From the Ground Up: The Challenges and Triumphs of Building a New Multi-use Lab

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Abstract:

After twenty-eight years of sharing labs with Rochester Institute of Technology's Mechanical Engineering Department, the Manufacturing & Mechanical Engineering Technology Department had the opportunity to develop new laboratory facilities due to enrollment growth in both departments. The Manufacturing & Mechanical Engineering Technology Department had nine months to design, equip, and implement a multi-use lab in a new building. The lab had to serve courses in materials testing, statics, strength of materials, dynamics, geometric dimensioning & tolerancing, and hydraulics in order to maximize space utilization. The budget established for this was approximately $240k.

This paper describes the process that was followed from conceptual design to class use. Some of the important aspects of the process were 1) the challenges resulting from having multiple classes, and most faculty, sharing space; 2) the process of selecting equipment which balanced educational needs, budget, and lead time restrictions; and 3) the involvement of students projects to design and build lab equipment as well as to ameliorate the noise and vibration concerns raised by other departments occupying the building.

Background:

The engineering technology programs at RIT have shared space in the James Gleason Building at RIT with the engineering programs since they were started in 1970. Over the years, both the engineering technology and engineering programs have expanded. New programs have been added in both areas requiring additional space for laboratories and faculty offices. To accommodate the growth, several classrooms were converted to laboratories and office areas and additional space was found in other buildings. This resulted in a reduction of several classrooms in the Gleason Building, and faculty and laboratories for both engineering technology and engineering were spread between several buildings. In addition, the Gleason Building, which was constructed in 1968, lacked the infrastructure to support the complex and changing needs for the programs it supported.

In 1994, a joint task force of engineering technology and engineering faculty, staff and administrators was formed to plan the renovation of the Gleason Building. This group met numerous times from 1994 to September of 1998 in an attempt to plan the renovation of the Gleason Building to satisfy the needs of all the occupants. The problem was made even more difficult because the renovation was to occur while the building was still at least partially occupied and used for instruction. Despite extraordinary cooperation between the academic departments there was just not enough space. Also, the problem of carrying on the academic programs at the same time as the renovation was not practical.

As a result, in the fall of 1998 RIT decided to construct a new building to house the Electrical Computer and Telecommunications Engineering Technology Department, the Manufacturing and Mechanical Engineering Technology Department (MMET) and the Information Technology Department. Although this was a reasonable solution, it presented some very difficult problems. The external funding for the Gleason Building required that renovation begin in the spring of 1999. That meant that the new building had to be designed, constructed and equipped for the fall of 1999. A decision was made to construct a fast-track building that would accommodate the most crucial needs of the departments and to follow it up with an addition to the building to provide for the remaining needs.

The initial planning for Phase I of the new building began in November 1998 with an allocation of space. After some negotiation, the MMET Department was allocated 2560 ft^2 of lab space and 120 ft^2 for storage. The remainder of the MMET Department laboratory needs are to be met in a Phase II building.

Challenges:

A. Sharing

The decision was made to build and equip a multi-purpose lab to be used for materials, mechanics, pneumatics and hydraulics, and metrology labs in this space. This was decided because there were no other temporary alternatives for these labs, but there were for other labs that are used by the department. A multi-purpose lab was proposed to maximize the utilization of space within the department. This had been done successfully in a lab in the Gleason Building for mechanics, pneumatics and hydraulics, and metrology and it was felt that the addition of a materials capability in the lab would be workable.

The problems associated with a multi-purpose lab include scheduling, conflicting interests of different courses, and the desire to use the equipment for industrial testing and experiments. Due to the many courses served by this lab, it is necessary to schedule some classes at common times. To accomplish this, courses that are compatible have been identified and are scheduled at the same time. This prevents two courses requiring the use of the same equipment from being scheduled at the same time, and also minimizes confusion in the lab. Although there is a desire to allow industry to use our equipment, the priority for use of the lab is for instructional purposes for RIT students. Industrial use of the lab is scheduled at times when the lab is not in use for courses.

Furthermore, the other departments sharing the building expressed concern regarding the potential noise and vibration that may be caused by the operation of equipment in the lab. The source of vibration and noise are the fatigue testing machine and hydraulic trainers. This problem was solved by installing sound absorbing material in the ceiling and ensuring that the magnitude of noise transmission through the walls and ceiling were low enough to prevent noise problems in adjacent spaces. In addition, two student projects were undertaken to reduce the noise generation at their source. These projects are described later in the paper.

B. Equipment

The primary need for new equipment to get the new lab functional was for a materials testing lab. This equipment was identified by the end of February. This would require a capital expenditure of $240k. The details of the budget can be found in Appendix A. At $100k, the most expensive item was the universal-testing machine. Initial contacts with vendors indicated that procurement would require a six to eight month lead-time. To have this equipment installed and instructors trained on its use by December 1 meant that it needed to be ordered in March. Unfortunately the funding was not released until the end of May. A different vendor was found; MTS would supply a 45,000 lb.-capacity system in four months.

Part of the budgetary agreement was that MMET would take over some of the ME department's old equipment. Only equipment that had limited use in the MMET Department, were in reasonably good condition, and where new models had not changed significantly in the last 30 years was determined to be acceptable. The Tinius-Olsen Air-O-Brinell and impact tester could be used with some repairs. The hand sanding stations for metallographic preparation could also be used. This reduced the budget to $215k. The repairs to the Brinell and impact tester had to come out of the departmental operating budget instead of the new equipment fund.

As new material testing equipment was selected, the current needs of the introductory materials testing course, future growth, and student projects had to be balanced against time and budgetary considerations.

Planning for the future was accomplished through two routes. One was to obtain equipment that can be used for industrial testing. This allows for a revenue stream to be available to maintain and calibrate the current equipment, as well as provide money for future equipment. The second approach was to buy equipment that would meet the immediate needs and could be improved by add-on accessories. For example, the heat treat furnace chosen was a Lindberg 12" x 12" x 30" box furnace for student projects and student teams, such as the SAE Mini Baja team. This furnace can have a retort added to allow atmospheric control, which would give us additional experimental capabilities. The polishing wheels were also chosen with expansion in mind. While budgetary restrictions would not allow us to buy the automatic polishing heads, the model chosen can have the heads added at a later time.

C. Student Projects

Four student projects were completed to assist in getting the lab operational. The first arose from difficulty in finding a supplier for a Jominy test fixture. This fixture is used to test the hardenability of steels. A survey of a few other universities' materials testing labs revealed that many schools made their own fixtures. This project was assigned to an independent study student. The student was tasked with researching the requirements of the fixture, designing, building, and testing the fixture, all within a ten-week quarter. Figure 1 shows a picture of the completed device.

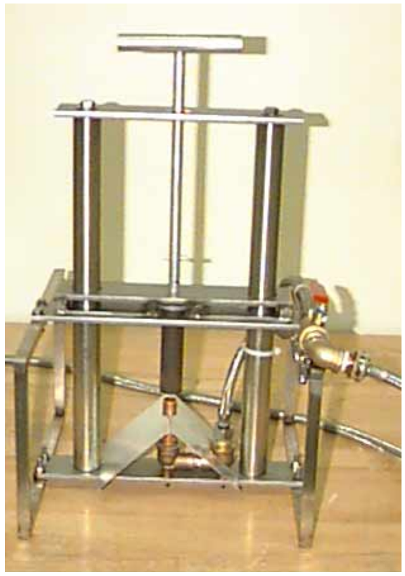

Figure 1. Student-designed Jominy hardenability test fixture. Tank removed for better clarity.

The second project involved reducing the noise from the hydraulic trainers used in the Pneumatics and Hydraulics course. The quietest of the four trainers is approximately 70 dB. The addition of various circuit elements adds to the noise levels. One team of students in the upper-division technical elective Vibrations & Noise was given the task of reducing the noise from these trainers. The students measured the sound levels at different frequencies from 31 Hz to 16 kHz. By exploring different options the students were able to reduce the high frequency vibrations by 15 dB. Unfortunately the students had less success at reducing the lower frequency vibrations, achieving only a 1 – 2 dB reduction at frequencies below 1 kHz.

Another team of students in the Vibration & Noise course was given the task of designing and building the vibration isolation pad for the lab. When the building was designed, this pad was planned for to help reduce the vibrations transmitted to the building from the fatigue tester. The team of students researched different isolator and floor design options. The pad was designed such that it could be lifted by a 2000-lb engine hoist and the isolators could be changed. By this design, the pad will be used as an experiment in future Vibration & Noise classes to test how different isolators behave. Springs, neoprene rubber, and fiberglass isolators were all donated. The team had responsibility for designing the pad, procuring the materials, and fabricating the pad.

The fourth project was to replace the impact head of the Tinius-Olsen impact tester. The model owned by the MMET Department is no longer made and replacement parts are not available. Creation of the drawing of the impact head and machining of the head were projects for students in the computer-aided drafting and machining classes.

Concluding Remarks:

The biggest problem encountered in this project was the tight schedule required for making decisions and implementing them. This was aggravated by the slow response of the administration in releasing funds for the purchase of equipment. These difficulties were overcome by paying careful attention to detail in planning for the lab, adhering strictly to the part of the schedule that could be controlled by the MMET Department, and assessing alternatives as soon as problems arose. All of this was accomplished with exceptional input and cooperation from faculty, students, and the MMET Department administration.

Phase II of the building will require the construction and equipping of a thermal fluids lab and perhaps a machine shop, a manufacturing processes lab, and plastics lab. Although time constraints are not likely to be as severe a problem in Phase II, the lessons learned in Phase I will provide guidance. For example, it is apparent that paying careful attention to details and dealing with problems as soon as they occur are very important. Also, the model of having student projects contribute to the design of the lab proved to be helpful and will be used again in Phase II.

Due to the combined efforts of all those involved, the lab was completed on time and under budget for classes at the beginning of Winter Quarter in December of 1999. The lab is well equipped and very functional with some very nice state-of-the art equipment. It has become a showplace for the MMET Department. With its completion, we have turned what was a deficiency, from a program perspective, in to an asset.

Appendix A: New materials testing equipment budget

Equipment	Manufacturer	Budgeted	Actual Cost
Universal testing machine	MTS	$100,000	$102,790
12"x12"x30" Heat treat furnace	Lindberg	$13,145	$13,145
Quenching station	Lindberg	$1,380	$1,380
Rockwell hardness testers (2)	Instron	$30,900	$26,762
Cut-off wheel	Buehler	$8,400	$8,595
Jominy end quench		$2,000	$150
Polishers (4) – with tables	Buehler	$26,930	$17,060
Wet belt sander	Buehler	$3,230	$3,295
Computers with Carts (3)		$10,000	$4,797
High power microscopes (2)		$8,000	$18,093
Low power microscopes (2)		$8,000	donated
Specimen mount press	Buehler	$2,470	$2,525
Sanding stations	Buehler	$1,565	not funded
Impact tester	Tinius-Olsen	$12,615	not funded
Brinell hardness tester	Instron	$11,840	not funded
	Requested	$240,475	
	Allocated	$214,455	
	Spent		$198,592

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