allow students to design, share designs and understand interaction. They would include a central room for large group interaction, and be connected to breakout rooms for smaller teams to work on their projects. They would be IT accessible in proximity to build space, reinforcing the design-build connection.

Implementation spaces would allow students to build small, medium and large systems. They would offer mechanical, electronic and specialty fabrication, and would be visible to other students and visitors. They would offer opportunities for software engineering and integration. A key element (and challenge) would be to make them safe yet accessible as much as possible outside the "normal" school day.

Operate spaces would create opportunities for students to learn about engineering operations. There, they could operate their experiments and projects and simulate operations of real systems. In addition, they would eventually offer I-lab (digital) links to real systems.

The definition of these four spaces was a starting point for the department to identify resources necessary in the teaching laboratory for supporting conceiving, designing, implementing, and operating activities. However, this oversimplified coupling of activities with space was challenged by how users actually utilize the settings soon after the teaching laboratory was occupied.

1.3.11 From Concepts to Architectural Spaces

A document entitled Programming Summary for the New MIT Aero/Astro Teaching Labs that summarized the department's investigation of the various modes of learning, the themes for sustainable success of the new learning lab and the lessons learned from the benchmarking was compiled by the lead system engineer in 1998. The document, together with the concept of CDIO spaces was shared with Cambridge Seven Associates, the architectural design firm that has been

17

commissioned to design the new laboratory.

The requirements produced by the department helped architects to articulate new possibilities for space configuration potentials. The 21 education modes enabled the architects to understand the various teaching and learning activities as well as necessary settings to support these activities. At the early stage of the design, various activities were grouped to derive activity settings such as presentation, testing, designing, fabricating and storing (resource accommodation). In addition, these settings were molded by qualities that reinforced and enhanced aspects of the strategic direction portrayed by the CDIO program.

The renovation and construction focused on two main areas, namely the upgrade of two facilities named building 33 and building 17, and the creation of the "filling" for the renovated space. In addition, a "hangar" space for large projects was developed in the rear of building 33. A wide range of informal and formal settings varying in sizes and general configurations were created in the new lab.
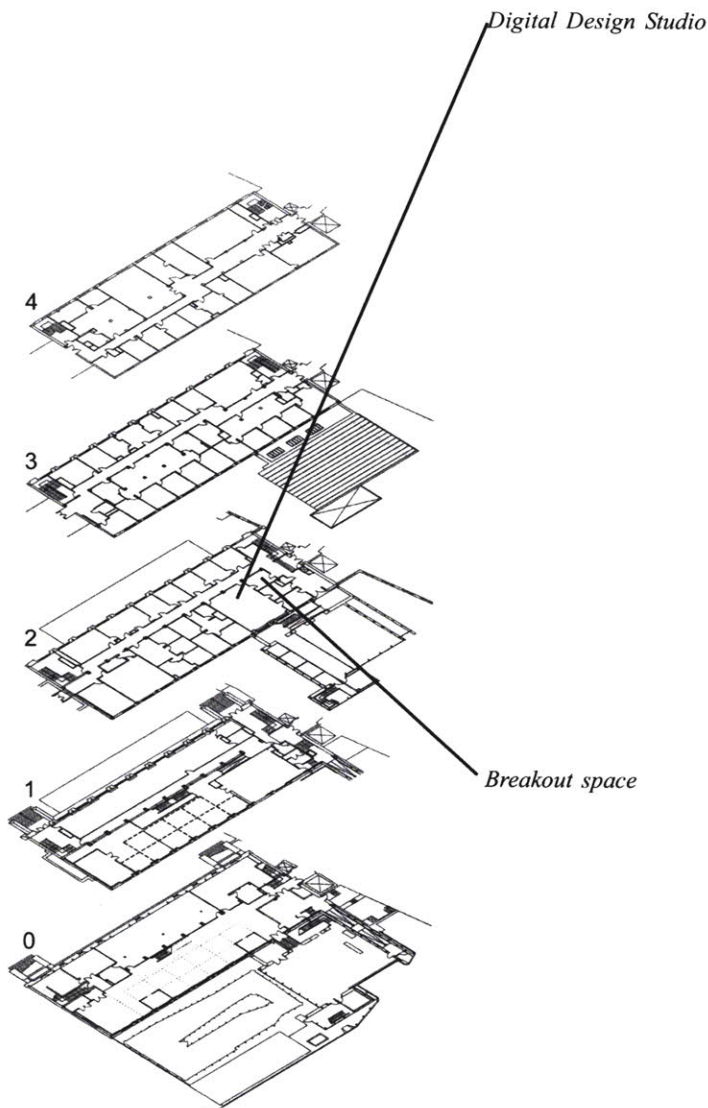

Location of building 33 and building 17 on the campus of MIT
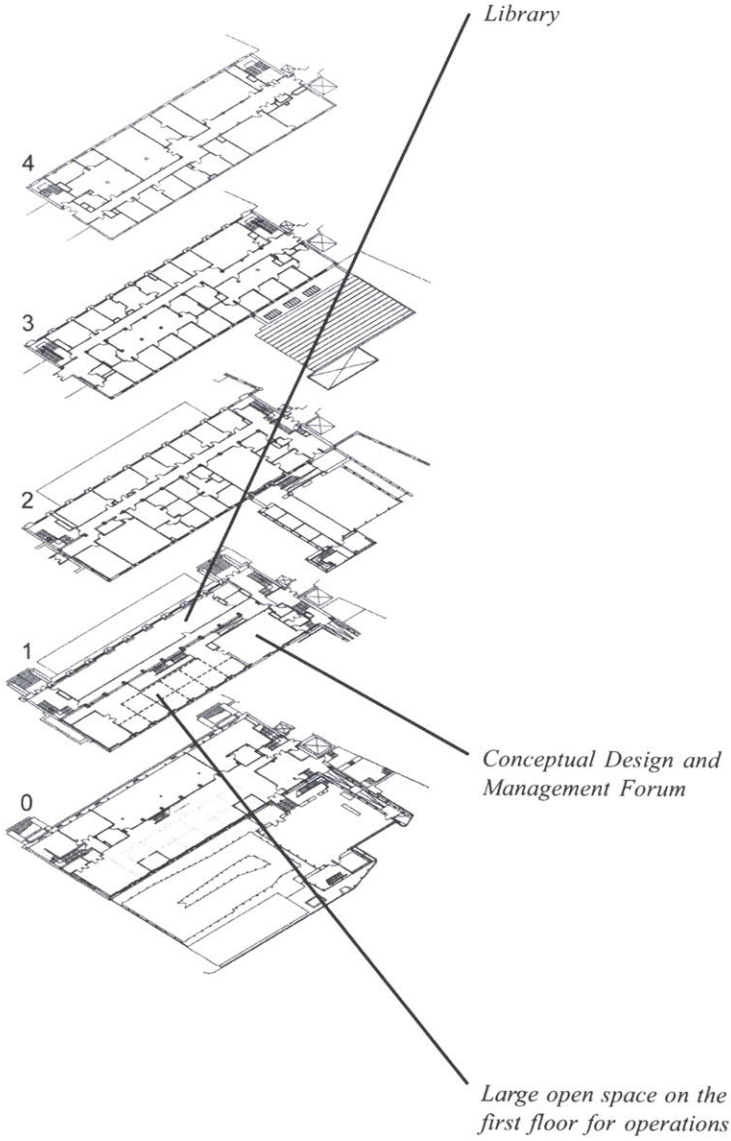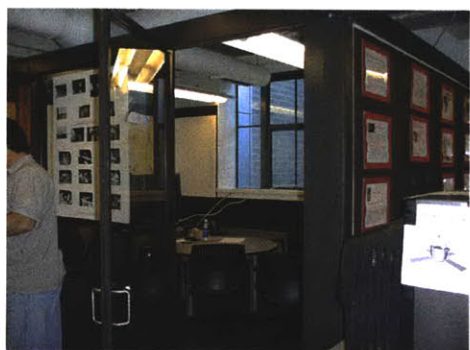*Building 33 is connected to building 9 and building 35 on the second floor*

Building 33

18
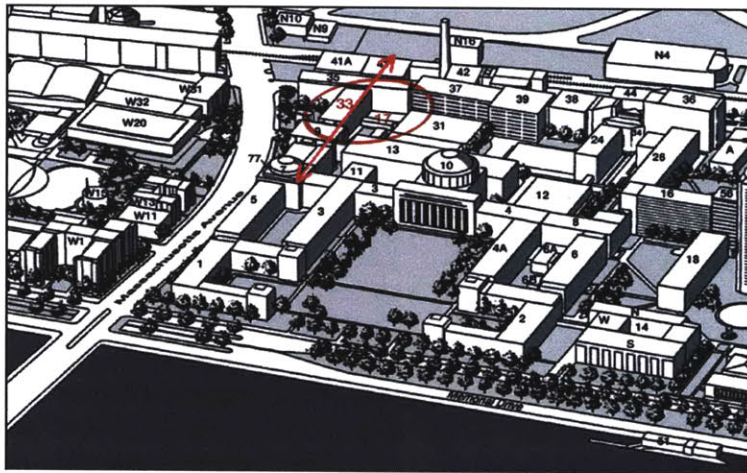
There are four main spaces in the new laboratory. On the second floor is the Digital Design Studio, with three small breakout spaces attached to it. On the first floor is the Seamans Laboratory, which houses the Library, a multi-purpose Conceptual Design and Management Forum, and a large open space for operations, as well as academic support offices including Unified TA office and two project offices. In addition, there is a kitchen on this floor, the kitchen and the area between the kitchen and the stairs was dedicated for social interaction. One floor below is the Gelb Laboratory, which is the main implementation space, with electronics, mechanical and specialty fabrication facilities, as well as open area for project construction. Adjoining the old building is the newly constructed hangar area, which is a large space for the execution of large projects and the housing of the two wind tunnels. The mezzanine of the hangar was indented to function as a design loft.

Digital Design Studio

Breakout space

Library

4

3

2

1

Conceptual Design and
Management Forum

0

Large open space on the
first floor for operations

Unified TA office

4

3

2

1

0

Project office

Kitchen

Machine shops with electronics, mechanical and specialty fabrication facilities

Open workbenchs area for project construction

4

3

2

1

0

The mezzanine of the hangar

Lounge between the design studio and the hangar mezzanine

The newly constructed hangar area

23

2 MIT AERO/ASTRO LEARNING ENVIRONMENT ASSESSMENT

A preliminary assessment of MIT Aero/Astro Teaching Laboratory was conducted in fall 2001 by the author and Beng-Kiang Tan from Harvard Graduate School of Design. In summer, 2002, the Department of Aeronautics and Astronautics at MIT invited the author to conduct another assessment of its teaching laboratory. Because the teaching and learning activities of the Department in the fall semesters are quite different from those in the spring semesters and the Teaching Laboratory is utilized differently during springs and falls, the department suggested that the assessment of the new teaching laboratory should be a yearlong effort. The assessment process was divided into two phases. The first phase took place in fall 2002; the second phase will take place in spring 2003.

This chapter introduces rationale, processes, and methods employed in conducting MIT Aero/Astro teaching laboratory assessment in fall 2001 and fall 2002, reports findings from the assessment, and discusses proposed solutions.

2.1 Assessment Conducted in Fall 2001

In fall 2001, in the context of an architectural workshop co-instructed by William L. Porter and Frank Duffy at the MIT Department of Architecture, Beng-Kiang Tan and the author conducted a case study of the MIT Aero/Astro Teaching Laboratory development process. To collect information on the design intention and the design process of the new teaching laboratory, we reviewed documents related to the department's reformation efforts since fall 1996 and the development rationale and process of the teaching laboratory. We interviewed the Head of the department and the Lead Project Engineer. In addition the Lead Project Engineer gave us a guided tour in the new teaching laboratory. The previous chapter describes the situation where Beng-Kiang Tan and I found ourselves.

To finalize the case study, we decided to conduct a preliminary assessment of the new teaching laboratory.

2.1.1 Rationale For the Assessment

Learning environments are settings that facilitate the students' education. To evaluate the performance of the learning laboratory, we believe that we should start with investigating how the settings in the new teaching laboratory had been supporting the students' learning activities. Instead of focusing on users' satisfaction and dissatisfaction, we decided it was

necessary to investigate how teaching and learning activities were actually taking place in the environment. Potentially, issues, problems, even opportunities associated with the learning environment would be identified during the process of understanding the coupling of teaching, learning activities and the settings in the learning environment. Thus, the assessment itself could therefore be seen as an opportunity for improving the learning environment.

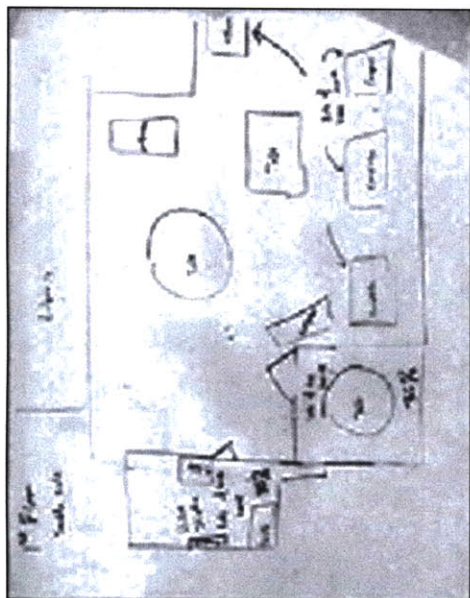### 2.1.2 Methods and Findings

Figure 2.1.2a

Figure 2.1.2b

The assessment conducted in fall 2001 took approximately two weeks. To collect information on the performance of the new teaching laboratory we interviewed faculty and staff members from the department. The facility manager of the department gave us a tour in the new teaching laboratory. Another guided tour was given to us by a senior lecturer from the department. The principle method of collecting information was conducting mental map of physical space exercises with students from the department.

Mental map of Physical Space Exercise and Findings

When one lives or works in an environment, s/he inevitably reconstructs that environment in his/her mind. Physical representations of that mental image such as sketches of an environment one made based on memory (as opposed to scaled layouts and plans) are filtered by one's memory base on how one has been engaging within that environment. These mental map drawings help to indicate familiar elements in the environment. The mental maps provide information on how one perceives various settings of the environment. However, it does not provide enough information about what activities are taking place in those setting. To understand the bases upon which the users formulate their mental images of the environment and to understand the coupling between teaching, learning activities and settings in the learning environment, we decided that the drawing of the mental map should be followed by verbal interviews.
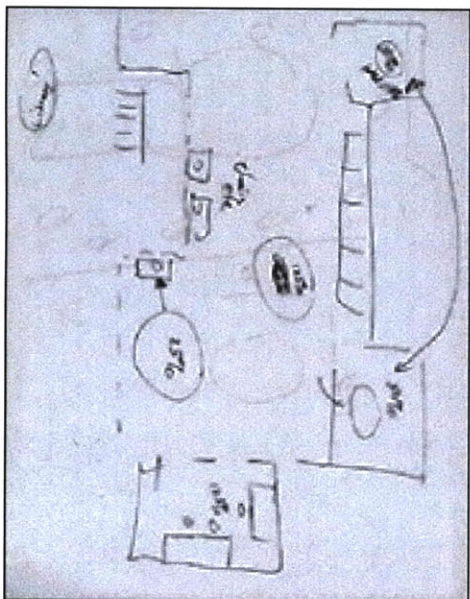
During the assessment process, two sessions of the mental map of physical space exercise were conducted. Seven undergraduate students from the department participated the exercise sessions. Participants included sophomore, junior, and senior students.

At the beginning of the exercise, the interviewees were asked to draw their learning environment based on memory. It was up to the interviewees to decide how they would like to represent the environment.

25

After finishing the drawings, the interviewees were asked to explain their drawings and what they usually do at the settings they had indicated on the drawings.

Figure 2.1.2a, 2.1.2b, and 2.1.2c are three sketches produced by the students during the exercise sessions. Figure 2.1.2d is the scaled floor plan of the first floor of the new teaching laboratory.

Figure 2.1.2c

First Floor Plan of the Teaching Laboratory
Figure 2.1.2d

All the sketches made by the interviewees focused on the first floor of the teaching laboratory. The Unified TA office, the open area, the two project offices, and the library were clearly indicated on the drawings. The Unified TA office and the open area were indicated in much detail than the rest of the spaces. It seemed that the Unified TA office, the open area, the project offices and the library were the most important settings for the students. It also appeared that students might have been spending a large amount of time on the first floor of the teaching laboratory. We asked the students how much time they had spent on the first floor. Some students reported that they spent up to 80% of the non-class awaking hours on the first floor of the teaching laboratory.

First floor of the new teaching laboratory

From the open area look toward the Unified TA office

Unified TA office interior

When we asked the interviewees why they spent so much time on the first floor rather than in the rest parts of the teaching laboratory, or even in the other parts of the campus, students told us that all the undergraduate students at the Aero/Astro department took a class called Unified Engineering, a two term long class, during their sophomore year. The students in this class had weekly assignments. The Unified Engineering class was one of the few classes of the department that had teaching assistants. There were TA-hours three afternoons per week during which the TAs were available for consultation in the Unified TA Office. During the TA office hours, the students came to the open area on the first floor, worked on their homework in groups (the instructors of the class encouraged the students studying in groups), and consulted the TAs when they had questions.

The two graduate TAs were stationed in the Unified TA offices. With no other dedicated offices, the undergraduate students spent a large amount of their time doing their own work in the Unified TA Office. Therefore, the teaching assistants were often available even outside the TA office hours. The students soon realized that when they had questions, they could always come to this area. There would always be someone in this area to whom they could ask questions, either one of the TAs or one of the classmates. By the time the sophomores finished the Unified Engineering class, they had developed the habit of coming to the open area to work.

The resources available in this pace were capable of supporting multiple learning activities. Students came to this area to study in teams, to participate the TA office hours, as well as to work individually. Gradually the open area became a space where the undergraduate learning community members gather and learn cooperatively. Students expressed that they liked the 24/7 access of this space. The furniture, computers, whiteboard and easy power and data access in this area supported multiple modes of the students' learning activities. The students liked the fact that they were able to rearrange the furniture (all tables and chairs are on wheels) to work in groups of different sizes. The students also appreciated the teamwork atmosphere in this space.

Unified TA office interior

The Unified TA office and the Unified Engineering class TAs stationed in the Unified TA Office were what initially attracted students to this area and had been functioning as the center of gravity of the learning community space. In fall 2001, when we conducted the preliminary assessment, both sophomore and junior students came to this open area to work, in teams, individually, or just work among other people. The area could be crowded from time to time. The junior students at the time expressed that in the year after, when they became seniors, they would continue coming to this area to work. Students were concerned that this area would become over-crowded in fall 2002.

First floor open area

Workbenches area in the basement

The stair between the open area and the library was indicated on several drawings. Although the basement was not indicated on every one of the mental maps, judging from the presence of the stair, we suspected that the basement might not be unimportant or rarely used. When we asked the student when they would use the basement, the student reported that they would go to the

basement when they needed to build things, or when they needed to use the machine shops downstairs. The students also reported that when the first floor open area was over crowded, they would sometimes go to the basement to work in the workbenches area. In that way, the basement served as an extension of the open area on the first floor.

On the drawings made by the students, the kitchen and the Design Forum were either missing or proportionally much smaller than the actual dimensions of the space. We suspected that they might have been under-utilized. During the verbal interview sessions students reported that they had not been using the kitchen much. There was a refrigerator in the kitchen, but there was no microwave or vending machine in the kitchen. As for the design forum, students sometimes called it the conference room, or the lecture room. During the day, it was usually occupied by classes, lectures, or meetings. The room was usually locked when it was not occupied by classes, lectures or meetings. When the room was not used, it is usually locked. The room locked in the evenings and weekends. The students do not get to use it much.

Left: Kitchen

Right: Design Forum

Although there is only a transparent glass wall separating the library from the rest of the first floor area, on many of the drawings made by the students a hard line was drew indicating the boundary between the library and the rest of the space. In comparison the boundaries on the other three sides of the library were not always marked on the drawings. We asked the students what they usually did in the library. The students explained that the open area could be noisy sometimes. When they needed to find a quiet space to concentrate on individual work, sometimes they would go to the library. Although there is a visual continuity between the open area and the library, acoustically they are two radically different settings.

The number and location of the computers next to the stair were precisely indicated. On the other hand, the computers located between the two Project Offices were either vaguely indicated or missing from the drawings. If the computers next to the stair were different kind of computers from those between the two project offices, the precise indication of the number and location of the computers next to the stair may indicate an inadequacy of resource in the open area. We asked what was the difference between these two groups of computers. Students told us that the computers between the two project offices were flight simulators and not everyone had access to them. The computers next to the stairs were accessible to everyone. But sometimes they are occupied when one needed to use one of them. When we asked the students how they would like to improve the first floor of the teaching laboratory, students expressed that they would like to have more computers (especially PCs) in the open area.

The students also hoped there were more quiet spaces in the new teaching laboratory for team meetings. Currently, when students need to find a private place for a team meeting, they would go to one of the project offices on the first floor. However, the project offices are not acoustically well insulated. The Steelcase Pathway system does not have ceilings for the two project offices. Although the two project offices are enclosed on the four sides, they are open on the top. Students also expressed that they wished the library open for longer hours. (The library closes at 6:00pm.)

Project room on the first floor

We also asked the interviewees about spaces that have not been indicated on their sketches. Students reported that they rarely used the lounge area located on the second floor between the Design Studio and the Hangar mezzanine.

The Hangar mezzanine was designed as the Design Loft, where computers were available for students to do design work; tools and work surfaces were available for students to do build project work. The space had not been popular among the students. Users complained that the space was too noisy. The ventilation duct on the roof produces quite a lot of noise.

Lounge between the Design Studio and hangar mezzanine

During the preliminary assessment process we identified several surprises regarding how various spaces were intended to be used and what they had evolved into.
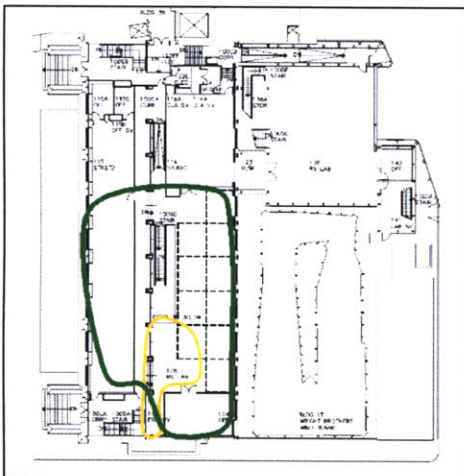

Figure 2.1.2e

The open area on the first floor was originally designed to be the operation area, where equipment for vehicle simulation and network operation would be located. After the teaching laboratory was occupied, the Unified TA Office and the Unified TA attracted students to the open area. The resources in the open area supported a variety of students' learning activities. Gradually an undergraduate learning community was formed and operated in the open area. Thus the open area evolved into a kind of a student lounge. Students came to the area to work and to socialize. Initially, only the kitchen and the space between the kitchen and the stair were designed to be the social area (as marked in orange in figure 2.1.2e). A year after the occupation of the new teaching laboratory, the whole open area on the first floor, including the Unified TA Office had evolved into a social area. Although the undergraduate Unified Engineering class teaching-assistants were not assigned desks in the Unified TA Office, the undergraduate TAs and their friends often gathered outside Unified TA office hours in the Unified TA office to work on their own homework or to chat. Meanwhile, the kitchen itself had not been used much.

Library

When designing the new teaching laboratory, the department wishes the library and the open area to be a continuous space. It was preferred that the library completely open up to the rest of the first floor area. The transparent glass wall currently separating the library from the rest of the space was a compromise the department had to make due to security reasons. Although the library had to be an enclosed space, the department wished to maintain at least the visual continuity between the library and the open area, therefore, transparent glass wall was chosen as the partition. Surprisingly, the originally unwanted glass wall became one of the crucial reasons why the library had been heavily used by the students. The glass wall acoustically separates the library from the rest of the first floor area, making the library a quiet setting for students concentrating on their individual work.

A computer in the first floor open area chained down to the railing

To achieve flexibility, the department decided that all furniture should be on wheels and none of the computers should be fixed to a location. Within several months after the department moved into its new teaching laboratory, seven flat panel monitors were stolen. Security concerns forced the department to finally chain all the computers to the floor, wall, or the railing.

2.2 Assessment Conducted in Fall 2002

A work plan for the assessment was formulated in summer 2002. As stated in the work plan, the objective of the assessment project was to evaluate the performance of the teaching laboratory in supporting the department's educational goals and practices, and to develop a conceptual design package to address specific issues and opportunities identified during the evaluation.

An assessment steering committee was established by September 2002. The responsibilities of the steering committee included reviewing project progress; forming a shared understanding of identified issues, problems and opportunities; deciding how to attack particular problems; recommending individuals to be invited to assessment events including interviews, exercises etc; and evaluating assessment methods employed. Besides the author, the member of the committee included Edward Crawley, the Head of MIT Aero/Astro Department; William Litant, Communication Director of the department; Peter Young, a senior lecture of the department; William Porter, a professor from MIT Department of Architecture, Frank Duffy, a visiting professor at MIT Department of Architecture, and Michael Joroff, a senior lecturer from MIT Department of Urban Studies and Planning.

2.2.1 Rationale For Learning Environment Assessment

When the learning environment is viewed as a strategic element to produce learning, the criteria of evaluating its performance should inevitably be: Does the learning environment meet the department's education goals? Does the learning environment support the department's teaching and learning activities? This

requires the goals and activities of the department's education practice to be clearly understood. The learning environment assessment should be directly related to teaching and learning practice.

In the MIT Department of Aeronautics and Astronautics, the teaching and learning activities are viewed as something that should be continuously improved through experimentations and rigorous assessments. The changing nature of the education practice demands the learning environments to co-evolve with the teaching and learning activities. Any assessment of the learning environment can only evaluate the performance of the learning environment during a specific period in supporting the teaching and learning activities as it is at that moment. The learning environment assessment should be a continuous process. Therefore developing methods and tools for ongoing assessment is just as necessary as evaluating the current conditions of the learning environment.

The ultimate goal of learning environment assessment is to identify latent problems and opportunities for future improvements. Learning environment assessment should examine the past, the present, and explore future possibilities and explore the processes of change.

The deliverables of a learning environment assessment should consist not only the evaluation of current conditions, but also the tools for ongoing assessment and a conceptual design package to address specific issues raised and opportunities identified during the assessment.

2.2.2 Methodology

To evaluate the performance of the learning environment in supporting the department's teaching and learning activities demands a clear understanding of the teaching and learning activities currently in practice. The activities should be understood in terms of their goals, characteristics, participants and the roles they play in these activities, and the space, equipment, technology, and service that necessary to support each of these activities. Then we can examine the settings within which these teaching and learning activities occur, assess how well the learning environment supports these activities, diagnose latent problems and identify potential opportunities for improving the learning environment.

In the learning environment, a variety of settings are available. Each setting has its unique features and capacities and affords certain activities to take place within. Examining the learning environment through the lens of settings would enable us to understand the settings currently available within the learning

environment, how each of the settings has been utilized and managed, to gain insight into how teaching and learning activities are actually coupled in the learning environment, to identify merits and problems of the settings in supporting teaching and learning activities currently taking place in them, and to explore possibilities for improve the learning environment, as well as possibilities to better utilize various settings.

Investigating how teaching and learning activities and settings are actually coupled in the learning environment provides an opportunity for looking at teaching and learning activities from a different angle. Potentially, the findings from these investigations will provide information for improving teaching and learning activities.

The ultimate goal of the learning environment is to support students' education. It is in the students' individual lives that activities and settings converge. Students' lives provide concrete scenarios of how teaching and learning activities unfold in the learning environment. By investigating how students learn, what do they do in order to learn, and where they learn, we will be able to gain insight into both the adequacy of the settings and the relevance of the teaching and learning activities.

Thus, to conduct the learning assessment guided by the objectives and rationale described above, it was deemed necessary to examine the learning environment through three lenses: activities, setting, and individual life.
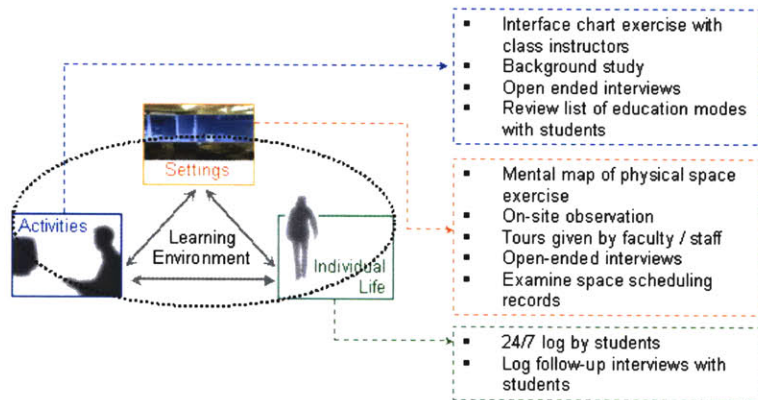
The principle method employed to examine the Aero/Astro teaching laboratory through the lens of activities was interface chart exercises with class instructors. The interface is defined as any media through which information is transferred. Interface chart exercise is designed to systematically identify activities currently take place in the context of a specific class. This method was supported by other methods including background

research, open ended interviews with faculty, staff and students, and reviewing the list of teaching and learning activities with teaching assistants and students.

Conducting mental map physical space exercises with Aero/Astro undergraduate students was the principal method for evaluating the performance of the teaching laboratory through the lens of setting. The mental map of physical space exercise was designed to identify merits and problems of the settings by investigating how students perceived the learning environment. This method was supported by on-site observations, guided tours given by Aero/Astro faculty and staff, examining space scheduling records, and open ended interviews with Aero/Astro faculty, staff, and students.

To evaluate the performance of the learning environment through the lens of individual life, a group of student volunteers were asked to keep records of their waking hour activities for a week. At the end of the week, the author reviewed the log with the students.

2.2.3   Work Plan
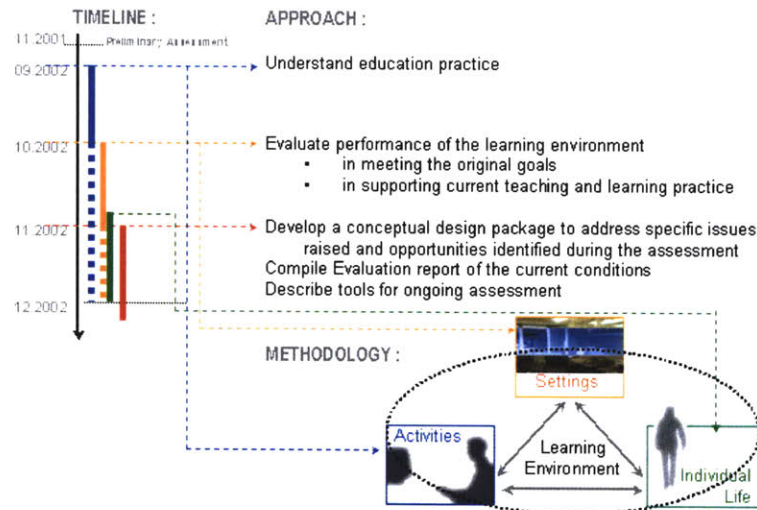
The process of the MIT Aero/Astro teaching laboratory assessment in fall 2002 can be roughly divided into three stages. The first stage took approximately four weeks. The focus during the first stage was to understand the department's education goals and activities. Methods for examining the learning environment through the lens of activities were employed during this stage. Additional tasks during the first stage of the assessment included identifying changes made to the teaching laboratory since fall 2001 and investigating education modes that are currently in practice in the department and comparing them with the list of 21 education modes identified by the

department in 1997.

The second stage focused on evaluating the performance of the learning environment in meeting the department's education goals and in supporting the department's current teaching and learning practice. Methods for examining the learning environment through the lens of settings and individual life were applied during this stage. The second stage took approximately eight weeks.

The third stage focused on developing a conceptual design package to address specific issues raised and opportunities identified during the first two stages of the assessment process. The tasks included exploring future possibilities and exploring the processes of change.

2.2.4 Changes Made to The Teaching Laboratory Since Fall 2001

To identify changes made since fall 2001, the author revisited the teaching laboratory and interviewed faculty and staff. A guided tour was given by a senior lecturer from the department.

Several noticeable changes to the learning environment have been made since fall 2001. The flight simulators that used to be in the open area on the first floor had been moved to the hangar mezzanine area. On one hand, this change gives more space in the open area for furniture and tools to support students' learning activities, on the other hand, this change had improved the use of the hanger mezzanine area. The noise produced by the ventilation duct in the mezzanine area is no long an issue. Students expressed that, when they use the flight simulators, the noise reminds them of wind when they fly a real vehicle.

More computers had been installed in the open area. The computers are accessible to every undergraduate student in Aero/Astro.

Hangar mezzanine, Fall 2002

The student lounge area between the design studio and the hangar mezzanine has been converted into an Athena workstation cluster.

Room 33-202 used to be an Athena cluster, with only Athena workstations in it. In the past year, the department has converted the cluster into a PC computer room due to the fact that most of the time the students work on PC computers and there were not enough PC computers in the building to support the students' work. This room has now become one of the most popular spaces in the building and has been frequently used by the students.
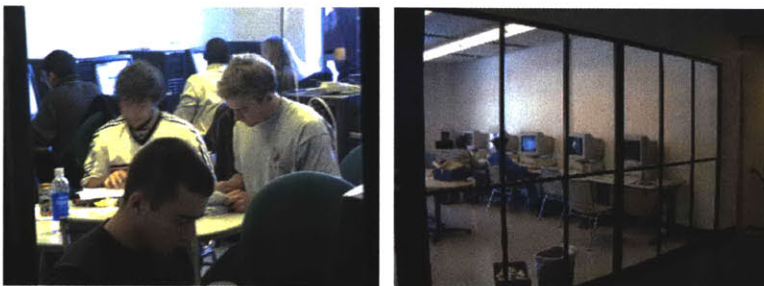
Wireless Internet access has been installed in the whole building by MIT.

2.2.5 Examine The Learning Environment Through The Lens of Activities

Interface Chart Exercise With Class Instructors

The list of twenty-one education modes identified and described by the department in 1997 provided a good start-point for identifying the department's current teaching and learning activities. Based on these education modes, the interface chart exercise was designed. The goal of the interface chart exercise was to identify and understand the department's current teaching and learning activities in terms of goals, characteristics, participants and the roles they play in these activities, and the space, equipment, technology, and service that were necessary to support each of these activities, and how the activities had been currently supported by the learning environment.
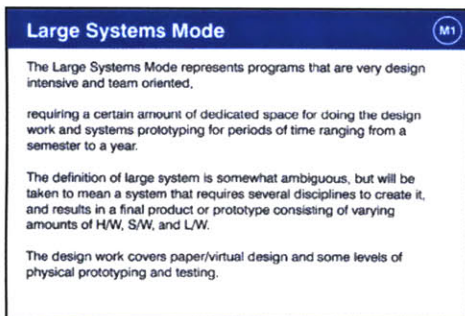
One of the education mode cards
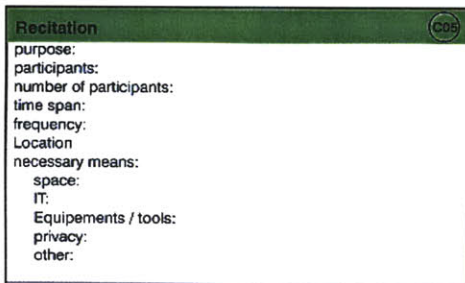
One of the activity cards

Materials used during the interface chart exercises include education mode cards, activity cards, and the floor plans of the teaching laboratory. On each of the education mode cards, the title and description of one education mode identified by the department in 1997 is printed. Several empty cards were prepared for the interviewees to define new education modes if they thought there were modes missing from the cards.

On each of the activity cards, the name of one teaching and learning activities, for example TA Office Hour, is printed. Several blank cards were prepared for the interviewees to define activities missing from the cards.

Preparation for the exercise include making an appointment with a class instructor, deciding with the instructor which class she or he has been teaching should be the context for carrying on the exercise, background research on class information, including class syllabus, calendar, assignments, and students' work from previous years, and preparing the cards and floor plans.

The exercise has four steps. They are:
Step one:
At the beginning of the exercise, a class instructor is asked to read through the 21 education modes identified by department in 1997, and identify those s/he thinks currently in practice in the context of the class s/he has been teaching. If s/he thinks there are education modes that have not been included in the provided one, s/he should define them.

Step two:
The interviewee will then be asked to look through the activities cards, identify those s/he thinks currently in practice in the class s/he has been teaching. Describe those activities in terms of

purpose, roles (instructor, supporting staff, teaching assistant, or student) and number of participants, frequency and duration of the activity, and means (space, tools, technology, and service) necessary to support each type of activity. If s/he thinks there are activities not included in the activities cards, s/he should describe them on the blank cards provided.

Step three:
In this step, the interviewee is asked to indicate on the floor plans the places where each of activities s/he has identified in step two takes place. For example, if the interviewee identified Students' Projects Progress Review as one of the teaching and learning activities taking place in her/his class, s/he is asked to indicate on the floor plans the places where her/his class has the progress review. In addition, the interviewee is asked to explain why those places are chosen for the progress review to take place, and what are the issues and problems the class has encountered.

Step four:
In this step, the interviewee is asked to map the activities to each education modes s/he identified in step one. For example, if in step one the interviewee identified Design Project Mode as one of the modes currently taking place in her/his class, in this step s/he is asked to identify the activities necessary for the Design Project Mode of education.

Interface chart exercise procedures
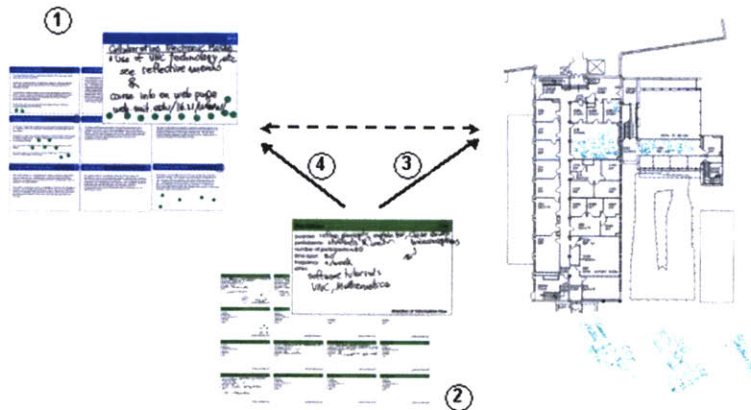
The interface exercise as described above is an effective way to obtain a thorough understanding of the teaching and learning activities the class members engage in order to teach and learn, as well as how the learning environment has been utilized. Issues and opportunities mentioned during these exercises can cover a broad range, from features of physical space, technology and tools in space, to how the department has been operating. The draw back of these exercises is that the exercise sessions care time intensive. One session conducted in fall 2002 took approximately four hours to complete.

An abridged version of the exercise is the following:

Material necessary for the exercise:

- Stack of cards, each with the name of one teaching and learning activity printed on it. Several blank cards are provided for the interviewee to define missing activities.
- Floor plans of the learning environment.

Exercise preparation:

- Make appointment with a class instructor, decide with the class instructor a class which s/he has been teaching as the context within which the exercise is to be conducted
- Background research on class information, including class syllabus, calendar, assignments, students' work from previous years
- Prepare activities cards and floor plans of the learning environment.

The exercise has the following four steps:

Step one:

At the beginning of the exercise, the interviewee is asked to look through the activities cards and identify those s/he thinks currently in practice in the class s/he has been teaching. If s/he thinks there are activities missing from the card, s/he should write down the name of those activities on blank cards provided by the interviewer.

Step two:

Among the list of activities s/he has identified, the interviewee is asked to point out those s/he thinks have been ill supported by the learning environment.

Step three:

In this step, the interviewee is asked to describe each of those ill-supported activities in terms of purpose of the activity, roles of the participants (instructor, supporting staff, teaching assistant, or student), number of participants, frequency and duration of the activity, and means (space, tools, technology, and service) necessary to support that type of activity.

Step four:

In this step, the interview is asked to indicate on the floor plans where each type of ill-supported activities takes place, and explain why s/he thinks they have been ill supported.

Each session of the abridged version of the exercise takes approximately one hour. The shortened exercise has been proved to be as efficient in identifying issues and problems related to the performance of the learning environment as the longer version. However, the abridged version is less effective for the interviewer to gain a deep understanding of the instructor's

educational goals.

The outcome of these exercises was a list of teaching and learning activities currently in practice at the MIT Department of Aeronautics and Astronautics. Later on, the author reviewed the list of teaching and learning activities with students.

The byproduct of these exercises was feedback from the class instructors regarding the learning environment.

After operating in the teaching laboratory for more than two years, the members of the department consider the teaching laboratory capable of supporting most of the needs of the department's education practice – especially in the first floor open area, the basement, the hangar and design studio on the second floor, where flexibility for adaptation to changing needs had been party of the reaching laboratory program and design concept.

The instructors reported that the audio and video equipment installed in the teaching laboratory were difficult to use. The user interfaces of the equipment were complex and confusing. There was no official technical supporting staff in the department for assistance. There had not been any organized sessions offered to train the members of the department on how to use the equipment. Because of the difficulties of using this equipment, the faculty members often hesitated to take advantage of it in the classrooms. The audio/video equipment was under-utilized.

During one of the exercise sessions, the class instructor expressed his wish to equip his students with wireless laptops so that students in his class could do hands-on exercises during the lectures and recitations.

Review teaching and learning activities with students

The review sessions started with discussing with the students what they would like to do after graduating from MIT, and what they expected to get out of their education at MIT. The list of teaching and learning activities, together with descriptions for each activities, and photos to demonstrate each activity was given to the students. The students were asked to read through the list, identify those they believed to be important for their education, and explain why they think those are important. Later they were asked to identify what activities they would like to have more.

The following summarizes feedback from students that suggested opportunities for improvements:

More TAs for more classes

Students talked about the difference between a recitation given by a class instructor and the recitation given by a TA. The purpose of the recitations is to review the concepts presented during the class lectures, introduce examples and answer students' questions. A class instructor is usually an expert on the subject s/he is teaching. Students reported that while a question was answered, an instructor would tend to say more than just answering the questions. More concepts were likely to be introduced. Thus the recitation would turn into a mini lecture session. Students often left the recitation with questions from the class lecture, which they were not able to ask because of the time limitation, and with more questions about the new concepts introduced during the recitation. When a teaching assistant gives a recitation, s/he normally still remembers from her/his own experience what are the materials students most likely have difficulties to understand. On the other hand, it is less likely for a TA to introduce new concepts or deliver mini-lectures during the recitation and s/he would most like to spend time on answering the students' questions and help the students to digest concepts from the class lectures.

In addition, if there is a TA for a class, that usually means there will be TA office hours, during which students can ask for individual help. In general, students found it is much easier for them to ask questions in a small group setting than in large group settings such as class lectures. They found that faculty office hours and TA office hours are extremely helpful.

More opportunities for hands-on learning

The redesigned curriculum of the department introduces hands-on learning in the classes. This has been greatly appreciated by the students. During the interview session, students expressed that they would like to have more opportunities for hands-on learning and more opportunities to use the tools in the machine shops.

Hard to find time for tinkering

One of the education modes defined by the department in 1997 is the Tinkering Mode. The Tinkering Mode represents the individual projects people do on their spare time. Due to the heavy workload for the undergraduate students at MIT, unsurprisingly the students expressed that they have difficulties to do work on individual projects. They see conducting extra-curriculum projects as important part of their learning. There are many students in the department have been actively engaged in extra-curricular projects despite the difficulty of finding time.

More opportunities to have contact with graduate students

have been minimum

Students expressed that they have had very little contact with the graduate students of the department except with several graduate teaching assistants. The graduate students in the department are spread out in several other building on campus. The learning community operating at the open area on the first floor of the teaching laboratory mainly consists of undergraduate students. The students interviewed expressed that they do not know what the graduate students are working on, or even what the faculty members of the department are working on. The undergraduate students, especially those who plan to attend graduate school later on, expressed that they would like to have more contact with the graduate students.

2.2.6 Examine The Learning Environment Through The Lens of Settings

Two more mental-map of physical space exercise sessions were carried on with the students during the second stage of the assessment.

Based on the information collected during the mental map exercise, the open are on the first floor continues to function as the space for the undergraduate learning community to operate within.

As predicated by the students a year ago, sophomore, junior and senior students are now sharing this space. Because the flight simulators have been moved to the hangar mezzanine area, there is more space in this area for furniture and tools for every student to use. Thus, the open area is not as crowded as the students imagined a year ago.

During the mental map exercise sessions and the open-ended interviews, students expressed that they wish there were more computers, especially those with Matlab[2] installed, in the open area for them to use.

More computers means less table and chairs in this area. Students expressed that they would trade the table and chairs for more computers. The decision-makers of the department, on the other hand, now view this space as a social area. They are worried that less furniture and more computers would weaken the capacity of this space to support social interactions. On the other hand, when the students were asked why they came to the open area, students frequently stated: " We come here to work, not to socialize!" One student said: " yeah, we would ask 'how is

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[2] Matlab is a technical computing environment for high-performance numeric computation and visualization, produced by The MathWorks Inc. It includes a number of subject specific toolboxes as well as a dynamic system simulation package, Simulink.

it going?' or 'what have you been up to?' when we meet here. But those are mostly short conversations, If we have a lot of to talk, we would go somewhere else."

The following are some of the reasons students reported to having attracted them to the open area:

"I usually come here between classes, work on home work, and wait for the next class."
" I come here when I have questions. There is almost someone here I can ask."
" It is the (Unified Engineering Class) TA hour. During the TA hour, most of us come here to work on our homework together. If we have questions, we can ask either one of the TAs or other students."
"My teammate and I are supposed to meet here. He is a bit late. But it is okay. I am just going to check email on this computer."
"I could have worked in the Design Studio upstairs. But it is Saturday. Most likely no one is in the Design Studio. I prefer to work somewhere with other people around, so I came here..."

2.2.7 Examine The Learning Environment Through The Lens of Individual Life

To find out exactly why the students come (and not come) to the open area and the teaching laboratory, and where they go, what they do, and how they spend their time, a group of 4 student volunteers were asked to record their waking hour activities for a week.

A template for the activities log was provided to the participating students to ensure the types of information to be collected. The students were asked to record what they do during which time at where and with whom. They were also asked to report the equipments and technology they. To ensure the level of detail of the information to be collected, a sample log was provided to the students. The sample log recorded the author's activities in a day.

Activities log template

When	Where?	What do you do?	With whom?	What do you use?	Further notes

building 33
other parts of the campus
home

class
recitation
tutorial
lecture

work alone

group study
team work
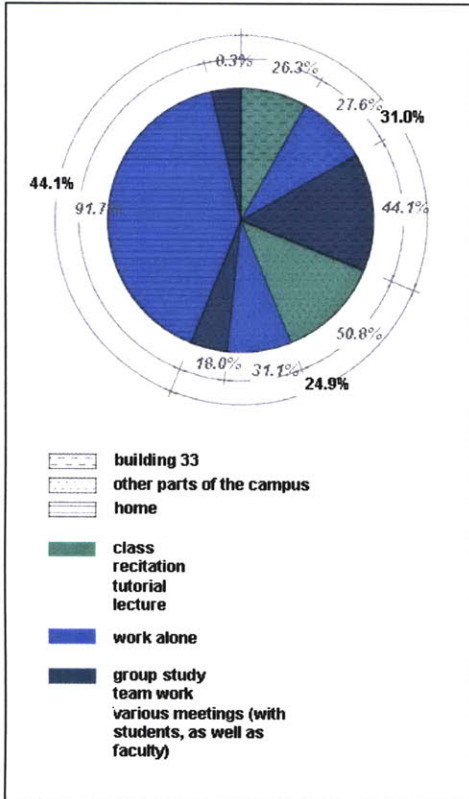various meetings (with
students, as well as
faculty)

Figure 2.2.7a

Figure 2.2.7a indicates how much time on average the interviewed students spent on studying at various places and whether they were studying individually or engaged in teamwork.

On average, the students participating this investigation spent 21 percent of their waking hours in the new teaching laboratory or the classrooms above the teaching laboratory. About 25 percent of their waking hours was spent on other parts of the campus. Approximately 44 percent of their waking hour was spent either at home. Teamwork of various formats accounted for about 40 percent of the time they spent in the new teaching laboratory. Attending classes and lectures accounted for approximately 26 percent of the time they spent in the teaching laboratory and the classrooms above the teaching laboratory. Working alone accounted for about 28 percent of the time.

When students worked outside the teaching laboratory, the amount of time they spent on working in teams was greatly reduced. Teamwork accounted for 18 percent of the time students worked in the other parts of the campus. When the students were working at home, only 8.3 percent of the time they were working with other people, either in person, or via phone, email and instant messaging.

Data also indicate that students spent large amount of time working at home. During the log review session, one student explained the reason she worked mostly at home was because she had everything at home. As most of the undergraduate students in the department, she did not have her own desk or locker in the new teaching laboratory. There was no space in the teaching laboratory for her to store personal belongings. She kept all the paper-based material, such as books and handouts, at home. Similar to most of the students who had participated in the assessment, she owned a computer at home. What different from other students was that her computer was configured with most of the software necessary to support her work. She preferred working at home also because her home is quieter than most of the settings in the teaching laboratory. She could concentrate better. A large portion of her collaboration with her teammates took place via phone, email, and instant massaging. She reported that she only came to the teaching laboratory when she had classes or when in-person meetings were necessary.

Another student also reported that he had a computer at home. He had difficulties to transfer files back and forth from the computer at home and computers at school. When he starts working on something on the computer at home, he usually would continue working on it at home. Unlike the previous case, his home is not a place for him to concentrate. He reported that when he works at home, he was often distracted by roommate,

video games, television etc.

In the logs, there were activities that could have taken place in the teaching laboratory, however, due to the lack of availability of resources in this area, students chose to go to other parts of the campus. For example, on one occasion, three students needed to work together on three adjacent computers. Since they could not find them in the teaching laboratory at the time, they decided to work in a computer lab at MIT Student Center. On another occasion, a student needed to use Matlab. Since there was not a computer with Matlab available in the teaching laboratory, he went to a computer laboratory on another part of the campus.

2.2.8   Explore Future Possibilities

Based on the information obtained from the mental map exercises, the students' logs and open-ended interviews with the students, what attracts the students to the open area is the resources, including human resources, available in this area to support the students' learning activities. The social activities taking place in this area are largely work-centered. If there were not enough recourses in the space to support the students' learning activities, the students would go elsewhere. Therefore, the students' desire for more computers in the open area should be considered. On the other hand, the decision-makers concerns must also be considered. The introduction of more computers into this space means there will be less table and chair in the space to support paper based teamwork and individual work. Introducing more computers into this space also means the space will be less flexible, for all the computers will be chained down to either the walls or the floors. In addition, desktop computers occupy a large amount of space. With more computers in the space, there might be less room for people.

One possible solution to solve this dilemma is to equip students with wireless laptops configured with necessary software to support their learning activities. The Laptop Computing Project at MIT presents an opportunity to obtain the laptops to equip the students. The Laptop Computing Project is an ongoing educational experiment at MIT. The intention of this program is to determine and measure the pedagogical and learning benefits of wireless, mobile computing in education. Students enrolled in a participating course receive laptops configured with software specific to that course, and are set up to work in MIT's wireless and wired networking environment. Support to participating students is provided through departmental staff and through Information Systems.

Providing students with laptops configured with necessary software means that the department does not have to introduce

more desktops into the open area. The open space could remain in the current configuration and the students will not have to worry about not being able to find a computer to use in this space. They can always bring their laptops. However, having a wireless laptop means that one can work anywhere and at anytime. This could mean that students will spend less time in the open area. This could weaken or even dissolve the learning community currently operating in this area. Another possibility is that the community will move toward more of a virtual community in which the members communicate via email, instant messaging, and chat rooms.

To investigate the impact the wireless laptops could have on how and where the students will spend their time, the same group of student volunteers who kept the 24/7 logs were asked to go through their own logs, activity by activity, and explain in detail how their day would be different if each of them had a wireless laptop with necessary software installed to support their learning activities.

Figure 2.2.7b

without a laptop   with a laptop

building 33   class, recitation, tutorial, lecture
other parts of the campus work alone
home   group study, team work, various meetings
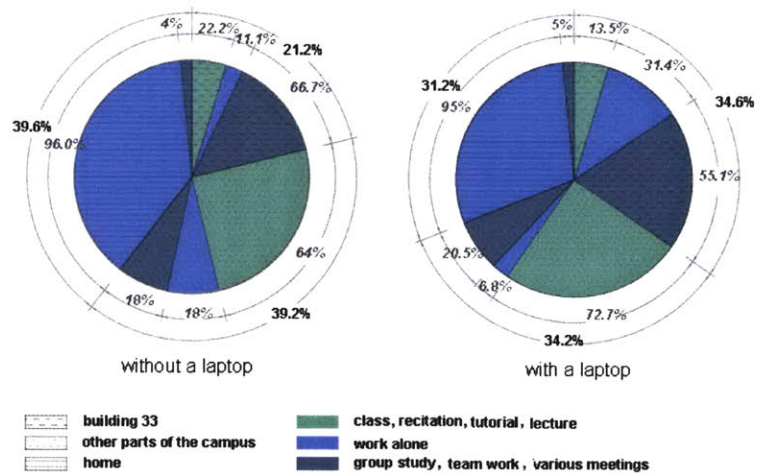
Figure 2.2.7b shows how and where one of the students spent time without a laptop and how and where he imagined he would spend his time if he had a laptop.

Surprisingly, the result indicates that with a wireless laptop, the student will spend more time in the teaching laboratory and most of the time will be in the open area. In addition, students expressed that the laptops might help them to work more efficiently. The reason is that when they work at home, they tend to be distracted by TVs, video games etc and when working in the teaching laboratory, they usually could concentrate better and get tasks done much quicker. Another finding is that the amount of communication among the students might increase if proper and standardized communication tools are installed on all the laptops. Two out of the four students interviewed have been

using instant messengers such as AOL Messenger and ICQ to talk with their friends. Students expressed that if they had laptop with the same instant messenger installed, they would use it to communicate with their classmates, friends, and TAs.

2.2.9 Explore Processes of Change

If informal learning is about learners taking advantage of resources, including human resource, that are available in his/her immediate environment, then a crucial first step would be for the learner to know what is available nearby and to become part of the ongoing processes of change.

In the case of the MIT Department of Aeronautics and Astronautics, a learning community has been operating actively. The open area on the first floor has been functioning as a home base for this learning community. The community consists mainly of undergraduate students in this department. The undergraduate students have minimal interaction with the graduate students. Students reported that they know very little about what the graduate students are working on. They do not know much about the faculty members' work either. On the other hand, the graduate students in the department belong to many of the many laboratories that are scattered in several buildings on campus. It is normal for graduate students in the Aero/Astro department to not know each other after many years of studying at MIT.

To provide opportunities for the graduate students to form a departmental learning community, and for both graduate and undergraduate students to be better informed about the intellectual resources available in the whole department, an exhibition was proposed by the author. The proposed exhibition features both curricular and extra-curricular work of the graduate students and undergraduate students, and also work of faculty and staff members of the department.

The planning process of the event was also seen as an opportunity for bringing the graduate students and the undergraduate students together. To explore this opportunity, this exhibition needed to be an event that was co-organized by a group of graduate students and graduate students.

By the end of December 2002, an event organizing team had been established. The exhibition is planned to take place at the beginning of February 2003.

3 REFLECTIONS

3.1 Team Space and Teamwork

Student project team members meet with class instructor during faculty hour in one of the project rooms on the first floor.

Students work on team project in the Design Studio on Saturday afternoon

A naïve belief that has been popular among the designers for sometime now is that if we provide team space, team behavior will be encouraged and eventually happen. Recently, this belief has been frequently questioned. In the book entitled 'Workplace by Design', Becker and Steele (1995) remarked:" Physical design, by itself, will not change behavior patterns and guarantee teamwork. It can make some activities more likely than others, and when it is in tune with the social system, it can create the kind of lively, interactive setting that supports teamwork and collaboration."

In the case of the MIT Department of Aeronautics and Astronautics, what made the learning environment a successful teamwork environment is not simply because the spaces are designed to facilitate teamwork, but more importantly because the classes are structured in such a way that either requires the student to work in teams, or encourages them to study in groups. Overtime, the students realize how teamwork can help them to learn more efficiently and more effectively. A culture of teamwork is thus installed among the learners. During the assessment, the author noticed cases where students forming teams on their own to work together. These teams were formed not because class requirements or because it was recommended by class instructors, but because the students had come to realize how rewarding teamwork can be. In some of the cases, students formed teams with students from other departments to work on extra-curricular projects.

### 3.2 Flexibility, Adaptability, and Agility

Flexibility refers to the capacity of a place to support a variety of activities that have different demands on the space. It suggests that the users of a place can easily rearrange the resources available at the place to undertake actions.

In the case of the MIT Aero/Astro new teaching laboratory, the flexibility of the place is achieved not only by the reconfigurability of the resources available in space, the but also by the "porosity" of the space.

Porosity of a space refers to characteristics of the spatial arrangement that affords an individual located at one space to

view other spaces, people in other spaces, and activities taking place in other spaces. In this way the porosity of the space enhances opportunities for users to choose appropriate settings to learn. In the teaching laboratory, partitions of spaces are often transparent glass walls to preserve visual continuity. The stair between the open area and the library provides visual connection between the basement and the first floor areas. Another example is the windows of the design studio that open towards the hangar mezzanine area.

Cross-section of the teaching laboratory
Source: Cambridge Seven Associates
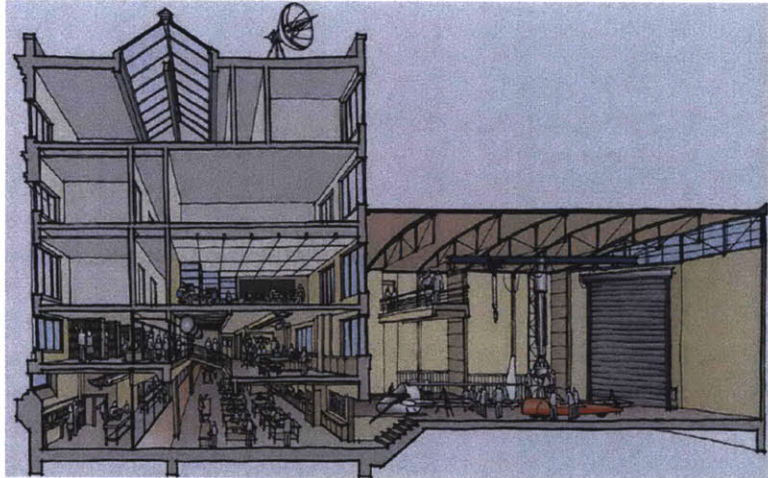
First floor

Left: space between hangar mezzanine and the design studio

Right: From basement workbench area look toward the machine shops

The rigorous investigation into the department's teaching and learning activities, and the carefully formulated requirements for the new teaching laboratory conducted prior the design of the teaching laboratory were critical in ensuring the flexibility of the place. However, the department was aware of the necessity for the teaching laboratory to accommodate unexpected demands. One of the design principles for designing the teaching

laboratory was 'not to over design, let it evolve'.

Adaptability refers to the capacity of the place to accommodate unexpected demands. The first floor open area was originally designed to be the area for operation. It is no functioning as a kind of student lounge where students come to work in teams as well as individually. During an on-site observation session, the author witnessed another unexpected activity taking place in the open area.

On that day, a class was scheduled to have a students' project process review in room 33-116. Due to an unexpected event that had to take place in the same room at the same time, the class moved to the open area. A Steelcase Pathway system partition curtain was drawn, dividing the space into two. On one side, the class divided into groups, rearranged the tables and chairs, and set up whiteboards to sketch on. The progress review took place in the open area. On the other side of the curtain, the students worked as usual.

Left: Student projects review in the open area

Right: On the other side of the curtain
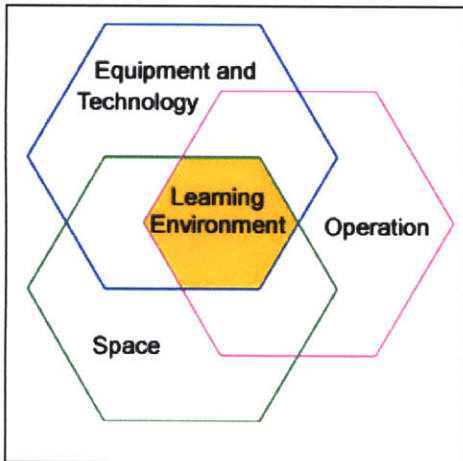
Conceptual structure of learning environments

If the flexibility and adaptability of the learning environment reply heavily on the design of the space, equipment and technology, to achieve agility, the operation of the environments plays the crucial role.

Agility of the learning environments refers to the ability of the learning environment to quickly and effectively respond to changes. It requires the managers as well as users of the learning environment to have to ability of detecting changes and to have the will of making continuous improvement through experimentations. At the core of the operation of an agile learning environment is the attitude of viewing both education practice and learning environment as something that can be improved through continuous assessment and experimentations. In the case of the MIT Department of Aeronautics and Astronautics, this attitude is not only held by the decision makers, but also by all faculty and staff members. The class instructors are encouraged to actively search for better ways of teaching and learning.
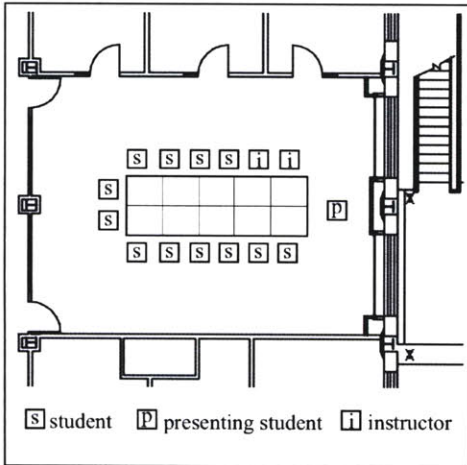
S student   P presenting student   i instructor

Figure 3.2a

S student   P presenting student   i instructor

Figure 3.2b

Students' project presentation in the Design Studio

The usual arrangement in the design studio during students' project presentation is indicated in figure 3.2.a.

The class instructors noticed that with this arrangement, because the class instructors sit close to the presenting student, the student tended to speak relatively softly, especially during questions and answers. The presenting student's voice would be loud enough for the instructors to hear, however, the rest of the participants, especially those sitting at the back of the room might have difficulties to hear. This made it difficult for them to actively participate the discussion. To improve this situation, for a presentation took place in last November, the class instructors decided to arrange the room as indicated in figure 3.2b. In this arrangement, the instructors sat at the opposite side from the presenting student. The intention of making this change was to force the students to speak louder so that everyone in the room could hear the presentation and participate the discussion. This arrangement also increased the length of the tableside so that more people can sit around the table and feel involved.
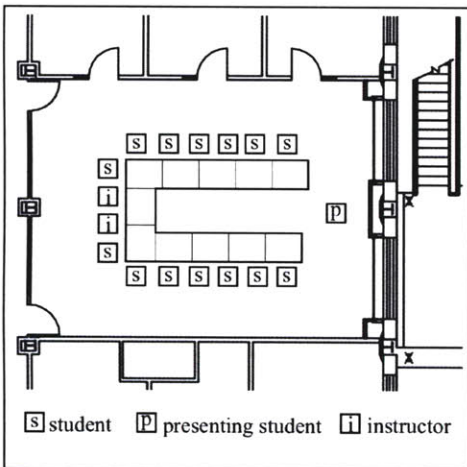
Another example is how the department realized the first floor open area has become a space for the undergraduate learning community to operate; the department then decides to change accordingly their intention of how to use this space.

3.3   Conceptual Structure of Agile Learning Environments

Conventionally the operation of learning environments means facilities management. However, the case of the MIT Aero/Astro new teaching laboratory demonstrates that teaching and learning itself is crucial in managing an agile learning environment that supports and co-evolves with the teaching and learning activities. Therefore, the author argues that teaching and learning itself should be included in the operational dimension of the learning environment.

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