COST OF SHOP INSTRUCTION IN THE UNIVERSITY OF ILLINOIS

BY

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OF THE UNIVERSITY OF ILLINOIS

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THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

Ira Blair Altekruse

ENTITLED Cost of Shop Instruction in the University of Illinois

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE

DEGREE OF Bachelor of Science in Mechanical Engineering

Instructor in Charge.

HEAD OF DEPARTMENT OF Mechanical Engineering

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The object of this thesis is to show the relative cost of instruction in the various shops of the University, and to devise a system for keeping a record of the material used in the operation of the shops.

By cost of instruction is meant -

Salaries
Material
Upkeep of Shop
Interest and Depreciation on Equipment.

There has been no account taken for the value of the buildings and ground, nor of the power, which is furnished by the University Power Plant. Of this latter, we have no record. If the kilowatt hours were known, it could be taken into consideration. However, by leaving these two items out, the cost obtained is that which is charged up directly to the Mechanical Engineering Department, and paid for out of Current Account, Shop Practice, Equipment, and Salary funds. The Building Department also furnishes a janitor who spends the greater part of his time in cleaning the shops. This expense has also been neglected in calculating this data.

A record of all the expenditure for the shops has been kept in the office of the Assistant Professor of Machine Construction for the last four years, and it was from this record that the information has been taken. No data could be secured previous to that time.

The information secured is shown in the form of curves, no tabulated results being given. The years have been used as
abscissae and the cost in dollars as ordinates. There are four sets of curves for each of the above listed items, and then the total or combined cost is shown, making five sets in all. The first sheet shows the relative cost per shop; the second, the percentage of the total amount spent for each shop; the third, the cost per student; and the fourth, the cost per credit hour per student per shop.

In the cost per student, the Machine Shop is considerably the highest, due to the fact that thirty-six weeks work, eight hours per week are required of each student, while in the Pattern Shop, only eighteen weeks and the Forge and Foundry only nine weeks work, the same number of hours per week, are required.

The cost per student credit hour gives a more even basis for comparing the relative cost. In this, however, the Machine Shop is again at a disadvantage. In the Pattern Shop, Foundry and Forge, three credit hours are given for eight hours work per week per semester, while in the Machine Shop, two and one-half credit hours are given for the same amount of time. For this reason, to make a correct comparison of costs based on the actual time put in by the student, the values for the Machine Shop should be decreased by one-sixth.

There are also curves drawn showing the number of students per instructor. By this is meant the actual number of students per instructor working in the shop at one time.

The floor space per student working in the shop is also shown. All of the shops are crowded, therefore, this is not a fair basis upon which to judge the room necessary per student in shops of this kind. It is more nearly the minimum amount required.
The following set of curves show the cost of actual instruction in the shops. This includes only the salaries of the instructors in each shop, one tool room attendant in each the Pattern and Machine Shops, and the salary of the Professor in Charge divided proportionately among the shops.

About the middle of the year 1907-08, an additional instructor was secured for the Machine Shop. Also, the instructor in charge of the Foundry was given an assistant at the beginning of that year. This accounts for the large rise in the curves for these two shops.
TOTAL COST OF INSTRUCTION PER SHOP
INCLUDING ONLY INSTRUCTORS' & TOOLROOM ATTENDANTS' SALARIES
Sept. 1-07 - Additional Instructor in Foundry
Jan. 1-08 - " " " Mach. Shop

Time in Years
0 06-07 07-08 08-09 09-10
COST OF INSTRUCTION
PER SHOP
IN PERCENT OF TOTAL COST
INCLUDING ONLY INSTRUCTORS' AND
TOOL ROOM ATTENDANTS' SALARIES
Sept. 1, '07 - Additional Instructor in Foundry
Jan. 1, '08 - " Mach. Shop

Time in Years
0 '06-'07 '07-'08 '08-'09 '09-'10
COST OF INSTRUCTION
PER STUDENT PER SHOP
INCLUDING ONLY STUDENTS COMPLETING THE COURSE.
Sept 1-07 - Additional Instructor in Foundry
Jan 1-08 - " " " Mach. Shop

Time in Years
0 06-07 07-08 08-09

Cost in Dollars
4
8
12
16
20
24
COST OF INSTRUCTION
PER CR. HR. PER STUDENT PER SHOP
INCLUDING ONLY STUDENTS
COMPLETING THE COURSE
Sept. 1-07 - Additional Instructor in Foundry
Jan. 1-08 - " " " Machine Shop
--- Cost of Material ---

This data includes all of the raw material purchased by the various shops for instructional purposes, such as -

- Pattern Shop: Lumber, Glue, Nails, Screws, Sand paper, etc.
- Foundry: Pig Iron, Coke, Sand, Core making materials, Facings, etc.
- Forge Shop: Steel, Coal, etc.
- Machine Shop: Steel, Castings, Bolts, Screws, etc.

Here again the Machine Shop is considerably the highest. The material is the most expensive, and more time is put in for a credit hour than in the other shops. It will be seen that for the year 1906-07, the cost per student in the Machine Shop was considerably higher than for the following years. During that year, the old number twelve exercise and the large cast iron gears were used. These were extra heavy, and a great many were spoiled by the students, sometimes two or three being made before one would be accepted by the instructor. This made the cost of the castings considerably more.

The number of students was also less, and the cost of material for operating the shop does not vary directly as the number of students taking the work. Hence, the increased cost per student.
COST OF MATERIAL
PER SHOP
INCLUDING ONLY MATERIAL USED
FOR INSTRUCTIONAL PURPOSES

Machine Shop

Pattern Shop

Forge

Foundry

Time in Years

0 06-07 07-08 08-09

Total Cost in Dollars

200 400 600 800 1000
COST OF MATERIAL PER SHOP IN PERCENT OF TOTAL COST

Machine Shop

Pattern Shop

Forge

Foundry

Cost of Material in Percent of Total Amount

Time in Years

0 '06-'07 '07-'08 '08-'09 '09-'10
COST OF MATERIAL
PER STUDENT PEP SHOP
INCLUDING ONLY MATERIAL USED
FOR INSTRUCTIONAL PURPOSES
1906-07 - Fewer Students in Mach. Shop

Machine Shop

Pattern Shop

Forge

Foundry

Time in Years

Cost in Dollars

0 06-07 '07-'08 '08-'09

1 2 3 4 5 6 7
COST OF MATERIAL
PER CR. HR. PER STUDENT PER SHOP
INCLUDING ONLY MATERIAL USED
FOR INSTRUCTIONAL PURPOSES
1906-07 - Fewer Student in Mach. Shop

Cost in Dollars

Machine Shop

Pattern Shop

Forge

Foundry

Time in Years
0  06-07  07-08  08-09
The following curves show the cost of the upkeep of the shops. This includes the cost of all repairs to the machinery, slight building repairs, cost of material used in repairs, cleaning, etc. The regular janitor's payroll is not included, as he is paid by the Building Department. It does, however, include all cleaning done by the students and outside men. Also, a tool room boy in the Machine Shop and Pattern Shop. One mechanician is employed in the Machine Shop to make repairs for the various shops, and also to do work brought in by outside departments.
TOTAL COST OF UPKEEP PER SHOP
including:
- Cost of Repairs
- Cost of Material Used for Repairs
- Cost of Student Cleaning

Machine Shop

Pattern Shop

Foundry

Forge

Time in Years

0 06-07 07-08 08-09
COST OF UPKEEP
PER SHOP
IN PERCENT OF TOTAL COST
INCLUDING: Cost of Repairs
Cost of Material used for Repairs
Cost of Student Cleaning

Cost of Upkeep in percent of total amount

Machine Shop
Pattern Shop
Foundry
Forge

Time in Years
0 06-07 07-08 08-09
COST OF UPKEEP
PER STUDENT PER SHOP
INCLUDING: COST OF REPAIRS
COST OF MATERIAL USED FOR REPAIRS
COST OF STUDENT CLEANING
1906-07 - Fewer Students in Mach. Shop

Machine Shop

Pattern Shop

Foundry

Forge

Time in Years

Cost in Dollars

06-07 07-08 08-09
COST OF UPKEEP
PER CR. HR. PER STUDENT PER SHOP

INCLUDING:
- Cost of Repairs
- Cost of Material used for Repairs
- Cost of Student Cleaning

1906-07 - Fewer Students in Mach. Shop

Cost in Dollars

<table>
<thead>
<tr>
<th>Year</th>
<th>Machine Shop</th>
<th>Pattern Shop</th>
<th>Foundry</th>
<th>Forge</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>.50</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>.75</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1.00</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1.25</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1.50</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1.60</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

06-07 07-08 08-09
The total equipment was obtained from the annual inventory taken in June, at the end of each school year. This includes all machinery, small tools, motors, belting, pulleys, shafting, etc. The depreciation and interest was taken as ten percent, which the writer thinks is a fair value for these items. The value of the buildings is not included in this data.

It will be seen that the equipment is gradually on the increase. The Forge Shop took a sudden increase in 1908-09, due to the enlargement of the shop. Five four-fire forges were designed, built and installed by the University.

The increased cost per student and per student credit hour in the Machine Shop in 1906-07, was due to the fact that the attendance was about twenty-two percent less than for the following years, while the depreciation and interest was only slightly less.
TOTAL VALUE OF EQUIPMENT PER SHOP

Obtained from the inventory taken each year in June

Value of Equipment in Dollars

Time in Years

\( aO0O \)

\( t n \)

\( O \)

\( O \)

\( O \)

\( O \)

\( T O T A L V A L U E O F q u i F M E N T \)

\( P E R S H O P \)

\( O b t a i n e d ~ F r o m ~ t h e ~ I n v e n t o r y \)

\( t a k e n ~ e a c h ~ y e a r ~ i n ~ J u n e \)
COST OF EQUIPMENT
PER SHOP
IN PERCENT OF TOTAL COST
Obtained from the Inventory
taken each year in June

Percent of Total Equipment

Machining Shop

Pattern Shop

Foundry

Forge

Time in Years

0 '06-'07 '07-'08 '08-'09
DEPRECIATION AND INTEREST
TAKEN AS 10% OF THE EQUIPMENT
PER STUDENT PER SHOP

Value of Equipment obtained from
the Inventory taken each year in June
1906-07-Fewer Students in Mach. Shop
DEPRECIATION AND INTEREST
TAKEN AS 10% OF THE EQUIPMENT
PER CR. HR. PER STUDENT PER SHOP
Value of Equipment obtained from
the Inventory taken in June each year
1906-07 - Fewer Students in Mach. Shop

Pattern Shop

Foundry

Forge

Time in Years

0  '06-'07  '07-'08  '08-'09
- Total Cost of Operating the Shops -

The following set of curves shows the total cost of operating the shops, including:

- Salaries
- Material
- Upkeep of Shops
- Depreciation and Interest on Equipment.

The curve for the Machine Shop shows a much lower cost per student and per student credit hour for the year 1907-08 than for the other years. In 1906-07, the number of students was considerably less than for the other years, thus making the cost of each item higher. Heavier exercises were used, making the material cost more. In 1908-09 an additional instructor was added to the force and the small grinding machine was developed. All of these tend to increase the cost for the years 1906-07 and 1908-09.

In 1907-08 an additional instructor was put on in the Foundry. This is the cause of the increase in cost for the years after that date.
TOTAL COST OF OPERATION PER SHOP

INCLUDING: SALARIES
    MATERIAL
    UPKEEP
    DEPRECIATION %
    INTEREST

Sept. 1-07 - Additional Instructor in Fdy.
Jan. 1, 08 - "
    " Mech. S.

Machine Shop
Pattern Shop
Forge
Foundry

Cost in Dollars

Time in Years

06-07 07-08 08-09
COST OF OPERATION
PER SHOP
IN PERCENT OF TOTAL COST
INCLUDING: SALARIES
MATERIAL
UPKEEP
DEPRECIATION AND INTEREST

Machine Shop

Pattern Shop

Forge

Foundry

Cost of Operation in Percent of Total Amount

06-07  07-08  08-09
Cost of Operation

PER STUDENT PER SHIP

TOTAL

COST OF OPERATION

INCL. SALARIES

INTEREST

MATERIAL

UPKEEP

DEPRECIATION

1906-07 - Fewer Students in Mach. Shop

Sept. 1-07 - Additional Instructor in Foundry

Jan. 1-08 - Additional Instructor in Mach. Shop

Foundry

Forge

Pattern Shop

Mach. Shop

Time in Years

Cost in Dollars

0

10

20

30

40

50

1906-07

1907-08

1908-09

1909-10

1910-11
TOTAL COST OF OPERATION
PER CR. HR. PER STUDENT PER SHOP
INCLUDING: SALARIES
MATERIAL
UPKEEP
DEPRECIATION AND INTEREST
1906-07 - Fewer students in Machine Shop
Sept. 1 '07 - Additional Instructor in Foundry
Jan. 1 '08 - " " " Mach. Shop

Time in Years

0 06-07  07-08  08-09
The following two sheets of curves show the distribution of the money spent for equipment among the various shops. These curves are very irregular, showing that the money is not proportioned equally among the shops, but used for that one in which it is thought that it will do the most good.

In the Machine Shop in 1907-08, a number of new lathes were added. These were necessary in order to care for the increased enrollment.

In the Pattern Shop, 1906-07, a number of new benches were made.

In the Forge Shop, during the summer of 1908, additional space was added and five four-fire forges were designed and made in the University Shops.
TOTAL
EQUIPMENT PURCHASED
PER YEAR PER SHOP
1906-07 - New Benches in Pat. Shop
1907-08 - New Lathes in Machine Shop
1908-09 - Extension of Forge Shop
EQUIPMENT PURCHASED
PER SHOP
IN PERCENT OF TOTAL AMOUNT
1906-07 - New Benches in Pattern Shop
1907-08 - New Lathes in Machine Shop
1908-09 - Extension of Forge Shop
The square feet of floor space per student shown by the following curves includes the machine and bench rooms, tool rooms, and lockers. The basements, used for storage purposes, are not considered. The Machine Shop has only a small basement, more storage room being badly needed. In the Pattern Shop, the basement covers the entire floor area, but is not finished, and only a small part of it is used, i.e., the dry kiln and lumber storage. The Foundry basement also covers the entire floor area. This is used to good advantage, for storage purposes, blower outfit, rattler, and emery wheel. The Forge Shop has no basement. The coal is stored in bins outside and brought in on trucks.

The attendance in the Machine Shop was about twenty-two percent less for the year 1906-07 than for the following years, therefore, the drop in curve. During the summer of 1908, the Forge shop was enlarged. Five four-fire forges were designed and built by the University. This new addition is now the main forge shop, the old one being used for the extra large sections and Agricultural students.
FLOOR SPACE
IN SQUARE FEET
PER STUDENT PER SHOP

1906-07 - Fewer Students in Machine Shop
1908-09 - Extension of Forge Shop
Basements not included
- Number of Students per Instructor per Shop -

By the number of students per instructor is meant the number actually working in the shop at one time. The total number is divided up into sections, and the average of these sections for the year taken in determining this data.

In the Machine Shop an additional instructor was put on the first of January, 1908. In 1906-07, the Foundry only had one instructor, while for the following years there have been two.
NUMBER OF STUDENTS
PER INSTRUCTOR PER SHOP
AT WORK AT ONE TIME

Sept. 1-07 - Additional Instructor in Foundry
Jan. 1-08 - " " " Machine Shop

Time in Years
0  '06-07  '07-08  '08-09

No. of Students
10
20

Pattern Shop
Machine Shop
Forge
Foundry
A letter, with a set of questions attached, was sent to a number of Universities with the request that they fill in the answers and return to us. All but one or two of these were returned. The idea was to collect data regarding the cost of instruction per student, etc. from these different Universities and make a comparison. However, the work given and the time required varied so much that it was practically impossible to make a comparison that would be of any value.

The following set of curves showing the number of students per instructor in the shops was secured from this data. In all but the four Universities mentioned, the number of sections, the time required, or some other data could not be determined, therefore, further comparison with other schools was impossible.

It will be seen that the University of Illinois ranks rather high among these, the Pattern Shop being nearly thirty percent above that of the other three.
NUMBER OF STUDENTS
PER INSTRUCTOR PER SHOP
AT WORK AT ONE TIME
1909-10.
Univ. of Illinois
Univ. of Michigan
Purdue
Sibley
This chart is omitted as it is at any suggestion in order that it may be referred to in connection with other parts of the report.
A System for keeping a Record of the Material used in the Operation of the Shops

Shops used for instructional purposes differ so widely from those in the commercial world that it is almost impossible to apply the latter shop systems to their use.

Primarily, the instructors duty is to teach the student and not to look after the cost side of the shop. His time is spent in this instructional work, and any cost system that requires much clerical work is out of the question. However, a record of some kind must be kept, and it is the purpose of the writer to suggest a system of this kind, entailing as little extra labor as possible, and yet to give the essential information.

It is impossible to keep a record of all material used, for instance, nuts, washers, screws, etc., while on the other hand, it is necessary to know the amount of steel or castings on hand. Just where this dividing line shall be drawn is hard to say, and must be determined by the man in charge. This flexibility factor suggests a card system which may be applied to any number of items, and extended at any time.

With the above view in mind, cards have been gotten up for the following -

Patterns
Material
Heat and Casting Record
Total Record of Heats.
A record of the patterns should always be kept, and the above card is proposed for this purpose. As will be seen, it will contain the pattern number, date ordered, date made, kind of material, and number of drawing.

Under description should be given the name of the pattern, e.g., Cylinder, University of Illinois Gasoline Engine. If at any time the pattern is altered, the date and in general what the change is should also be put on the card. Lastly, a record of the cost should be made.

One of these cards should be made out for every pattern. If at any time the pattern is discarded, it should be marked on the card, and if scrapped, the card destroyed. The patterns for any one machine should be numbered consecutively, and filed according to the numbers in the office of the Assistant Professor of Machine Construction.
<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>USED BY</th>
</tr>
</thead>
<tbody>
<tr>
<td>ORDERED</td>
<td>USED</td>
</tr>
<tr>
<td>DATE</td>
<td>DATE</td>
</tr>
<tr>
<td>AMOUNT</td>
<td>AMOUNT</td>
</tr>
<tr>
<td>RECEIVED</td>
<td>USED</td>
</tr>
<tr>
<td>DATE</td>
<td>DATE</td>
</tr>
<tr>
<td>AMOUNT</td>
<td>AMOUNT</td>
</tr>
</tbody>
</table>

RECORD CARD FOR MATERIAL
The above card is suggested for keeping a record of the material received and used. The amounts should be carried in totals so that the last item would always show the total amount received or used. This card should be used for all of the leading materials used in the Shop. For the miscellaneous supplies, as found in the tool room, i.e., nails, screws, bolts, sand paper, etc., a record of this kind would involve more labor than the information would be worth. However, for lumber, coke, pig iron, steel, etc. this could be handled with very little trouble.

Pattern Shop: The lumber is the leading item for this shop. Stock should only be cut on order, and when the work is completed, the order returned to the tool room, where it could be posted on the record card. The stock should be cut in amounts sufficient for the class, and not as the individual student requires it, thus doing away with entries for a very small amount.

Foundry: In the Foundry this card should be used for the raw material, i.e., coke, pig iron, copper, tin, etc., and also for the castings ordered and delivered. The attached 3" x 5" card, used for keeping a record of the heats, would give the necessary information for posting when turned into the office. This small card should be filled out during the time of taking the heat and could also be used in connection with the heat record sheet, which is used for keeping a summary of the heats taken during the semester.

Such a record as outlined above would enable the instructor to know what castings are needed, the number required,
Heat Record Card

<table>
<thead>
<tr>
<th>HEAT NO.</th>
<th>DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CHARGE IN POUNDS</th>
<th>CASTINGS IN POUNDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>COKE</td>
<td>PIG IRON</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| LIGHT UP | IRON MELTED |
| BLAST ON | IRON TO FUEL |
| FIRST IRON | WEIGHED BACK |
| DROPPED | GOOD CASTS. |
|          | LOSS        |

Front of Card - Filled out by foreman at time of taking heat.

<table>
<thead>
<tr>
<th>GOOD CASTINGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>NAME</td>
</tr>
<tr>
<td>NAME</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

Back of Card - Filled out by foreman when cleaning floor, and turned into the office when completed.
<table>
<thead>
<tr>
<th>No.</th>
<th>DATE</th>
<th>TIME</th>
<th>CHARGE IN LB.</th>
<th>CASTINGS IN POUNDS</th>
<th>TOTAL LOSS</th>
<th>PERCENT GOOD CASTINGS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>LIGHT UP</td>
<td>BLAST ON</td>
<td>FIRST IRON</td>
<td>DROPPED COKE</td>
</tr>
</tbody>
</table>
or amount on hand. In this way, they could generally keep some on hand, and not hold up the Machine Shop as is often done under the present system.

Machine Shop: With the Machine Shop as arranged now, it would be difficult to operate a record system as outlined above. No stock is cut in advance. The student secures an order for the amount desired, and the tool room attendant or the student himself cuts it. This would make the entries too numerous and small. However, with the proposed new store room, a basement under the rear of the building extending the full width, this could be accomplished. The saws and cutting tools could then be installed in the basement. The stock for the standard exercises should be cut and placed in racks before required by the students, and a record kept only of the stock as cut. This stock should be cut only on order, and by either the tool room attendant or a student assigned especially for this work. On completion, the order with the amount cut should be signed and turned into the office, where it could be posted on the card. Stock used for special work, and not used by the students regularly, would have to be cut as needed. However, this would not entail many entries, as the amount used in a year would be small.

This card would also furnish a means for keeping a record of the number of castings received from the Foundry, and used in the shop. Also for the steel castings, oil cups, etc. bought by the University for the use of the students.
Forge Shop: The above in relation to the stock room for the Machine Shop applies equally well to the Forge Shop. The stock would have to be cut ahead of time, and a record kept of only the stock as cut. The amount used by the individual student is too small to be taken into consideration.

There is no way of weighing the coal, and unless scales should be installed, no record of this could be kept.