CASE
CASE WESTERN RESERVE UNIVERSITY

Case Western Reserve University
Case School of Engineering

MEMORANDUM

FROM: Eric Braun, Nicholas Duval, Jean Enge-Janes
TO: James Drake
DATE: April 17, 2005

SUBJECT: Feasibility of Creating an Undergraduate Student Manufacturing Studio within the Case School of Engineering

Summary

Throughout the course of the spring semester, our group has investigated the feasibility of building a new undergraduate manufacturing studio within the Case School of Engineering. Based on factors discussed in this report, we recommend an immediate effort to secure space and funding to set up this facility. Due to cost and safety concerns, we recommend initially creating the studio as a storage and light machining facility with a yearly budget that will be used to gradually improve its manufacturing capabilities.

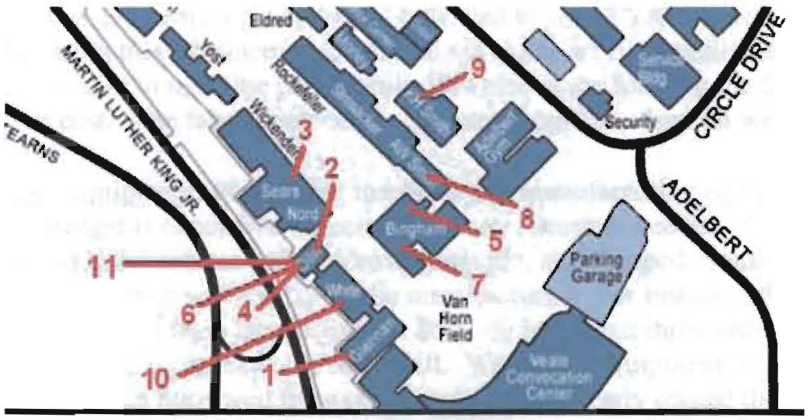
The three members of our group are engineering students at Case who have each been exposed to the manufacturing options currently available to students. We have become familiar with the structure and organization of the facilities, and we have interviewed the staff and faculty operating those facilities. Through this exposure, we have noticed a severe lack of manufacturing space for students.

The purpose of our proposed studio is to provide a safe and organized space where students can create, assemble, and store projects in one place. Students would be able to work on design projects on their own time instead of making appointments with already busy staff members or pay for professional fabrication. With proper training through safety classes, the facility would be open to all students on campus 24 hours a day.

The main criteria we used to evaluate the creation of this studio were cost, space consideration, student interest, and faculty opinions. We conducted a search for a suitable

room, interviewed faculty and staff members, compiled budgets for two alternative studio concepts, and surveyed over 200 Case students. Through our research, we determined that creating a student manufacturing studio is feasible if plans to build it are discussed and finalized promptly. The proposed location of this studio is rooms 103 and 107 in the Olin building. Figure (1) below shows the general location of this facility on a campus map relative to the engineering departments and other machine shops.

Figure 1 - Location of Proposed Manufacturing Studio



1 - MAE Department 2 - EECS Department 3 - BME Department
4 - Reinberger Shop 5 - Bingham Shop 6 - Manufacturing Services
7 - CIVE Department 8 - ChemE Department 9 - Macromolecular Department
10 - Materials Science Department **11 - Proposed Lab Space**

The studio is located near the center of the Case School of Engineering general area, and it would be near other machining facilities like the Bingham machine shop and the Reinberger Lab.

Introduction

At present, there are only four manufacturing options available for individual students and design groups. These options are listed below with brief descriptions.

- Bingham Machine Shop: Offers a wide variety of manual machines to use for wood and metal projects such as lathes, end mills, grinders, and welding equipment. It is only open to students who have taken EMAE 172 or an equivalent class. The hours of operation are 9am-5pm on weekdays, and the shop is used for classes on Mondays 12:30-4:30 and Tuesdays 9:00-2:30.

- Reinberger Lab: Contains computer-aided manufacturing machines used for more elaborate and precisely machined parts. This facility primarily supports mechanical engineering manufacturing courses and is only open to students in those classes and other engineering groups. The hours of operation are 9am-5pm

on weekdays, and the lab is used for classes on Wednesdays 12:30-4:30 Thursdays 10:00-12:00, and Fridays 10:30-12:30.

- Engineering Services Fabrication Center: Manufactures parts according to customer's designs. Students without manufacturing experience often choose this very expensive option because of its convenience even though ESFC charges approximately $45.00 per hour plus material costs for each project or part. Design groups with budgets can use them to pay for these fabrication costs, but individual students must pay out of their own pockets. For instance, Eric Braun and his pulsejet project group would have had to spend $900.00 out of pocket for machining in this lab since undergraduate projects are not usually funded, but they were able to machine parts themselves elsewhere for only the $100.00 material cost. The fabrication center operates from 8am-4pm on weekdays.

- Purchase equipment: Purchasing machining or manufacturing equipment with a project budget is expensive especially if many items are needed. Once an equipment purchase has been approved, bought, and shipped, training may still be necessary for even a single part to be manufactured. For instance, the Case Design/Build/Fly team has spent over $500.00 in the last three years buying wrenches, hand tools, and a Dremel drill. While this equipment was essential, it could have been borrowed from other groups that already owned the tools since they were not used very often by the team.

These options are extremely limiting for students who must pay to use the ESFC since the majority are not Mechanical Engineers in manufacturing classes. Even those students who are fortunate enough to have access to the Bingham Shop and Reinberger Lab do not have a place to manufacture parts after 5:00pm or on weekends since those facilities are closed. When classes are held in these labs, staff members are unavailable to offer much help with the projects of individual students or design groups. These restrictions make it difficult for students to work on a part at their convenience. For the design groups, departmental budget money is limited, so having to purchase machining equipment limits the quality of other parts that these groups can purchase.

In addition to the lack of manufacturing options, students also encounter problems storing, securing, and finding work space for their projects. Often, student design groups have no choice but to share laboratory space in already crowded environments. We have found the following primary options available to students:

- Bingham Machine Shop: Some groups are able to store parts of their projects here, but since the area is primarily for machining there is little storage space available. There are no storage lockers for general student use.

- GM Engines Lab: Located in the basement of Glennan, this lab is used for research. Although there is a small area that students use to store class projects, there is so much clutter that it is inconvenient to work on projects there.

- Robert M. Ward Lab: This lab, in Glennan 422, is the current workspace for the Design/Build/Fly team which shares the area with many students working on projects and experiments. No machining equipment is available in this space.

Since project storage space is so scarce, workspaces often become disorganized and cluttered. The lack of secure storage space has even led to misplaced items and some hand tools thefts.

Finally, software necessary for running CNC (Computer Numerical Control) equipment is difficult for students to access. Programs like *Mastercam 9.0*, used for CNC machining, are not readily available for student use. This program and others like it are integral in the manufacturing process and there should be available in a location where they can be easily accessed by undergraduate students.

A solution to these problems is to create a new manufacturing and storage option: a student manufacturing studio. This studio would positively impact the University and the School of Engineering in several ways. Opening a studio would give students a chance to design parts at their leisure which would speed up the manufacturing process, decrease the time needed to build, and increase the quality of a finished project. The studio would provide ample storage space with secure cages and lockers as well as an open work floor with machining equipment.

In addition to these immediate benefits, the studio will also have a positive impact on the engineering students' morale. An easily accessible, centralized lab will bring engineering groups closer together, as well as encourage creativity and collaboration between different areas of the University. 32% of the students surveyed indicated that they would be more likely to pursue personal projects if there was more space available on campus. If the Case Western Reserve University is indeed one of the most powerful learning environments in the world, a studio that promotes innovation through manufacturing among its students should be seriously considered.

This study evaluates the feasibility of every aspect of the creation of this studio. We have compiled a list of equipment and personnel costs and we have interviewed faculty and staff members in order to determine a suitable location for the facility. Finally, we surveyed graduate and undergraduate engineering and arts and sciences students to gather feedback in order to create a studio that would meet their expectations.

Critical Criteria Considered

We considered many important factors in determining the feasibility of a Student Manufacturing Studio but found the expenditures, space considerations, and student and faculty interest to be the most crucial. We will elaborate on each topic in the following order:

Studio Expenditures

- Space renovations
- Equipment and tools
- Employees (full-time and student)
- Annual cost (expansion and maintenance)

Space Considerations

- Location
- Size
- Access
- Safety
- Necessities (electricity, lighting, ventilation)

Student and Faculty Interest

- Administrators (funding & setting up)
- Faculty (overseeing the studio)
- Staff (operating the studio)
- Students (users)

Methods of Research

We consulted several resources while considering our criteria. Little information has been written on any subject near to this idea, so it was essential to talk to faulty and staff members who would know where to begin this research process.

Studio Expenditures

To determine the cost of the studio and develop an annual budget we used several methods. We began by interviewing Professor Malcolm Cooke, the Director of Technical Support Services and a professor in the Mechanical and Aerospace Engineering department. Professor Cooke was helpful in identifying the types of expenditures we would need to include in our budget. He suggested that we separate the budget into capital expenses and revenue expenses. Capital expenses would be those which are needed for the initial set-up (equipment, storage, benches, etc). Revenue expenses would include annual operational costs (consumables, staff salaries, maintenance, safety equipment, telephone and internet service, and the costs of the space and utilities). Details of our budgets can be seen in the Overview of Studio Design

Alternatives section. To see an outline of the interview with Professor Cooke, please refer to Appendix A.

After meeting with Professor Cooke, we interviewed James Drake, Assistant Director of Technical Support Services, who was very informative since he has worked on plans to create a space similar to our studio for some time. Mr. Drake provided us with information on the costs of equipment and renovations that may need to be completed, as well as annual maintenance costs of the location we are considering in our budget (Final budget information can be found in Appendices E and F). Since he plays a lead role in the operation and management of the Bingham machine shop, Mr. Drake was well qualified to advise us on all matters related to studio expenditures.

Other universities with spaces similar to our student manufacturing studio concept, Tufts and Carnegie Mellon, were contacted for any advice that they could contribute. Unfortunately, neither school responded with a satisfactory answer to any of our questions. To see the questions that were sent to these other schools, please refer to Appendix B.

Space Considerations

In an interview with Dean McGuffin-Cawley, we discussed the importance of a good location and the space requirements of several studio setups. Most of the discussion was general, but the interview helped us redefine our future research. He suggested that we make a budget based on what we absolutely need to start the studio since funding is more likely to be approved if a smaller budget is requested. To see an outline of the interview with Dean McGuffin-Cawley, please refer to Appendix C.

Specific locations were discussed during the interview with James Drake. Mr. Drake identified Olin rooms 103 and 107 (which are connected) as a good location for the studio as opposed to the smaller labs on the second floors of Glennan and Olin. He provided a floor plan layout of Olin 103 and 107 which was simple to update for our needs since he had developed similar plans in the past. Mr. Drake also referred us to Professor Kenneth Loparo, whom he believed was currently in control of the space.

Student and Faculty Interest

To judge the interest of the student who would be using the manufacturing studio, we created a survey which was sent to the following departments:

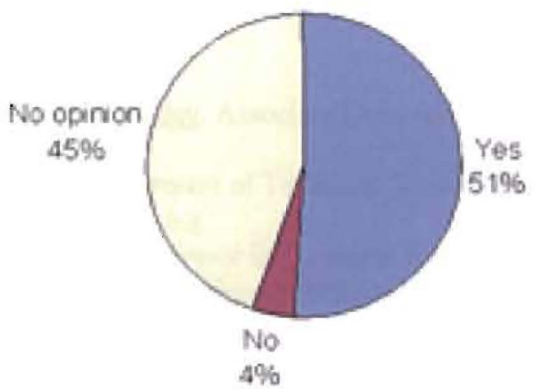
- Biomedical Engineering
- Chemical Engineering
- Civil Engineering
- Electrical & Computer Engineering
- Macromolecular Engineering
- Materials Science
- Mechanical & Aerospace Engineering
- Astronomy
- Biology
- Chemistry
- Mathematics
- Music
- Physics
- Theater
- Geology

Between March 17 and April 1, 2005, a total of 230 students participated in the survey, representing many areas of study. Students from Biomedical Engineering, Mechanical Engineering, Computer Science, and Electrical Engineering were among the top responders. There are several important results that should be noted.

First, it important to determine how many students use the current manufacturing facilities. About 39% and 18% of respondents use the Bingham Shop and Reinberger Lab, respectively. Since only 18% of those surveyed were Mechanical Engineering students, it seems evident that students in other areas also have manufacturing needs.

Our survey went on to ask if students would like to see more space on campus to create, assemble, and store their projects, and the majority of respondents indicated that they would. This can be seen in Figure (2) below.

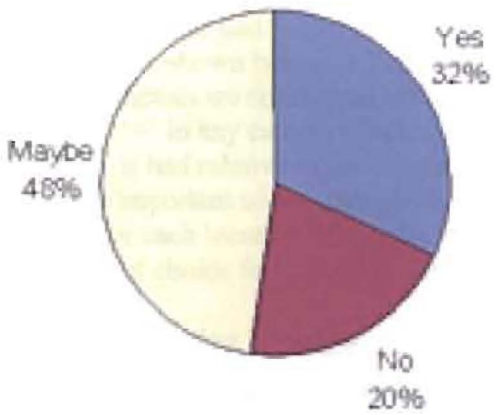
Figure 2 - Percentage of students who would like more space



Our survey also asked students if they thought having more space on campus would encourage them to work on personal projects and hobbies that involve fabrication

or assembly, and many stated that they would. Please see Figure (3) below for these results.

Figure 3 - Percentage of Students Who Would be Encouraged to Pursue Personal Projects



Finally, the survey asked what equipment and materials the students would like to see if a manufacturing studio were established. The most popular responses were wrenches and screwdrivers, a drill press, clamps, hand-held power tools, sanders, wood and metal stock (materials available for use), and a computer. To see the full survey and results, please refer to Appendix D.

We conducted several interviews with faculty and staff members to determine the involvement that the University would play in the development and support of a student manufacturing studio. We spoke with the following people to determine faculty and staff interest:

- Dean McGuffin-Cawley, Associate Dean for Undergraduate Programs in Engineering
- Professor Cooke, Director of Technical Support Services and professor in Mechanical Engineering
- Professor Loparo, professor in Electrical Engineering
- James Drake, Assistant Director of Technical Support Services and head of the Bingham machine shop

All interviewees expressed interest in providing support of some form and were generally excited about the project.

Overview of Studio Design Alternatives

After researching the range of possibilities for the creation of a studio, we realized that more than one concept should be created and evaluated. Since the cost of this studio could vary as much as $100,000.00 depending on the equipment purchased, we decided to first pick a suitable room and then create both a low cost and a high cost option.

Studio Location

During our research, we found several locations within the School of Engineering that we decided to consider. The positive and negative aspects of each were considered in a weighted Pugh screening matrix, shown below in Table 1. This Pugh screening matrix evaluates all the desirable factors we considered critical for the studio and creates a relative score for each room. A '+' in any category indicates that the room is good relative to the other rooms. A '-' is bad relative to the others and a '0' is relatively neutral. Certain factors are more important so they are given a larger weighting factor. While looking at the final score for each location, it is quite apparent that rooms 103 and 107 in the Olin building are the best choice for assessing the feasibility of a studio.

Table 1 - Studio Location Weighted Pugh Evaluation

Desirable Qualities	Weighting Factor	Glennan 422 Lab	Olin 103/107	CAISR Lab	Combustion Lab
Ground Level location	.3	-	+	-	+
Open Space	.25	0	+	0	-
Doors	.05	+	+	-	0
Electrical Outlets	.1	+	-	+	0
Lighting	.1	+	0	+	0
Ventilation	.05	-	0	0	0
Centralized Location	.1	0	+	0	0
Noise Control	.05	-	+	+	0
Total Score	**1**	**-.15**	**.65**	**-.1**	**.05**

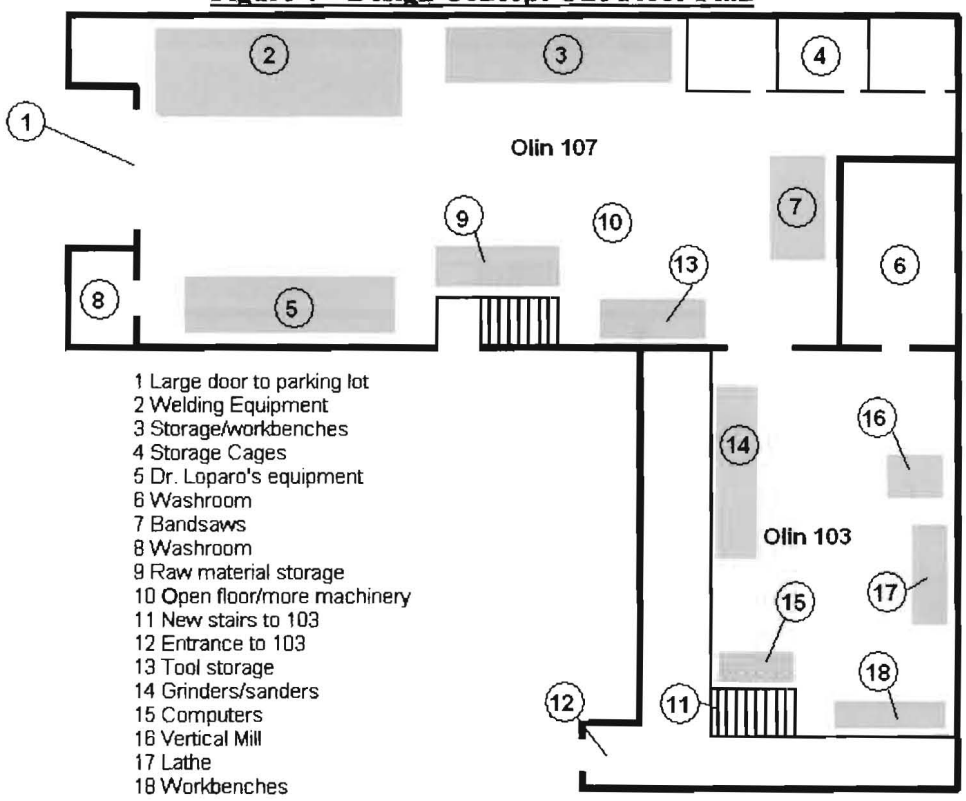
Studio Concept One

Our first concept is the creation of a large, well-funded facility with storage space and a full collection of manufacturing machines and tools. After reviewing catalogues to get an idea of the types of machines and tools available, we created a budget with funds for purchasing the items necessary for building a complete machine shop. We determined that the rooms would need to be renovated to improve and upgrade the internet connection, ventilation, stairs and electrical outlets. We also found that it would be necessary to hire a full-time employee to run the facility. The initial cost estimate for this concept studio is $139,000.00 with an annual cost after the first year of $62,000.00. A detailed budget for the facility is shown in Table (E1) of Appendix E.

A floor plan of the facility is shown in Figure (4). For this concept, Olin 103 would house two computers outfitted with programs like *Pro-ENGINEER 2001* and *Mastercam 9.0* for designing and machining parts. In the floor plan below, we arranged the machines to fit easily into the rooms with the welding equipment located near the entrance so the doors can be opened for maximum ventilation while welding. In the upper right corner of Olin 107, storage cages would be available for larger projects. Olin 107 would also provide plenty of open floor space for students to work on and store projects.

A full-time employee would be needed to supervise the studio. The role of this employee would be to oversee the studio between the hours of 2:00 P.M. to 10:00 P.M. It would be desirable for this employee to work when classes are not generally held, so working 4 weekdays and on Saturdays would be an ideal schedule. The employee would also be in charge of classes held to instruct students on how to use the equipment. In order to use the equipment, a student would have to complete one of these classes.

Figure 4 – Design Concept One Floor Plan



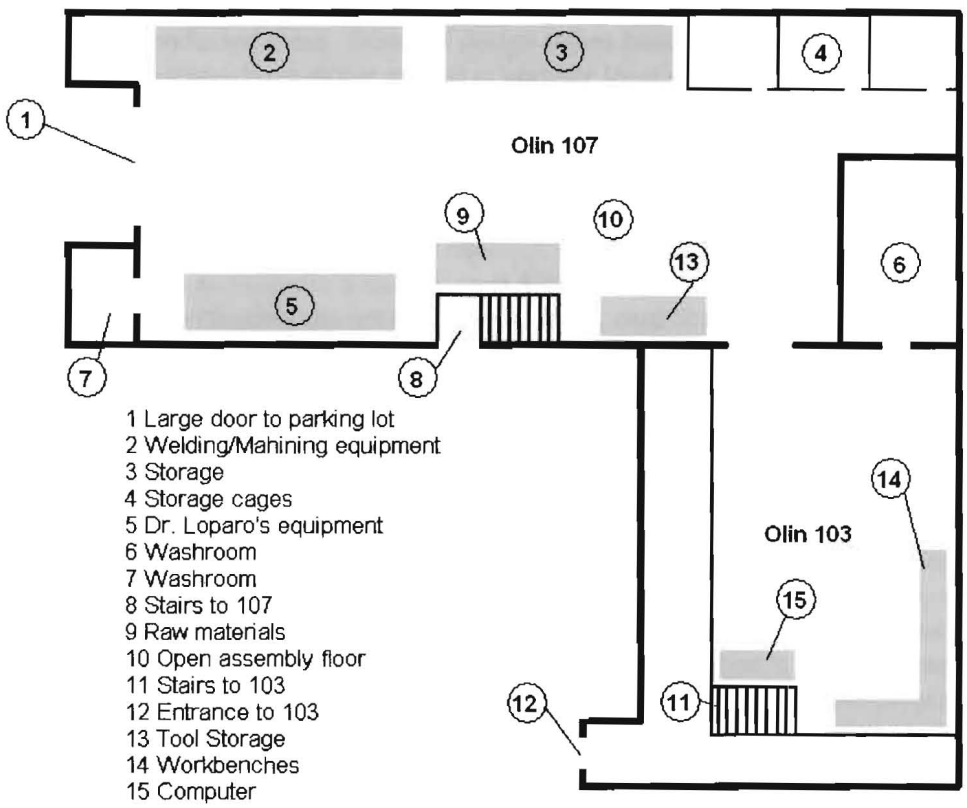
This drawing is not to scale, but room sizes are approximately proportional.

Studio Concept Two

While a studio with full funding would be wonderful, the majority of problems that undergraduate students have with manufacturing can be solved with a much simpler facility and budget. This concept will center on improving the quality of the rooms themselves, creating an open floor to work on projects, creating storage space, and building a collection of tools and machinery over time.

The initial cost of this concept is $27,000.00, with an annual budget of $20,000.00 for buying new equipment and improving the studio. A detailed budget for the facility is shown in Table (F1) of Appendix F. A floor plan of the facility is shown in Figure (5) below. For this concept, Olin 103 would be equipped with one computer with *Pro-ENGINEER 2001* and *Mastercam 9.0* and work benches. Olin 107 would be designed in the same way as it was for Studio Concept One, but there would be less heavy equipment such as band saws, a lathe, and a mill.

Figure 5 – Design Concept Two Floor Plan



This drawing is not to scale, but room sizes are approximately proportional.

In our budget in Table (F1), we allocated $18,000.00 per year towards purchasing new equipment so this concept would eventually become a full studio in approximately five years. This number was chosen so that the most expensive pieces of equipment could be purchased in a single year with a few thousand dollars left over.

Evaluation of Studio Location and Budget

Studio Location

There were many factors we examined in order to evaluate the feasibility of building a lab in Olin rooms 103 and 107. First, we determined who was in charge of the rooms and what the current status and future plans were for them. The rooms as we found, are part of the Department of Electrical Engineering and Computer Science. At present, Dr. Kenneth Loparo is the only professor to have equipment in the room. This equipment is a large device used in his research that requires a hard floor to eliminate vibrations. However, the device does not take up much space relative to the size of the room. Additionally, the device is portable and can be moved if the room is rearranged for the studio. The device will likely stay in this room since it requires a concrete floor. Other than Dr. Loparo's occasional usage of the rooms, there is currently no other important work conducted there. Some of design teams have used the rooms as recently as 2004, but these teams have either moved to another location or have disbanded. In summary, very little has happened with these rooms in the past decade.

Many years ago, these rooms were used as part of a structures lab with heavy equipment. When that lab was closed, little attention or maintenance was paid to the rooms. Because of this, many repairs are necessary before the space can be used again. As can be seen from each studio's budget, over $20,000.00 has been allocated in order to upgrade the rooms with adequate network connections, card access, lighting and stairs. If the washrooms and leaks in the walls were fixed, the rooms were painted and a new ventilation system was installed, the $20,000.00 renovation cost could easily run over $100,000.00, based on quotes by companies that could make these necessary repairs. However, we believe that $20,000.00 of room upgrades would be enough to begin using the studio.

There is a plan that could compete with the manufacturing studio for this location. There is a pending proposal for a rotating machinery lab organized by Case and Rockwell Automation. Although it has been pending for two years, the proposal's status was recently upgraded and is being considered by Rockwell Automation's upper management. After talking with Dr. Loparo, who has been working on the Case side of the proposal, it turns out that his lab could be moved to a different location if a manufacturing studio was built in Olin 103 and 107. However, the lab is likely to be placed there if the manufacturing studio proposal is not considered soon.

As far as the size of the rooms is concerned, there is enough room for all of the major design teams to store and work on their projects at once. In addition to the space that those groups will take up, ample space left over for personal projects. As shown in Figure (6), Olin rooms 103 and 107 have a central location on the southern half of campus. Also, their ground level location in Olin is perfect for moving vehicles in and out of the lab with access provided by the large garage door in room 107. Finally,

students will be free to make as much noise as they want while working. This would not have been possible in a location like Glennan room 422, which is right next to a classroom and a computer lab.

Professor Malcolm Cooke would be an ideal candidate from the Department of Mechanical and Aerospace Engineering (MAE) to oversee the facility, but his department should not have direct control over the rooms. If the MAE department obtained direct control of the rooms, it would have to trade an equal sized space with the EECS department. Since these rooms are large and the MAE department has no unused rooms, trading spaces is not feasible. Therefore, the Case School of Engineering will have to have direct control over this facility.

Concept One Logistics

Each studio concept has many positive and negative aspects which must be evaluated. For the fully developed facility, the sizable cost is obviously the major drawback to realizing this idea. Safety will also be a major issue. This problem can be solved by hiring a full-time staff member as previously mentioned who can educate students and help them learn how to use the machines. A likely candidate may be a retired employee willing to work with students during evening hours and weekends. Most likely, students wishing to use the machines will have to attend special sessions held by this employee in order to use the facility. These sessions should occur on a monthly basis on Saturday and should last about 2 hours to cover all of the basic machinery. If students only wish to learn about a particular machine, they could make an appointment to learn how to use it.

However, students will still want to use the machines when this employee is not available (especially at times right before competition deadlines where some students have been known to stay in their labs to finish projects for days). In order to make the studio available to these students, there will have to be special 24-7 access to the studio. The students with special access would have to be design team leaders, and they would have to have previous training on all of the machines. Also, they would be responsible for any problems that occur during these hours. In order to make sure safety is not compromised, the larger machines will be locked at night.

There are still many positive aspects to be considered. Opening a fully funded studio would have several positive effects on the Case community. For example, a studio of this magnitude will generate attention within the community. This attention will be very good for the school of engineering, and it will likely lead to more opportunities (i.e. more equipment donations, perhaps a Case-CIA industrial design partnership).

Concept Two Logistics

From the beginning, Studio Concept Two was meant to work with the most negative drawback of the first concept: cost. Concept Two is certainly much less of a

financial risk than the other one. Although building a full machine shop will help students the most with their design projects, creating a less costly storage and construction area is still a huge upgrade over the current conditions. The $18,000.00 annual budget can be used to purchase equipment as large as a lathe or a mill, but it could be reduced if there was not as much demand for these machines.

Most of the money in the budget for this project will be used for repairing the room which must be done if it is ever going to be used again. The two sets of stairs need to be replaced at a quoted cost of $6600.00 total. Electrical outlets and network connections must also be installed at a cost of roughly $15,000.00. If the studio was somehow unsuccessful, all of the money used for its renovation would still be going to a good cause to make the room potentially useful again for other purposes.

Although interest in the studio will be strong even if it is scaled down, there still may be some drawbacks to this concept when compared with the full studio. Not having some of the larger machines will still mean that many students will need to find time to go down to the regular machine shop to work. Also, having fewer machines will lower student interest in working on their own projects in the studio.

Conclusions

When compared with other options on campus, Olin rooms 103 and 107 are the ideal location for the placement of a student manufacturing studio. These rooms have not seen significant use in at least a decade and obtaining permission to use them is feasible. There is a proposal between Case and Rockwell Automation in progress that may compete for the rooms, but that will not be a factor as long as this study is seriously considered within the next six months or so.

After space consideration, the budget is the next limiting factor. The studio's cost will determine how much students will use the facility, but creating a less-expensive, scaled-down version of the studio will still be a major improvement over the current conditions. We have calculated an optimal annual budget of $18,000.00 for this concept, but this cost could be very flexible depending on the success of the studio. The feasibility of these concepts relies on the studio's initial costs: the larger the budget is the lesser the likelihood that the project would be funded by the School of Engineering. Most projects with a budget as large as our Concept One idea are generally funded by a source outside the University. However, the School of Engineering may be able to fund a project with an initial price of less than $30,000.00.

In general, the studio will be welcomed by Case students. According to our survey results, 51% of students would like to see more space created for personal projects and 32% would be encouraged to pursue their own projects. If it is built, design teams will become more competitive and individual projects will flourish.

Recommendations

Based on the feasibility of the two concepts we have developed for the student manufacturing studio, we recommend renovating Olin rooms 103 and 107 and building Studio Concept Two. We recommend structuring the management of this studio according to Figure (G1) in Appendix G. Undergraduate students will be ecstatic to have a storage and assembly area. Based on the initial popularity of the studio, our annual budget recommendation of $18,000.00 can be manipulated. The budget's funds would come from the School of Engineering and possibly and extra-University source. Once the studio is created, more equipment can be purchased or donated by other labs on campus that are replacing their old tools and machinery.

We recommend a meeting in the near future between Professor McGuffin-Cawley, Dr. Malcolm Cooke, the Bingham and Reinberger shop supervisor James Drake, and Dr. Kenneth Loparo to discuss the future of these rooms. Dr. Loparo can give more detailed information on what can be done with the equipment in these rooms. Dr. Cooke and James Drake can work towards building the actual studio, and Associate Dean McGuffin-Cawley can create an accurate budget for the studio through his position in the Case School of Engineering. A formal request should also be made to the Case Alumni Association for funding, and additional finances should come from the School of Engineering budget.

Appendix A

This appendix contains an outline of the interview with Professor Cooke.

Interview: Professor Cooke – 3/3/05 (Jean Enge-Janes)

Need for studio:

- he thinks finding support among the engineering faculty will definitely not be a problem, he very much supports the idea
- agrees that there is a great need for a wider access facility
- student design groups need more space to work, so they don't have to clean everything up and store it somewhere every day (DBF, Formula group, Mini-Baja, etc)

Collaboration with CIA:

- about a year ago, he met with the CIA director to discuss the possible collaboration between the CIA industrial design program and Case engineering, but nothing has been done yet because they have a new director
- CIA students don't have much exposure to formal manufacturing and design, and we don't have exposure to industrial design, so the studio could help to fill that gap

Suggestions on how to run the studio:

- hire a full-time, non-faculty person (who would report to James Drake) whose sole function is to support the studio facility – he would take care of the maintenance, supervision, ordering equipment and materials, and general upkeep of the area, as well as assist students as necessary. If he had free time, he would help Mr. Drake with whatever needed to be done
- this person would have to be paid about $45,000.00 per year plus fringe benefits of another $10,000.00 per year, and work clothes would have to be supplied (I'm guessing those uniforms that the maintenance workers have with the case paperclip logo)
- we could also hire some student help if it was needed.
- studio would be an extension of the current Bingham shop – "extra space under the general umbrella of the Bingham workshop."
- regardless of how lo-tech the studio is, it would still be necessary to have some type of safety training – the worker that we'd be hiring could hold short safety sessions from time to time at students' convenience

Money issues:

- to show that it's feasible, we should come up with a budget, including both capital and revenue expenses
- capital budget – should include what we need to initially set up (equipment, storage, benches, etc). Also, we should lay out the next 2-3 years – every few years we will need to replace equipment, and as the center gets more use, we

could set a target of adding new pieces of capital. we want to show that the large up-front cost is not going to repeat every year

- revenue budget – includes consumables, salary of supervisor and student help, maintenance, safety equipment, phone, cost of the space & utilities
- the department of whoever is in charge of a lab has to pay the dean's office a "rent" to use the space, as well as heating, lighting, etc – this should be included in the revenue budget

Appendix B

This appendix contains the questions that were sent to Tufts and Carnegie Mellon with hopes that these schools would be able to tell us their initial and annual costs.

School Questionnaire:
Please answer as many questions as possible. The more specific you can be the better.

How and why was the facility set up?

How has it evolved since it was first opened?

Who is allowed to use the facility? Is it open to all students in the university?

Is it used by certain classes or student groups?

Are students allowed to use the facility for personal projects?

Can students store projects in this area? If so, where? (storage cabinets, floor space, etc)

What are the approximate dimensions of the working space?

When is the facility open for use? Certain hours? Only when staff is on duty?

What tools and equipment are available for use in this facility?

What materials are available?

Is special training required to use any of the equipment?

Do you staff anyone to assist users with using the equipment?

How does the facility receive its funding?

What is the approximate annual budget (including all tools, materials, equipment, staffing, etc) for maintaining this facility?

How many people would you estimate use this facility on a monthly basis? (less than 20, 20-100, more than 100)

Appendix C

This appendix contains an outline of the interview with Dean McGuffin-Cawley.

Interview: Professor McGuffin-Cawley – 3/1/05 (Nicholas Duval)

Resources to pursue:

- RPI – has a well-developed studio/lab
- Dr. Joseph Prahl – he was thinking about creating a student machine shop
- Wyatt Newman - what lab could be good for, what it could be used for (not about getting the space on 2nd floor of Glennan) – would be insightful on potential problems & potential opportunities
- Carol Deitz & George Cadwaller
- Engineers without Borders (Alicia Baughman)
- Engineering World Health student group (Meragani)
- Ken Klika - CIVE
- Art Hucklebridge - CIVE

Case currently looking into ways to improve undergrad labs:

- currently in the middle of an effort to see how to improve undergrad labs: make them "new and different,"
- will start with people from materials science, chemical engineering, and macromolecular science depts. will tour other "distinguished" university labs, review literature from American Society of Engineering Education
- looking into a studio/lab concept (RPI has maybe the most developed studio/lab)

Uses & benefits:

- classes, student competitions, personal projects inspired by a "creative urge," engineering for community service, student groups such as DBF
- open to students from all areas of the university – create a bridge between university and rest of campus
- tend to make people more inclined to work with their hands
- we have the machine shop & the Reinberger lab, he would be interested in supporting something that is complementary to those – something that would fill in what is missing
- what is missing is a safe space in which to work, to leave something you have done, and be able to come back to it
- CIA students have studios available to them as long as they're there, places where they can leave half finished projects, come back to them

Costs & funding:

- question is: how much will it cost
- School of Engineering likes to support co-curricular activities, but the amount of requests is always more than what is available
- sometimes the school solicits outside funding which may be a good match for something like this (from foundations, companies, and alumni)
- alumni donations have least restrictions, company donations have most restrictions

Suggestions & issues to think about:

- at the beginning, a certain level of student commitment would be needed to start up and advertise
- should be "in the spirit of being outside the curriculum" to avoid political and territorial battles with priorities for classes…
- need to figure out what kind of machines people are looking for
- find out what we really need, then maybe upgrade later
- may want to have a threshold on the types of machines available so people don't need training to use the lab…we could keep machines that require training in the machine shop where there are people to supervise, then the studio could be open 24 hours a day

Space:

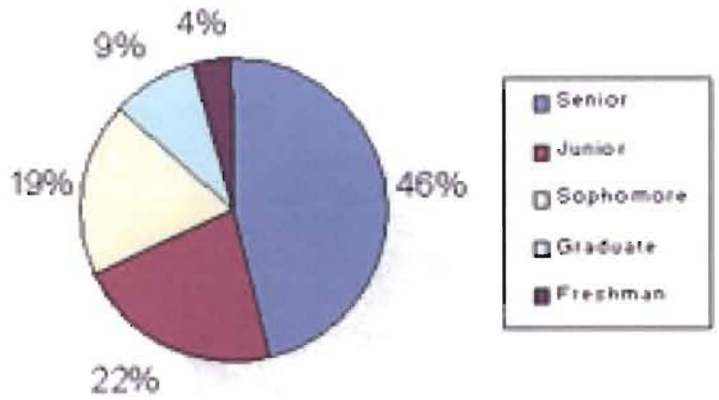
- we could definitely get the space (on main quad), but that would be an issue to resolve later (after involving all necessary people in discussion)
- location is important – distance from other machining facilities, high traffic areas

Appendix D

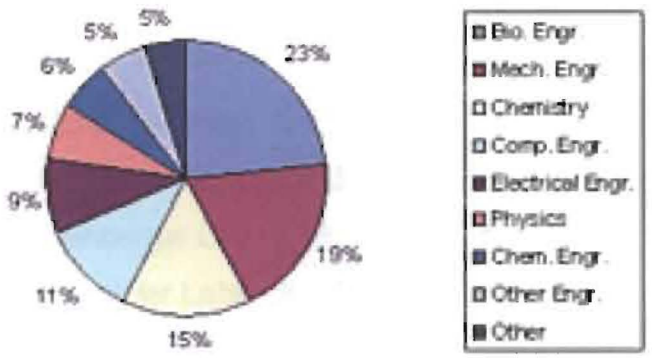
This appendix contains the questions that were asked in the survey sent to students to gauge their interest in as Student Manufacturing Studio.

Student Manufacturing Studio Survey

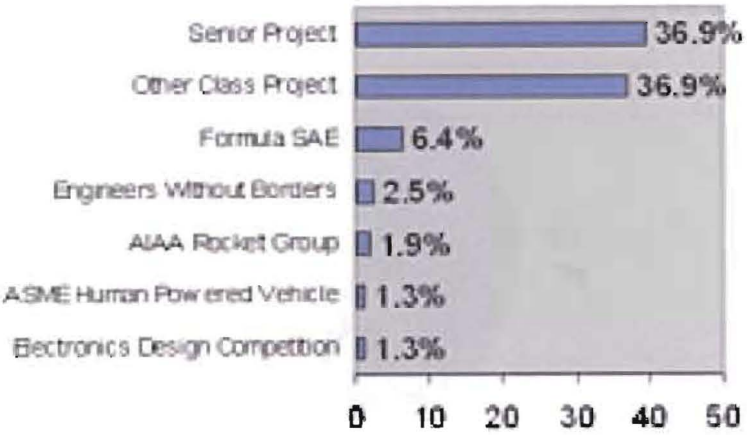
1. What is your class standing?



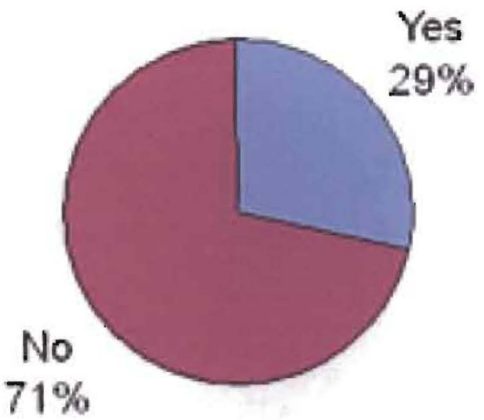
2. What is your area of study?



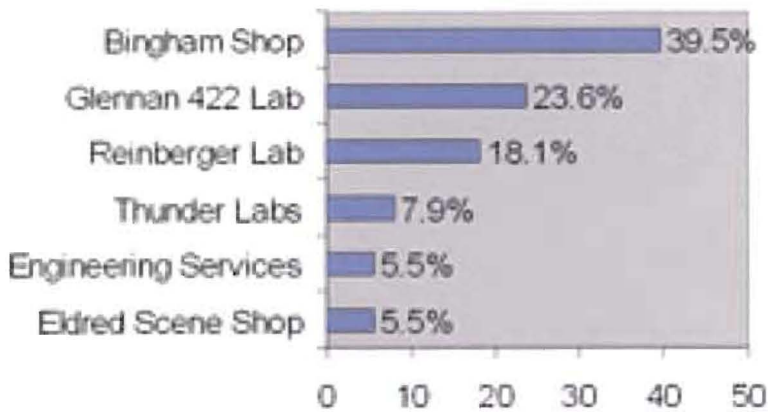
3. What, if any design or fabrication related projects have you worked on?



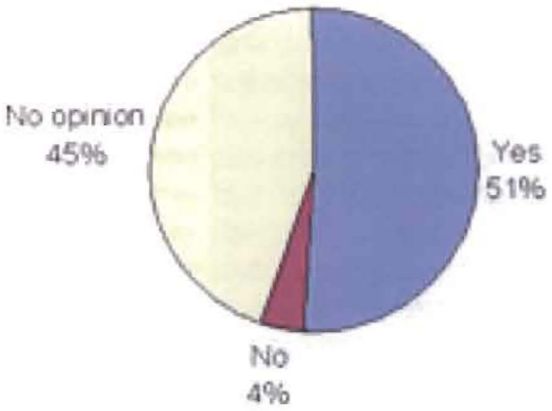
4. Do you currently work on any personal projects or hobbies that involve fabrication or assembly?



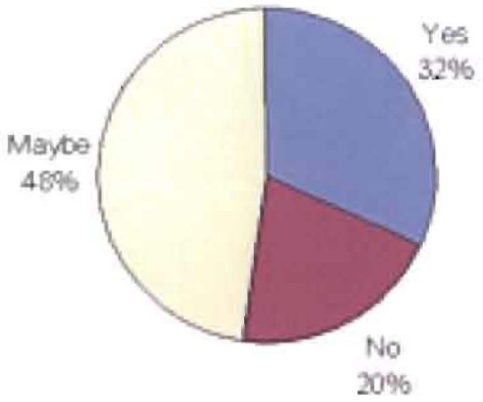
5. What campus facilities have you used for the projects referred to in questions 3 and 4?



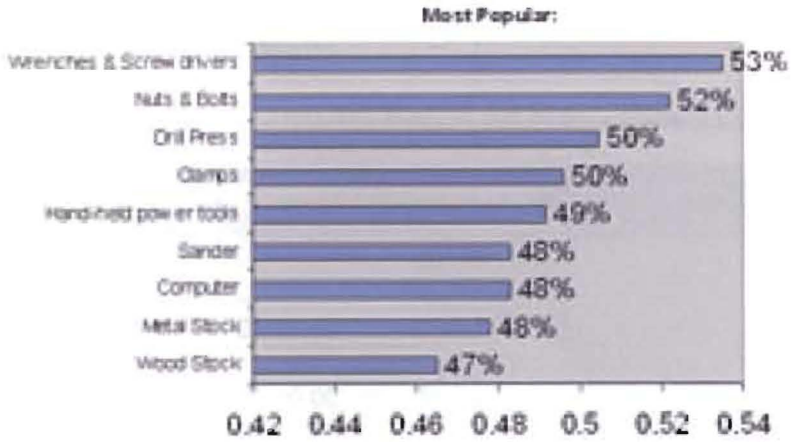
6. Would you like to see more space available on campus for creating, assembling, or storing your projects?



7. If you answered "no" for question 4, do you think having space available to you on campus would encourage you to work on personal projects?



8. If a space was created on students to work on and store projects, what equipment and materials would you like to see available?



Appendix E

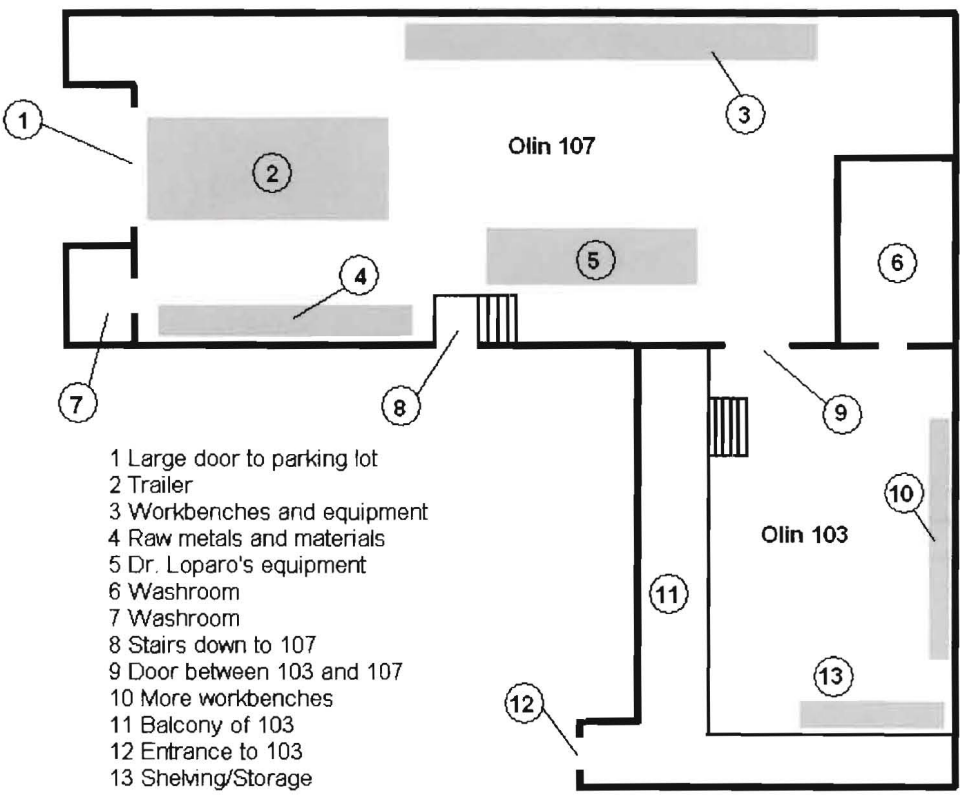
This appendix contains a budget and floor plan for the first design studio concept, Studio Concept One. Table (E1) shows the budget for the concept and Figure (E1) contains a floor plan of the current facility.

Table E1 - Detailed Budget for Studio Design Concept One

Item Name	Initial Cost	Company Quoted	Annual Expense	Miscellaneous Information
New Stairs (2 sets)	$6593.00	McMeechan Construction	-	-
Storage Cages	$2004.00	Global Ind. Equipment	-	3 Cages
Card Access	$3000.00	-	-	-
Network Faceplates	$5000.00	-	-	-
Computers (2)	$3000.00	-	-	Probably could be donated
TIG Welder	-	-	$200.00	Bingham shop donation
Plasma Cutter	-	-	-	Bingham shop donation
Tube Bender	-	-	-	Bingham shop donation
Donated Hand Tools	-	-	-	Bingham shop donation
Hand tools	$2500.00	-	$500.00	Everything needed that is not donated
Tool Storage Cases	$1500.00	-	-	-
Welding Ventilation	$2392.00	Lincoln Electric	-	2 Miniflex units
Electrical Upgrades	$5860.00	Ullman Electric	-	-
Mill	$13370.00	Ornamental Products	$300.00	With all accessories
Lathe	$13246.00	Ornamental Products	$300.00	With all accessories
Vertical Bandsaw	$6472.00	Ornamental Products	-	-
Horizontal Bandsaw	$2129.00	Ornamental Products	-	-
Drill Press	$3375.00	Ornamental Products	$200.00	-
Sander	$999.00	Ornamental	-	-

Grinder	$648.00	Products Ornamental Products	-	-
Brake Press	$1175.00	Ornamental Products	-	-
Sheet Metal Shear	$2149.00	Ornamental Products	-	-
MIG Welder	$2000.00	-	$200.00	-
Welding Table	$3458.00	Praxair	-	-
Student Help	$5000.00	-	$5000.00	-
Full Time Employee	$50000.00	-	$50000.00	-
Repairs and Maintenance	-	-	$2000.00	A small budget for unseen expenses
Raw Materials	$3000.00	-	$3000.00	Many can be donated
Totals	**$138,870.00**		**$61,700.00**	

Figure E1 - Current Status of Olin 103/107



This drawing is not to scale, but room sizes are approximately proportional.

Appendix F

This appendix contains a budget and floor plan for the second design studio concept, Studio Concept Two. Table F1 shows the budget for the concept.

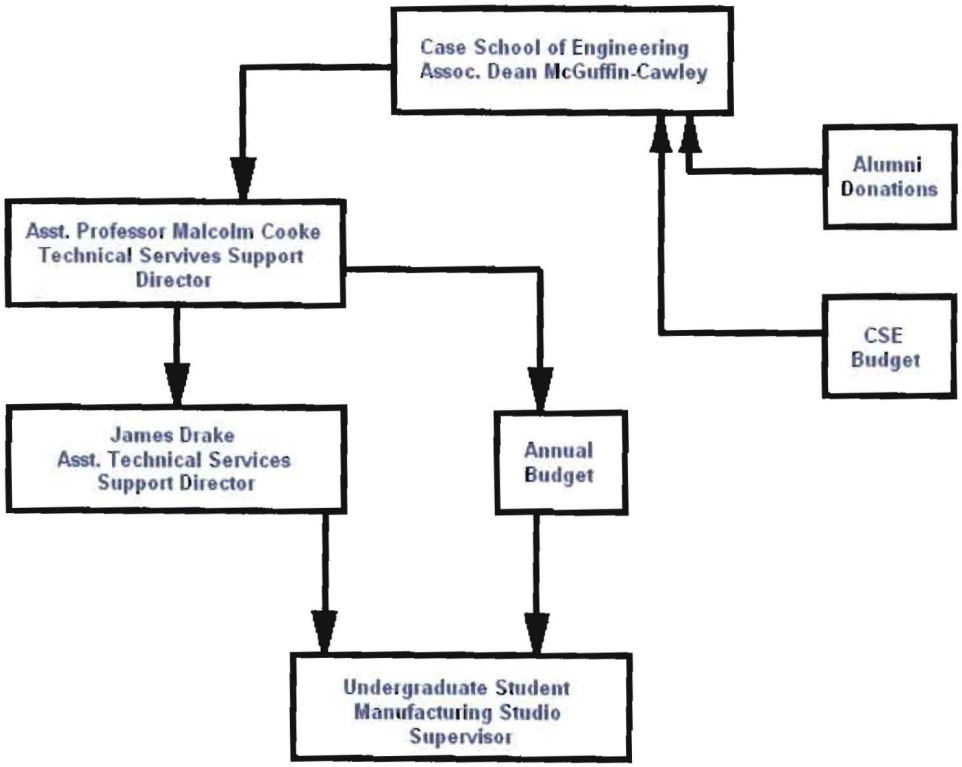
Table F1 - Detailed Budget for Studio Design Concept Two

Item Name	Initial Cost	Company Quoted	Annual Expense	Miscellaneous Information
New Stairs (2 sets)	$6593.00	McMeechan Construction	-	-
Storage Cages	$2004.00	Global Ind. Equipment	-	3 Cages
Card Access	$3000.00	-	-	-
Network Faceplates	$5000.00	-	-	-
Computer	$1500.00	-	-	Probably could be donated
TIG Welder	-	-	$200.00	Bingham shop donation
Plasma Cutter	-	-	-	Bingham shop donation
Tube Bender	-	-	-	Bingham shop donation
Donated Hand Tools	-	-	-	Bingham shop donation
Annual Purchasing Budget	-	-	$18,000.00	Each year money is spent on new equipment
Electrical Upgrades	$5860.00	Ullman Electric	-	-
Hand tools	$1000.00	-	$500.00	Everything needed that is not donated
Student Help	$1000.00	-	$1000.00	Mainly Cleaning throughout the year
Repairs and Maintenance	-	-	$500.00	-
Tool Storage Cases	$1000.00	-	-	-
Totals	**$26,957.00**		**$20,200.00**	

Appendix G

Below, Figure (G1) shows a chart of our recommendation for the management of the personnel and finances of Studio Concept One. The management would work the same for Studio Concept Two; only the studio supervisor position would be eliminated

Figure G1 – Studio Management Structure



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