

A SURVEY OF METHODS AND MATERIALS OF  
INSTRUCTION USED TO ATTAIN EDUCATIONAL  
OBJECTIVES SET FORTH FOR MANUFACTURING  
PROCESSES COURSES

by

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## CHAPTER I

### INTRODUCTION AND REVIEW OF LITERATURE

Engineering education has offered instruction related to the field of industrial manufacturing processes since inception:

THE HISTORICAL DEVELOPMENT of engineering education in the United States has been responsible for both strengths and weaknesses. With the advent of the railroad and the recognition of the part technology was playing in the industrial development of the nation, education of young men in the applied sciences became a concern. As there was no foundation for a system of apprentice training or any formal technical education, the field was open to a new approach to the education of engineers. American scientists and educators quickly fitted the training of engineers in the pattern of the traditional four-year collegiate program. This early formalization made it possible for engineering education to be drawn quickly into the mainstream of higher education and to assume the form of a professional discipline, free of outside regulations and capable of readily adapting its programs to the changing demands of industry.<sup>1</sup>

Early instruction was practical in nature and directed primarily to developing skills in and knowledge about manufacturing techniques. The method of instruction involved the student in actual exercises which were performed on equipment which was similar to that used in industry. The exercises were geared to the practices

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<sup>1</sup>Erick Walker, "Engineering Education Around the World; The United States", Journal of Engineering Education, Volume 57, number 2 (October 1966), 101.

of industry. This type of instruction prevailed as late as the early 1940's when Hesse made the following statement:

In recent years there has been a tendency to eliminate or curtail college laboratory courses dealing with wood shop, machine shop, and foundry practice and technique. This situation has developed because the professional and cultural content of the average engineering curriculum has been greatly increased, and also because it is practically impossible to include in a practice or laboratory course the new and diversified methods brought about by mass production.<sup>2</sup>

Prior to the 1940's the engineer was expected to roll up his sleeves from time to time in order to get things done. Instruction offered in manufacturing processes has varied from college to college since the transitional period of the 1940's. Instruction in the field ranged from textbook coverage only, to the experimental laboratory approach with some conservatives sticking with the lecture-demonstration method. The methods listed here do not include all the wide variations possible between these two major extremes. There is an indication, through publication of a few new texts,<sup>3,4</sup> that the extreme of the future could be a purely theoretical problem-

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<sup>2</sup>Herman C. Hesse, Engineering Tools and Processes (New York: D. Van Nostrand Company, Inc., 1941), p. vii.

<sup>3</sup>Joseph Datsko, Material Properties and Manufacturing Processes (New York: John Wiley & Sons, Inc., 1966), p. vi.

<sup>4</sup>Nathan H. Cook, Manufacturing Analysis (Reading, Massachusetts: Addison-Wesley Publishing Company, Inc., 1966), p. v.

solving course of instruction in the field of manufacturing processes. Datsko suggested a need for this type of instruction in an article entitled A Problem-Oriented Manufacturing Processes Course.<sup>5</sup>

The following is a statement and definition of engineering which implies the limits and bounds of the subject matter to be included in engineering curricula.

Engineering is not a science but is rather an application of science. It is an art composed of the skill and ingenuity in adapting knowledge to the uses of the human race. As expressed in a definition adopted by the Engineers' Council For Professional Development: 'Engineering is the profession in which a knowledge of the mathematical and natural sciences gained by study, experience, and practice is applied with judgement to develop ways to utilize, economically, the materials and forces of nature for the benefit of mankind.' In this, as in most other accepted definitions, the applied nature of engineering activity is emphasized.<sup>6</sup>

This statement and the included definition suggests that the scope of engineering education would be anything but narrow. Engineering educators are constantly striving to stay abreast of the technological changes which occur from day to day. Since change in engineering technology is a continuous process, one wonders if there is a specific type of course which would fit the purpose for engineering or if not, what variations exist in the types of courses currently offered.

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<sup>5</sup>Joseph Datsko, "A Problem-Oriented Manufacturing Processes Course", Journal of Engineering Education, 58:68, September, 1967.

<sup>6</sup>Holger G. Thuesen and Walter J. Fabrycky, Engineering Economy (Englewood Cliffs, N. J.: Prentice-Hall, Inc., 1964), p. 3.

### I. Delimitations

In 1932 eight major professional engineering societies in the United States organized an accrediting agency whose purpose was to promote and advance engineering education. This agency was named the Engineers' Council For Professional Development. In 1966 this Council accredited, at colleges and universities in the United States, 55 curricula and options in Industrial and Management Engineering.<sup>7</sup> Nine of these were Industrial Engineering options. Therefore, 46 curricula remained when these nine options were excluded. By searching the catalog holdings at the Virginia Polytechnic Institute Library, the researcher compiled a list of 43 Industrial Engineering curricula offered in colleges and universities in the United States which might offer course instruction in manufacturing processes. Some courses involved subject matter which was dissimilar to that of manufacturing processes courses even though each of several particular courses bore a similar title. Two of these were tool design and production planning courses. Therefore, the list of potential respondents included some who did not teach manufacturing processes courses per se.

Some of the colleges and universities listed still offered "shop" courses. Emphasis in this study was restricted to the manufacturing

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<sup>7</sup>Engineers' Council For Professional Development, Thirty-fourth Annual Report for the Year Ending September 30, 1966. (New York, New York: Engineers' Council For Professional Development, 1966), p. 9.

processes oriented courses which were taught in a curriculum accredited by the Engineers' Council For Professional Development.

## II. Statement of Problem

The problem was:

1. To determine the instructional methods and materials of instruction used in manufacturing processes courses offered in college Industrial Engineering curricula, and
2. To secure from the instructor of each such course his evaluation of the effectiveness of the methods and materials of instruction he used.

The investigation was designed to answer such questions as: Do variations in instruction exist with respect to educational methods, instructional materials, and laboratory techniques? Is there a variation in ratio of classroom hours and lecture hours? Are credit hours earned in each course approximately the same? Is there a difference in the number of instructional hours applied to the basic concepts which are fundamental to the manufacturing processes field? How does each instructor teaching manufacturing processes rate the effectiveness of his educational methods in attaining certain educational objectives in his manufacturing processes course?

## III. Purpose of Study

The purpose was to determine the methods and instructional materials used in manufacturing processes courses offered in college

Industrial Engineering curricula and evaluate the effectiveness of such methods and materials in accomplishing educational objectives.

Specific aspects were limited to:

1. Educational methods used.
2. Time devoted to required manufacturing processes courses.
3. Instructional materials used.
4. Laboratory techniques used.
5. Ratio of classroom hours to laboratory hours used.
6. Credit hours earned for completion of required manufacturing processes courses.
7. Time applied to each of the basic concepts which are considered to be fundamental to the manufacturing processes field.
8. A rating of the effectiveness of the educational methods used in attaining certain specified educational objectives.

#### IV. Design of Study

The investigation was conducted in the following manner:

1. Major engineering publications were examined until a list of curricula in Industrial Engineering accredited by the Engineers' Council For Professional Development was located in the 34TH ANNUAL REPORT FOR THE YEAR ENDING SEPTEMBER 30, 1966.
2. Catalogs of colleges and universities listed in the publication that had the Industrial Engineering curricula for manufacturing processes oriented courses were examined

and the department heads in charge were listed.

3. A questionnaire check-list-form was prepared for securing data from instructors in charge of manufacturing processes courses. (See Appendix C.)
4. A letter was sent to the department head in charge of manufacturing processes courses at each specified institution during September 1967. The letter introduced the recipient to the questionnaire included in the same envelope. (See Appendix A.)
5. The data contained in the completed questionnaires, (See Appendix F) were compiled and analyzed. The findings are presented in this report.

## CHAPTER II

### SOURCES OF DATA

As stated in the delimitations, only those colleges accredited by the Engineers' Council For Professional Development and offering manufacturing processes course instruction in the Industrial Engineering curricula were surveyed in this study. The course or courses offered were ones required for graduation in the Industrial Engineering curriculum at the particular institution.

Many colleges and universities did not at that time offer curricula in Industrial Engineering. At colleges and universities where Industrial Engineering curricula were offered, many were not accredited by the Engineers' Council For Professional Development. Each year the Engineers' Council for Professional Development publishes an official list of the colleges and universities which are currently accredited. This study was limited to the listing of accredited colleges and universities which appeared in the 34TH ANNUAL REPORT FOR THE YEAR ENDING SEPTEMBER 30, 1966, published by the Engineers' Council For Professional Development.

Some of the colleges and universities which offered curricula in Industrial Engineering did not offer manufacturing processes course instruction. The institutions surveyed in this study were selected from accredited colleges and institutions where manufacturing processes courses of instruction were offered as indicated in the catalog of each such institution. Since tool design and production

planning courses often had titles similar to manufacturing processes courses, it became necessary to search the Industrial Engineering curricula for each institution.

Data were collected only at institutions where manufacturing processes courses of instruction were currently offered. The questionnaire method of research was used for soliciting data. (See Appendix C.) The respondents are listed in Appendix E.

A cover letter and a copy of the questionnaire were mailed to the head of the Industrial Engineering Department at each institution selected to participate in the study. The letter explained the need for individual attention concerning the mode of current practices in manufacturing processes course instruction. (See Appendix A.)

The data were solicited in typical questionnaire form as specified by Best.<sup>7</sup> The combination rating guide and check-list-form used is a modification of Campbell's form<sup>8</sup> using Krathwohl's educational objectives, knowledge area.<sup>9</sup> Space was provided for the individual instructor's rating of the effectiveness of his major instructional method in attaining the specified educational objectives. (See Appendix C.)

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<sup>7</sup>John W. Best, Research in Education (Englewood Cliffs, N. J.: Prentice-Hall, Inc., 1959), p. 146.

<sup>8</sup>William G. Campbell, Form and Style in Thesis Writing (Boston, Massachusetts: Houghton Mifflin Company, 1954), p. 95.

<sup>9</sup>David Krathwohl, Benjamin Bloom and Bertram Mosia, Taxonomy of Educational Objectives - The Classification of Educational Goals (New York: David McKay Company, 1964), p. 186.

## CHAPTER III

### PRESENTATION OF DATA

A search of college catalogs indicated that 43 of the colleges accredited by the Engineers' Council For Professional Development offered a course in manufacturing processes which was required for graduation in the curriculum of Industrial Engineering. A copy of the questionnaire was mailed to the head of the Industrial Engineering Department in each of these institutions. Due to the similarity of names of certain courses previously mentioned, a copy of the questionnaire was inadvertently mailed to each of a few colleges which did not offer manufacturing processes courses.

The 43 questionnaires were mailed on September 29, 1967 and the first return was received within four days of the initial mailing. From this time on, returns were sporadic in nature, but finally materialized to 88.3% by December 17, 1967.

#### I. Synopsis of Returns

1. Number of colleges which offered degrees in Industrial and Management Engineering and were accredited by the Engineers' Council For Professional Development	<u>55</u>
2. Number of questionnaires mailed	<u>43</u>
3. Number of questionnaires returned	<u>38</u>

4. Percentage of questionnaires returned	<u>88.3</u>
5. Number of respondents who offered manufacturing processes course instruction	<u>27</u>
6. Number of respondents who offered manufacturing processes laboratory instruction	<u>24</u>
7. Number of respondents who taught manufacturing processes course of instruction and completed the questionnaire	<u>22</u>
8. Number of respondents who taught manufacturing processes courses and partially completed the questionnaire. (Did not complete rating - check-list-forms)	<u>5</u>
9. Number of respondents who did not teach manufacturing processes courses	<u>10</u>
10. Number of questionnaires which were not returned	<u>6</u>

Academic System. The respondents, from each of the 27 colleges where manufacturing processes course instruction was required, reported that 18 were on the semester system, seven were on the quarter system, one was on the term system, and one was on the trimester system. (See Figure 1.) The quarter system was used in this report since all other academic systems are of greater magnitude.

Course Level. It may be seen by examining the data recorded in Figure 2 that manufacturing processes courses were offered at one institution for freshmen, 18 such courses were offered for sophomores, 14 for juniors, ten for seniors and six for graduate students.

Engineering Departments. The majority of manufacturing processes courses were required and taught for both mechanical and industrial engineers as shown in Figure 3. There were 18 such courses taught for mechanical and industrial engineers and ten for industrial engineers alone. One college reported that all engineers were required to take manufacturing processes courses.

Number of Different Courses Required. Twenty-seven respondents reported that collectively they taught a total of 47 manufacturing processes courses as recorded in Figure 4. Of these 47 courses, 16 offered one course each; five offered two different courses; four offered three different courses; one offered four different courses; and one college offered five different courses in manufacturing processes.

## II. Educational Methods

The respondents at the institutions from which data were received for this study reported that seven educational methods were used an accumulated total of 54 times as represented in Figure 5. Of this accumulated 54, 26 were for the informal lecture method, eight were for the formal lecture method, and five each for the following methods: group projects and reports, resource persons-presentations, student reports-

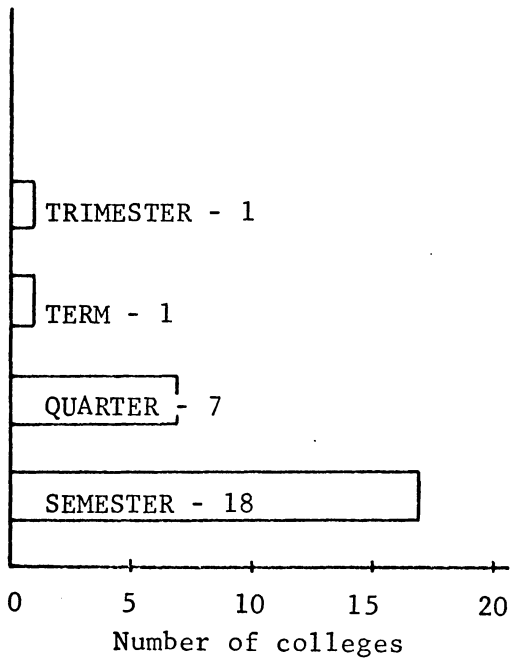


Figure 1. Academic systems reported by respondents

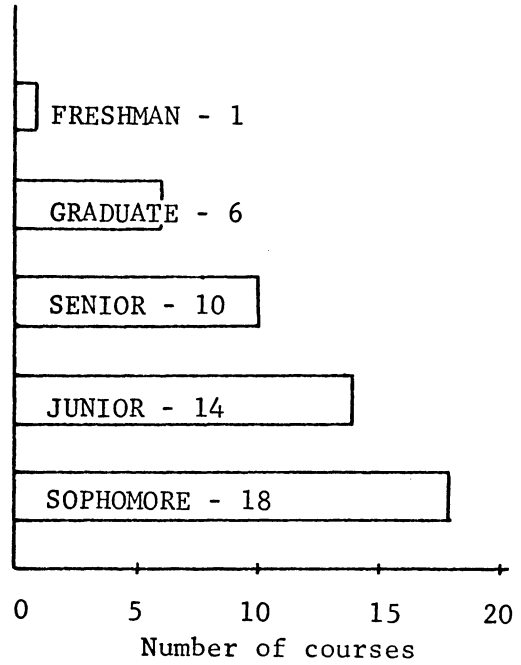


Figure 2. Course levels reported by respondents

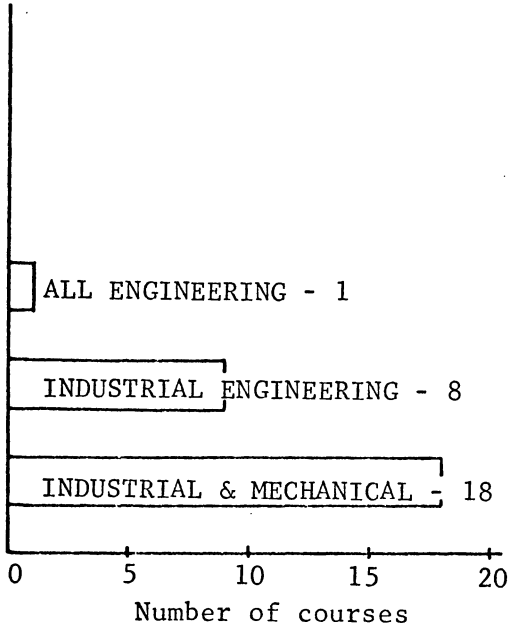


Figure 3. Engineering departments requiring manufacturing processes courses

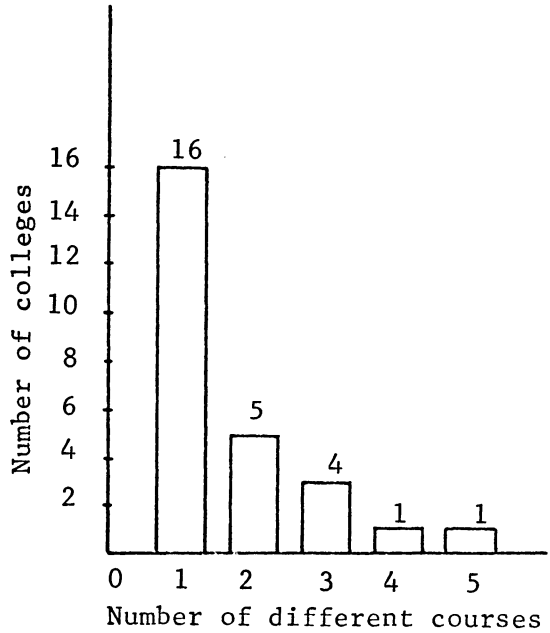


Figure 4. Number of colleges offering the same number of different manufacturing processes courses

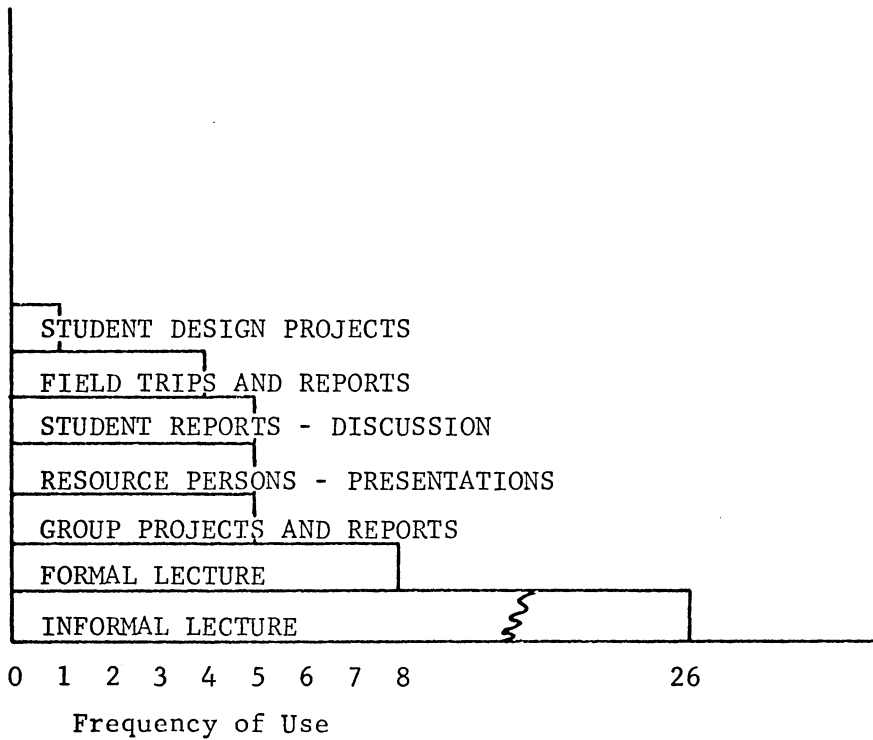


Figure 5. Instructional methods used by respondents in attaining educational objectives

discussion. Four were for the use of field trips and reports and one institution used student design projects as an educational method. The informal lecture method was used much more frequently than any other.

### III. Required Time

The total class hours of required manufacturing processes courses varied from college to college as recorded in Table 1 and Figure 6. These hours were all converted to the quarter system since this was the lowest common factor.

Total Class Hours. The more frequently reported range in the distribution of the total class hours was that of 30 to 60 hours with eight institutions included in this range. Three institutions in this range required 45 hours each, two required 50 hours each and one institution each required 30, 35, and 60 hours.

Six institutions were in the 60 to 90 total class hour range. Three institutions required 67 hours, two required 90, and one required 72 hours.

Four institutions were required in the 90 to 120 total class hour range. All four of these consisted of 112 total class hours.

One institution required 150 hours which was in the 120 to 150 hour range.

Three institutions, one each at 152, 157, and 180 hours, were in the 150 to 180 range.

One institution required 247 hours.

Four institutions required 337 hours.

TABLE I

TOTAL CLASS HOURS OF INSTRUCTION IN REQUIRED MANUFACTURING PROCESSES COURSES PER INSTITUTION FOR EACH OF THE 27 INSTITUTIONS

Institution	Total Hours	Institution	Total Hours
1	30	2	50
1	55	2	90
1	60	3	45
1	72	3	67
1	150	4	112
1	152	4	337
1	157		
1	180		
1	247		

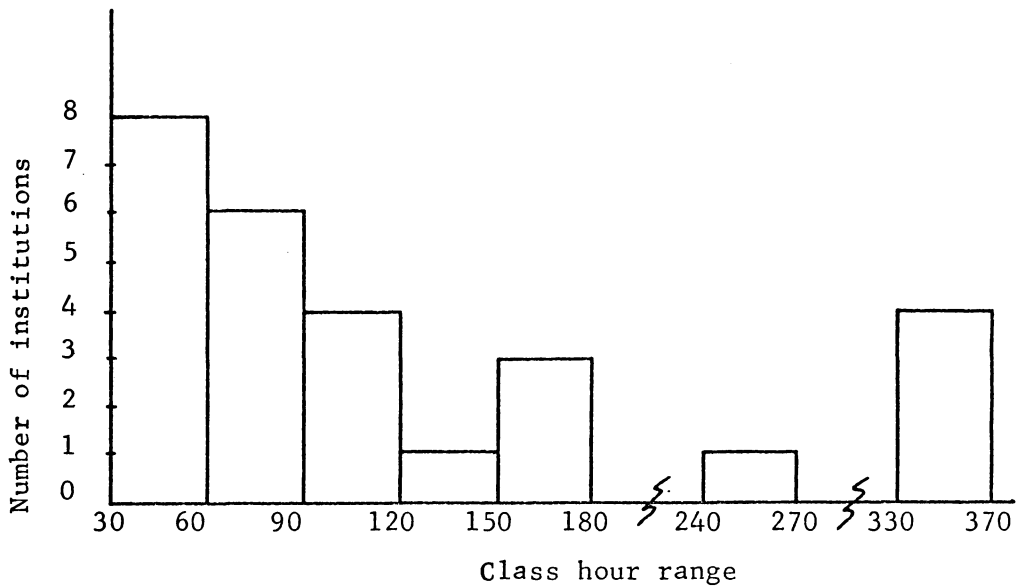


Figure 6. Distribution of the total class hours of manufacturing processes instruction for 27 colleges and universities

Class Size. Respondents from 27 colleges reported that variations in class size existed from course to course within an institution as well as from institution to institution (See Figure 7.) A total of 38 courses were reported by the 27 respondents. One class was reported to have had less than ten students enrolled, whereas 15 of the manufacturing processes classes had from ten to 20 students in each class. Nine classes each had 20 to 30 students, two classes were each composed of from 40 to 50, one class of from 50 to 60 and four classes of from 90 to 100 students each.

Laboratory Section Size. There was a wide variation in the size of the laboratory sections offered as shown in Figure 8. The data in this figure reveal the average number of students who were in each section and also the number of laboratory sections. Twenty-four of the 27 respondents representing institutions providing data for this study reported that the laboratory method of instruction was being used in teaching manufacturing processes courses.

There were 37 reports from 24 respondents on the average number of students per laboratory section. Of these 37 reports, nine reported laboratory sections of ten or less students, 16 (the majority) reported ten to 20 students, 11 reported 20 to 30 students, one respondent reported from 30 to 40 and one reported the maximum number of students in a laboratory section, 50 to 60.

Laboratory Group Size. Figure 8 reveals that there were many students in some laboratory sections. A large laboratory section may

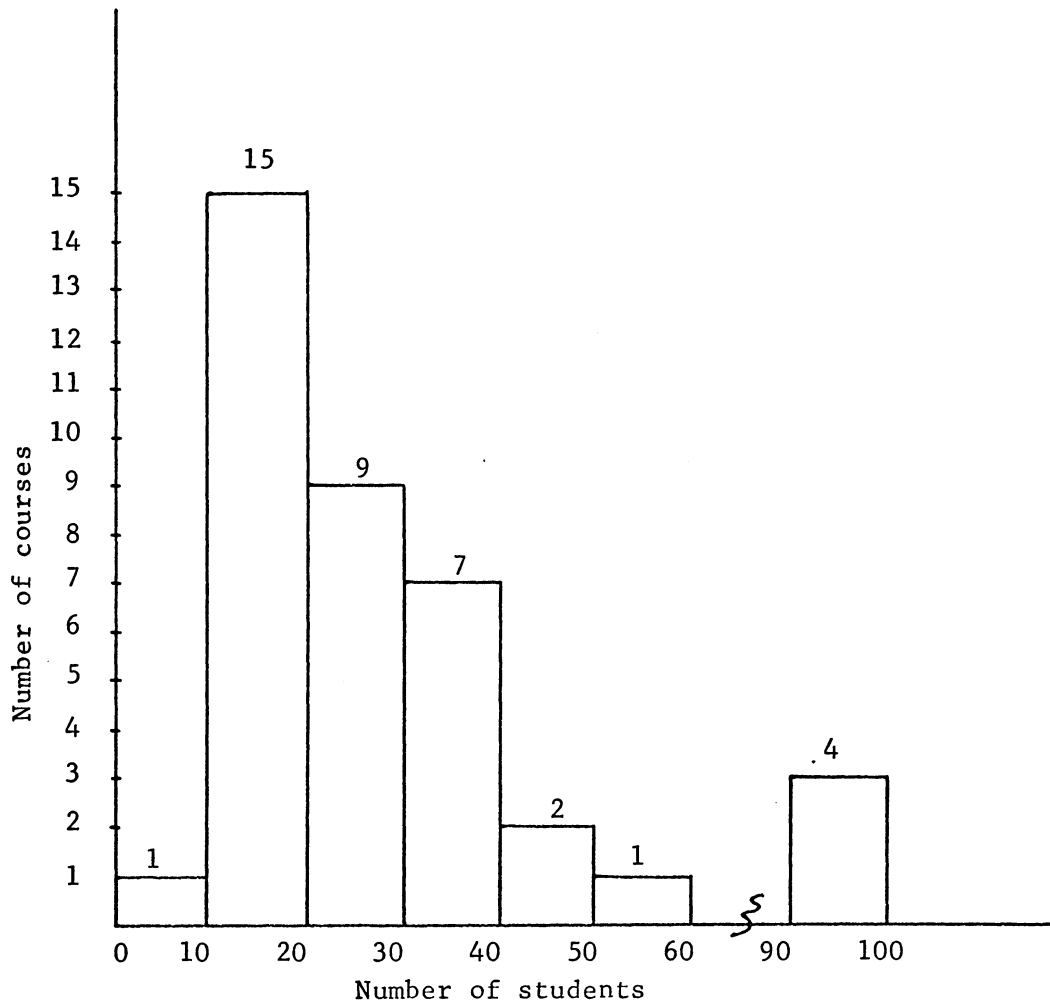


Figure 7. Average number of students per lecture class

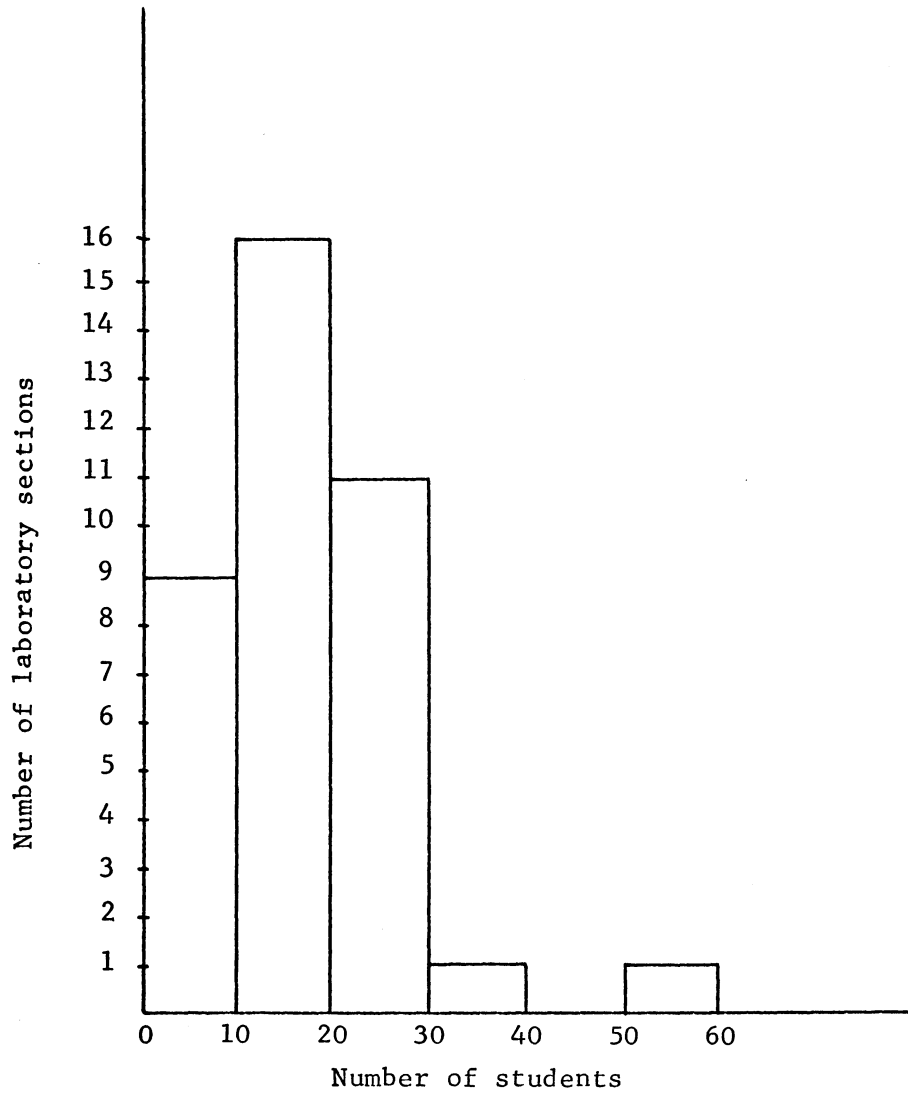


Figure 8. Average number of students per laboratory section

become difficult to manage unless the students are placed in small groups. Figure 9 contains the data reported relative to the number of students per group when laboratory sections were sub-divided into groups.

The report on one section indicated that the laboratory section was divided into groups of one or two students. Three laboratory sections were divided into groups of two or three students. Eight sections were divided into groups of three or four students. Three laboratory sections were divided into groups of four or five students. One laboratory section was divided into groups each containing 14 to 15 students.

#### IV. Instructional Materials - Informal Lecture

The instructional materials considered in this survey are listed on the check-list-forms included in Appendix C. Two areas of instructional materials were investigated. One area of instructional materials was related to the classroom whereas the second area was related to laboratory instructional materials. A separate page concerning the laboratory method was included in the questionnaire. A copy of the questionnaire and included forms is placed among the appendices of this report. (See Appendix C.)

A portion of the questionnaire form was reserved for a rating, by the respondent, of the effectiveness of the major educational method in attaining each specified educational objective. The eight

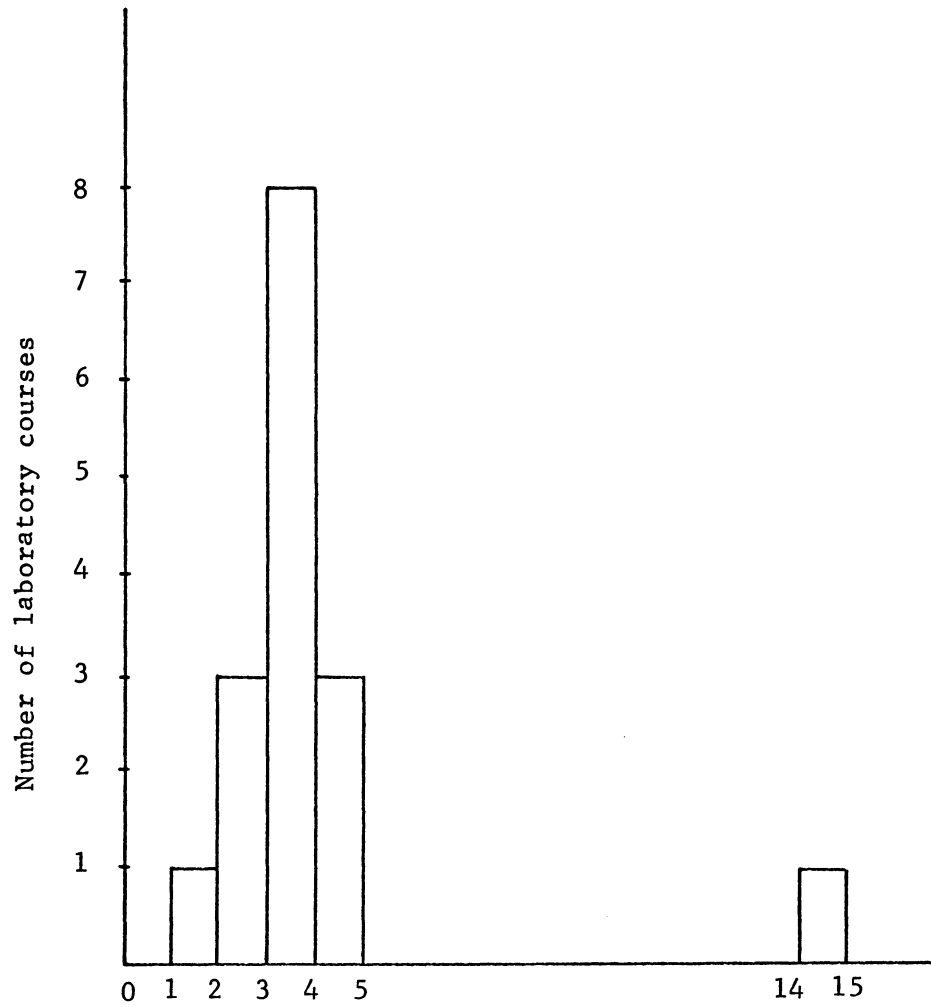


Figure 9. Average number of students per laboratory group

educational objectives are those stated by Krathwohl, Bloom, and Masia in their Taxonomy of Educational Objectives. (See Appendix D.) A space was provided to the side of each objective for checking the materials used in attaining each.

Knowledge of Specifics. The informal lecture method was the most used educational method reported on as recorded in Figure 5. Figure 10 represents the distribution of the informal lecture materials used in attaining the first educational objective specified: "Knowledge of Specifics." Respondent-added instructional materials were individually added to each educational objective on a limited basis only and therefore did not receive the attention of other respondents. The closed circuit television and demonstration methods as shown in Figure 10 were respondent-added. Tape recordings and opaque projectors were used on a limited basis. Text and references, chalkboards, objects, models and mock-ups, and motion pictures were the more frequently used educational materials. Slides and film-strips, overhead projection, charts, graphs and posters, and instructional pass-outs occupied central positions in applied use. A total of 109 reports were received for this objective.

Knowledge of Specific Facts. Reports on the use of the informal lecture materials in attaining the "Knowledge of Specific Facts" objective resulted in a shift in the emphasis of some materials. The data in Figure 11 shows the distribution of these materials. Motion pictures were used three times to achieve "Knowledge of Specific Facts" whereas they were used 15 times to attain "Knowledge of Specifics."

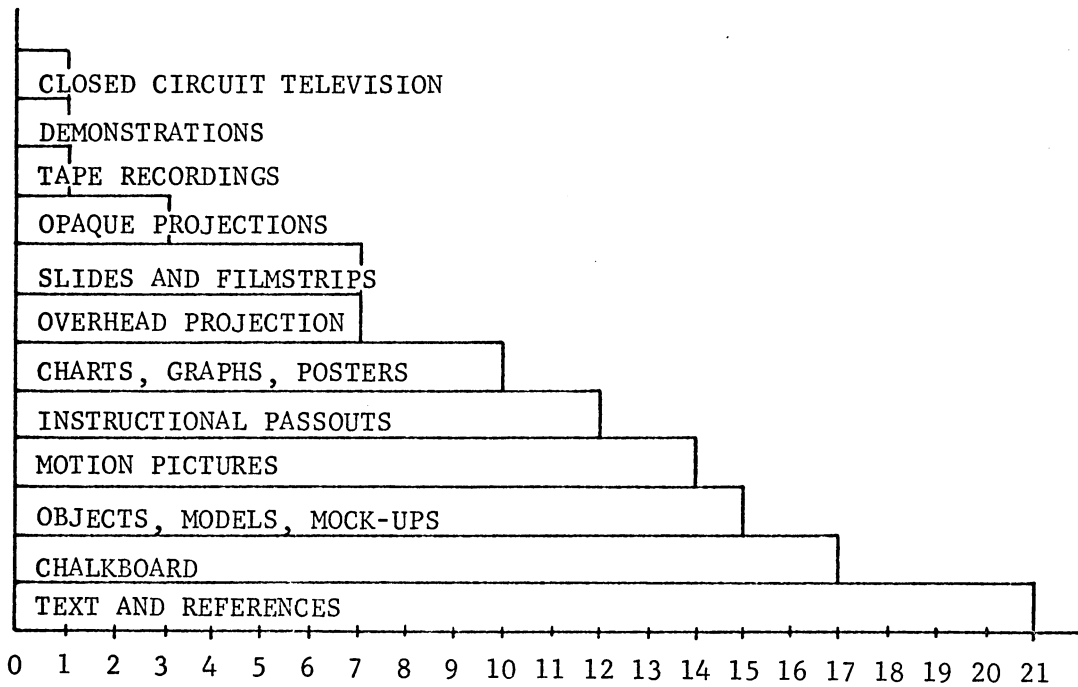


Figure 10. Distribution of lecture materials - Knowledge of Specifics

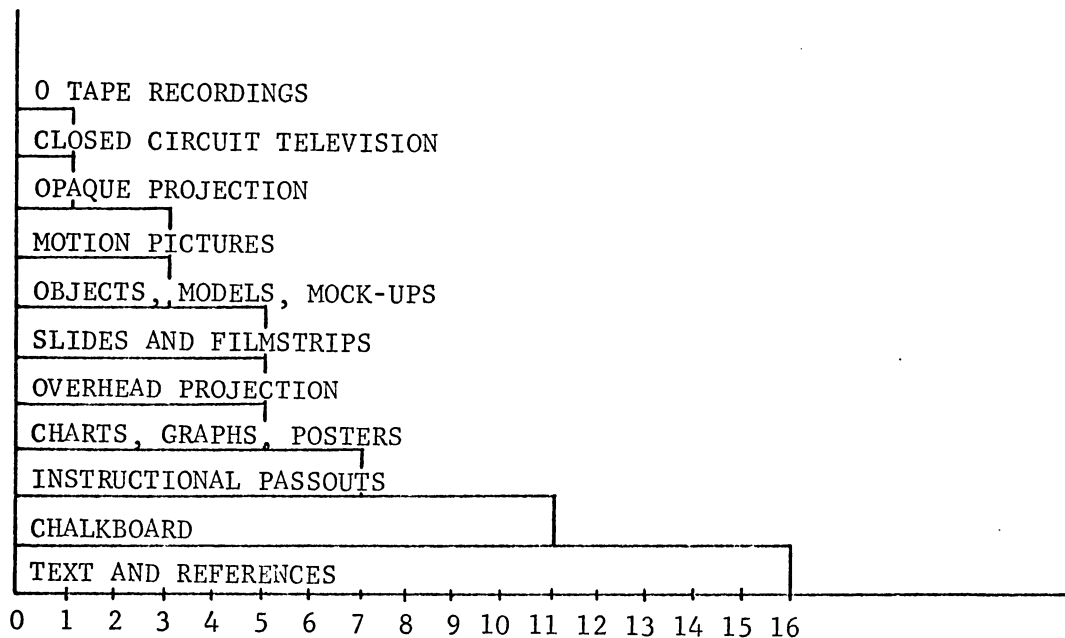


Figure 11. Distribution of lecture materials - Knowledge of Specific Facts

A total of 109 reports were received for "Specifics" whereas 61 reports were received for "Specific Facts."

The distribution of materials in "Specific Facts" is not radically different from "Specifics" other than the aforementioned. No reports of the use of tape recordings in attaining "Specific Facts" were reported. The demonstration method was added by one respondent.

Knowledge of Conventions. The respondents reported using the ten kinds of teaching aids listed in Figure 12, a total of 65 times, to support the lecture method in attaining the educational objective "Knowledge of Conventions." The use of tape recordings was not reported. Slides and filmstrips, overhead projection, charts, graphs and posters occupy a central position in the "Conventions" objective according to those respondents reporting. Closed circuit television was respondent-added.

Knowledge of Trends and Sequences. The data in Figure 13 disclose the extent to which lecture materials were used to achieve the educational objective, "Knowledge of Trends and Sequences." The 11 kinds of materials were used a total of 59 times in attaining this educational objective. Of these 59, 27 were listed for text and references, eight each for chalkboards and motion pictures, seven for overhead projection, and six for instructional pass-outs. Other materials were reported on a limited use basis with the exception of tape recordings which were not used at all. Closed circuit television was added by one respondent.

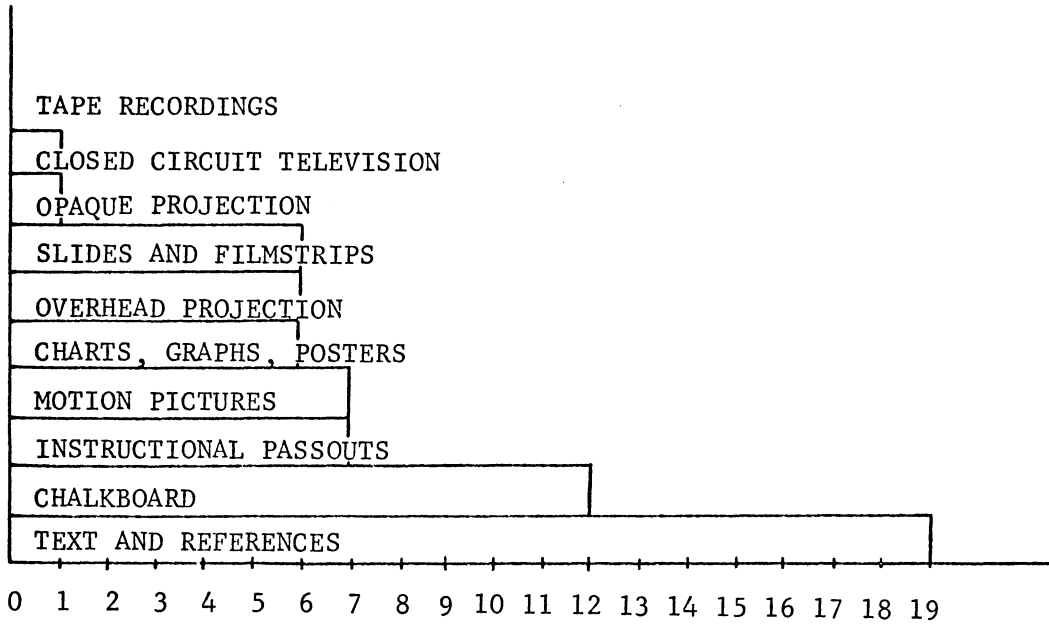


Figure 12. Distribution of lecture materials - Knowledge of Conventions

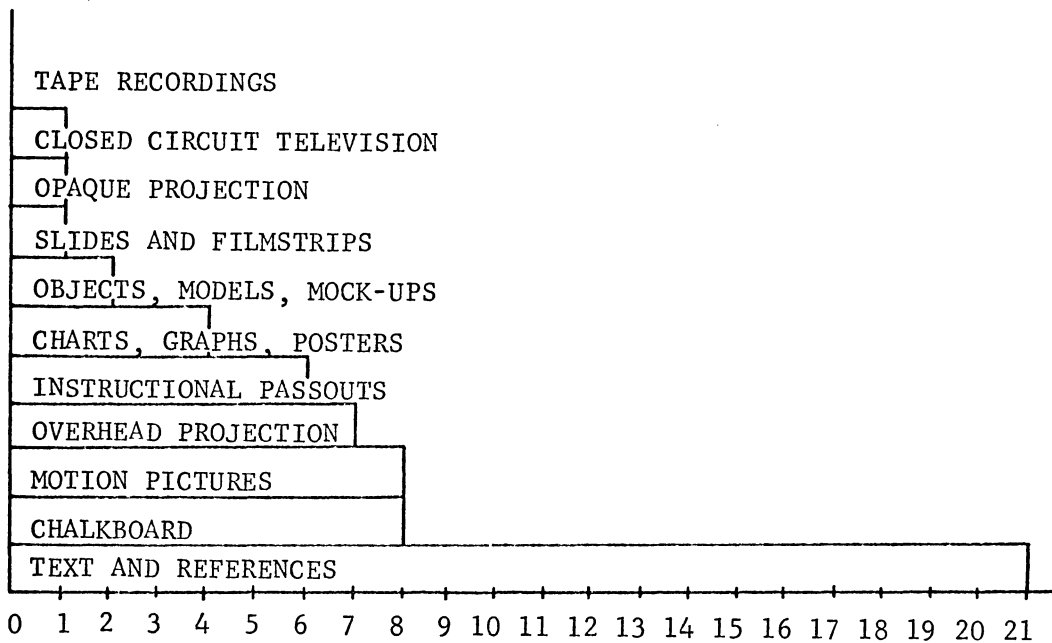


Figure 13. Distribution of lecture materials - Knowledge of Trends and Sequences

Knowledge of Criteria. The 27 respondents reported using ten kinds of instructional materials to support the informal lecture method in attaining the educational objective, "Knowledge of Criteria." The number of times each aid was used is recorded in Figure 14. Text and references were used 16 times, chalkboard 11, instructional pass-outs 8, charts, graphs, posters; overhead projection; motion pictures were each used five times. Objects, models, mock-ups and slides and filmstrips were each used two times. Opaque projection and demonstrations were used one time each. Tape recordings were not used to attain "Criteria." Collectively, lecture materials were used a total of 56 times to achieve this objective when using the informal lecture method.

Knowledge of Methodology. The 27 respondents reported that the lecture method was reinforced with one or more of the 11 teaching materials a collective total of 69 times in attaining the objective, "Knowledge of Methodology." Text and references were reported to be used 16 times in attaining this educational objective. Chalkboards were used 11 times, and motion pictures and pass-outs were used nine and eight times respectively. Instructional pass-outs were used eight times; objects, models, mock-ups and slides and filmstrips were used six times each. Charts, graphs, posters and overhead projection were each used four times whereas opaque projection was used twice in achieving the "Methodology" objective. Demonstrations were respondent-added. Tape recordings were not used.

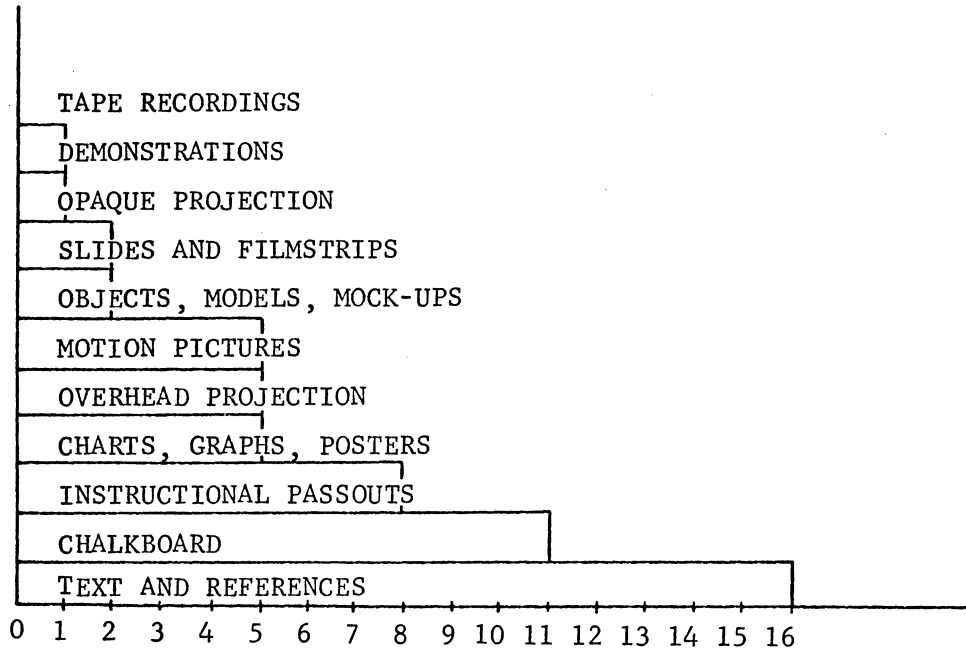


Figure 14. Distribution of lecture materials - Knowledge of Criteria

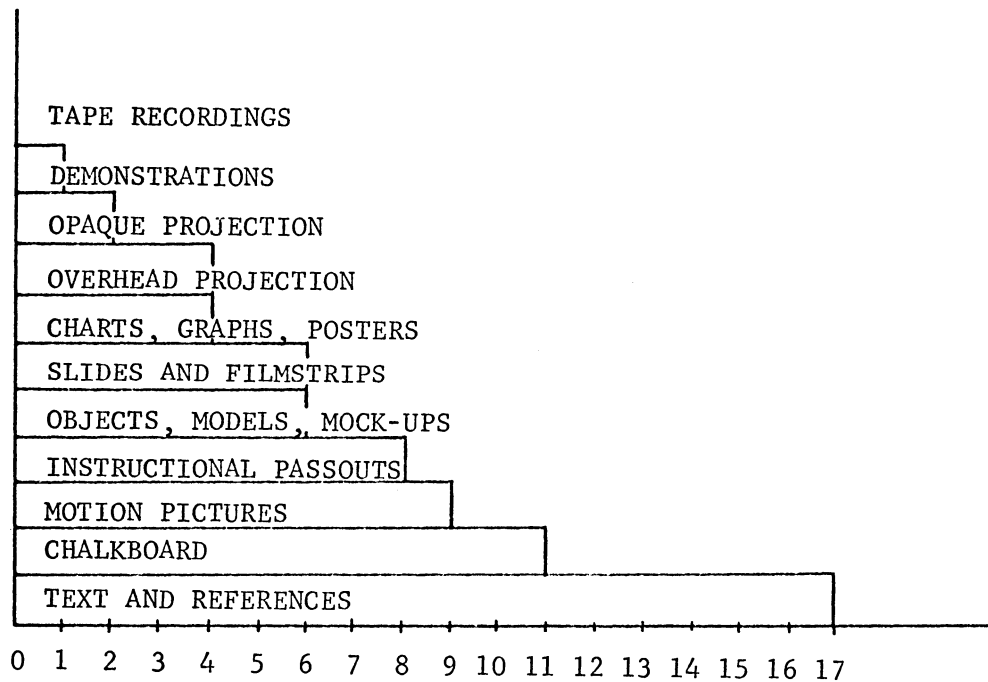


Figure 15. Distribution of lecture materials - Knowledge of Methodology

Knowledge of Principles and Generalizations. Figure 16 reveals that the 11 lecture materials were used for an accumulated total of 69 times to attain the "Principles and Generalizations" objective when using the informal lecture method. Of the 69, text and references were used 18; chalkboard 13; motion pictures 11; instructional pass-outs nine; objects, models, mock-ups seven; overhead projection six and slides and filmstrips were used five times. Charts, graphs, posters were used four times; opaque projection two; and demonstrations were respondent-added. Tape recordings were not used to attain this objective.

Knowledge of Theories and Structure. The 27 respondents reported that the informal lecture method was reinforced with the ten lecture materials for an accumulated total of 62 times in achieving the "Theories and Structure" objective. Of the 62, text and references were used 16; chalkboard 12; charts, graphs, posters and motion pictures seven each; instructional pass-outs and overhead projection six each; slides and filmstrips five and opaque projection was used twice. Closed circuit television was respondent-added. Tape recordings were not used. Twenty-eight of these reinforcements were attributed to text and references and chalkboard. Charts, graphs, posters, and motion pictures were used seven times each; instructional pass-outs and overhead projection were used 12 times; slides and filmstrips five; opaque projection two, and tape recordings were not used. Closed circuit television was respondent-added.

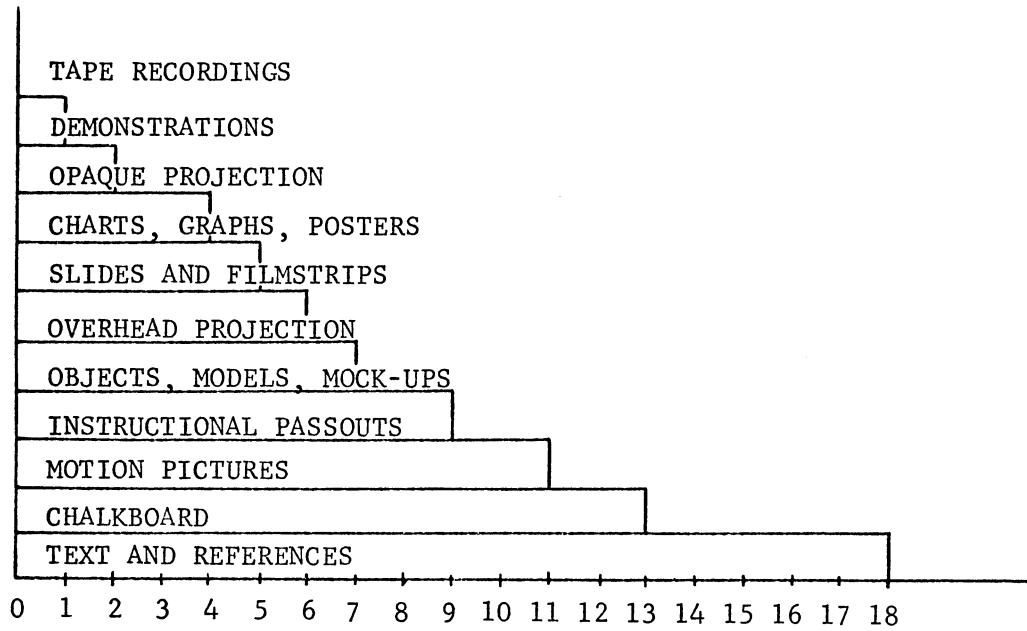


Figure 16. Distribution of lecture materials - Knowledge of Principles and Generalizations

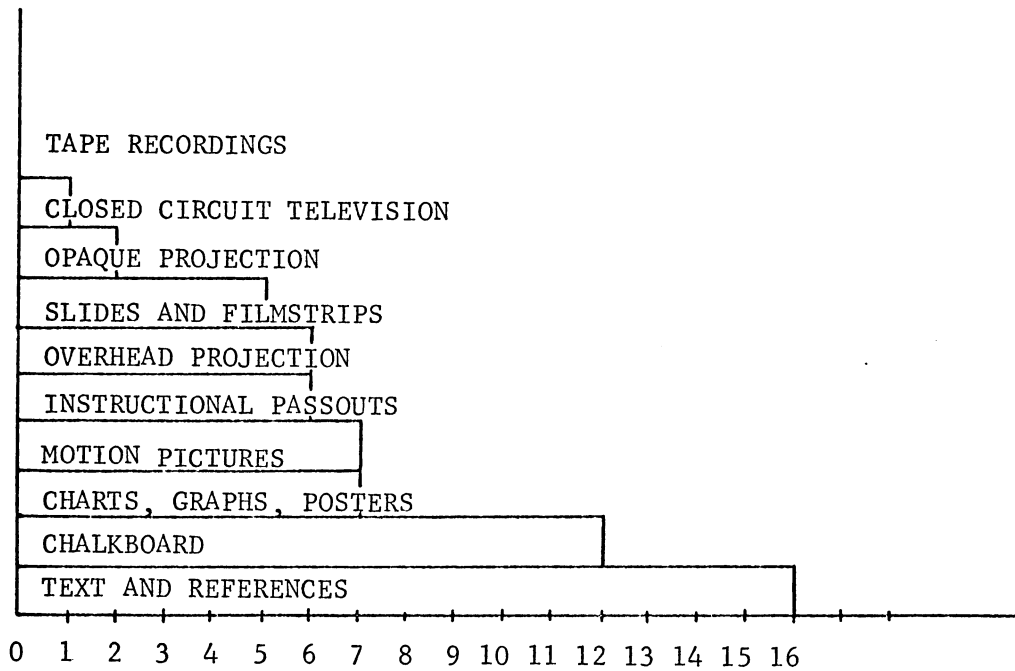


Figure 17. Distribution of lecture materials - Knowledge of Theories and Structure

### V. Instructional Techniques Laboratory

An individual rating guide-check-list-form was used to collect data on how each participating instructor attained each of eight educational objectives in his laboratory classes. Listed on the check-list were ten laboratory techniques which may be used in laboratory instruction. These techniques paralleled each educational objective and therefore were checked when used in presenting instruction for attaining each educational objective.

The instructors' reports were tallied and the collective frequency of the application of these techniques for each educational objective is presented in Figures 18-25. Twenty-two respondents reported data for this portion of the survey.

Knowledge of Specifics. Participating respondents reported that the laboratory method was reinforced with the ten specified techniques for an accumulated total of 72 times in attaining the "Specifics" objective (See Figure 18.) Of these 72, 29 were (specified) for written reports and demonstrations with 15 and 14 reports respectively. The experimental technique was used 11 times. These first three laboratory techniques account for 69% of the total reports received in this area. Manipulative exercises, investigation and practice were each used seven times. Project construction was used six times; research three, motion pictures two; and application none.

Knowledge of Specific Facts. A collective total of 54 applications are shown in Figure 19. These applications represent the reinforcement applied to the laboratory method in attaining the educational objective

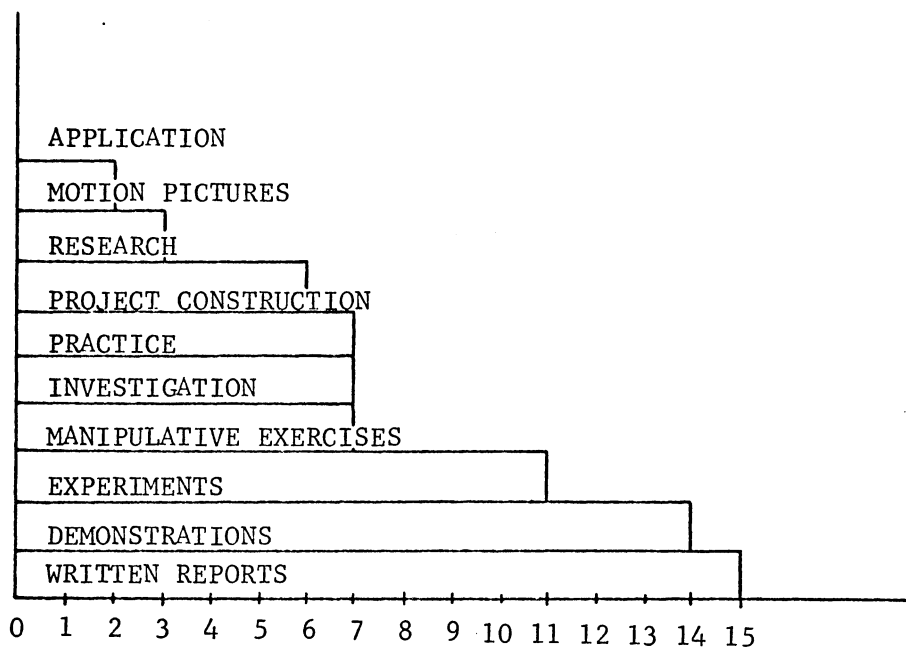


Figure 18. Distribution of laboratory techniques - Knowledge of Specifics

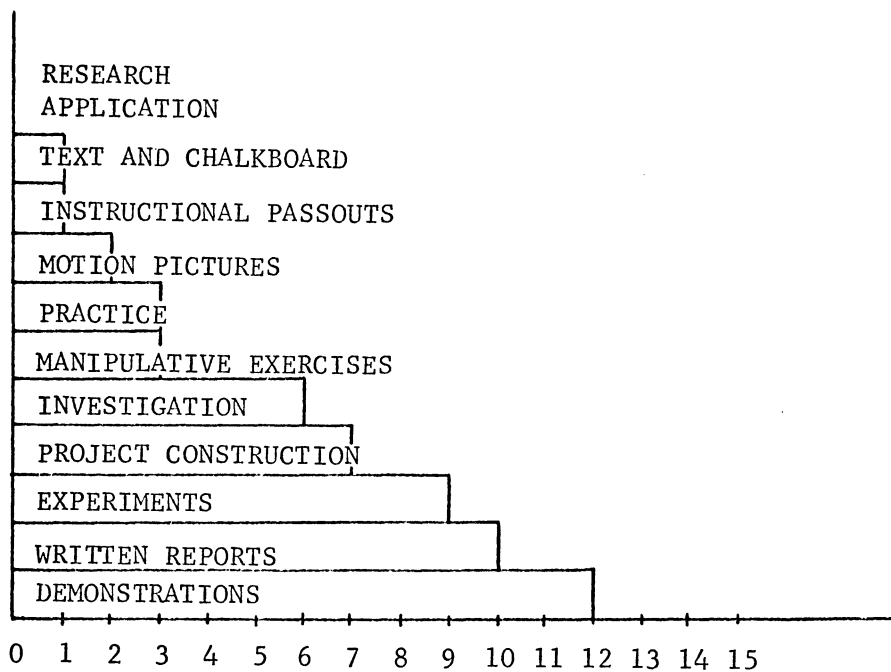


Figure 19. Distribution of laboratory techniques - Knowledge of Specific Facts

"Knowledge of Specific Facts." Demonstrations, with 12 applications, are in the first position in "Specific Facts" and written reports, with ten applications, are second. Experiments occupy the third position with nine. Project construction was used seven times; investigation six; manipulative exercises and practice were used three times each; motion pictures were added by two respondents and were therefore used twice; instructional pass-outs were used one time and application and research were not used. The text and chalkboard techniques were respondent-added.

Knowledge of Conventions. The laboratory method was reinforced a total of 42 times in attaining the educational objective, "Knowledge of Conventions"; Figure 20. Of these 42, written reports, demonstrations and experiments were used nine, seven, and six times respectively. The practice and project construction techniques were used four times each; manipulative exercises, investigation, and motion pictures (respondent-added) were used three times each. Application was not used.

Knowledge of Trends and Sequences. The 11 types of laboratory techniques were used a total of 22 times in assisting the laboratory method to achieve the educational objective, "Knowledge of Trends and Sequences"; Figure 21. Of these 22, demonstrations, written reports, and investigation share the maximum number of reports per technique with five reports each. Practice and project construction were used four times each; manipulative exercises, investigation and motion pictures

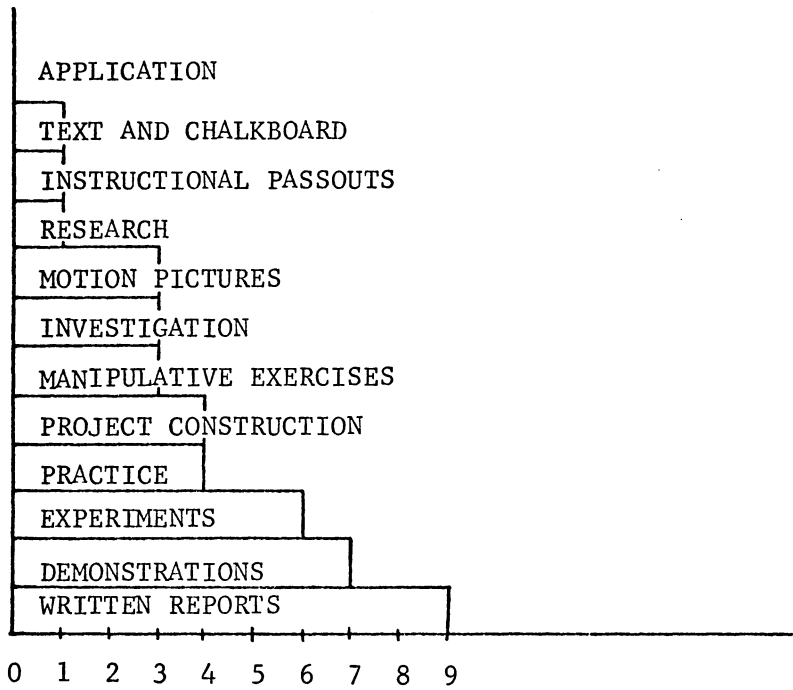


Figure 20. Distribution of laboratory techniques - Knowledge of Conventions

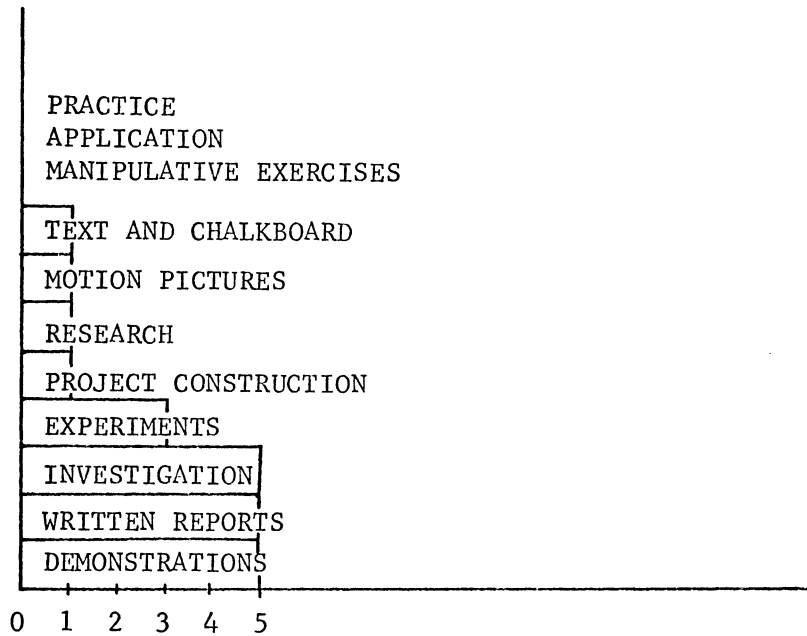


Figure 21. Distribution of laboratory techniques - Knowledge of Trends and Sequences

(respondent-added) were used three times each; research, instructional pass-outs, text and chalkboard (respondent-added) were used one time each. Application was not used.

Knowledge of Criteria. The 13 laboratory techniques listed in Figure 22 were used a total of 66 times to reinforce the laboratory method in attaining the educational objective, "Knowledge of Criteria." Of these 66, written reports, demonstrations, and experiments were used 12, 11 and nine times respectively; investigation, project construction, and practice were used nine, seven and six times respectively, manipulative exercises, motion pictures, and research were used four, three and two times respectively; instructional pass-outs, text and chalkboard (respondent-added) and field trips were used one time each. Application again was not used.

Knowledge of Methodology. Figure 23 reveals 69 reports. These 69 reports represent the usage of the ten laboratory techniques in assisting the laboratory method to achieve the educational objective, "Knowledge of Methodology." Demonstrations were used 13 times. Written reports followed with 11 and project construction and experiments each were used nine times. Manipulative exercises were used eight times; investigation seven, practice six, motion pictures four, and research two. Application was not used.

Knowledge of Principles and Generalizations. Figure 24 shows the utilization of the laboratory techniques in attaining the educational objective, "Knowledge of Principles and Generalizations." The listed techniques were used a total of 63 times. Laboratory demonstrations

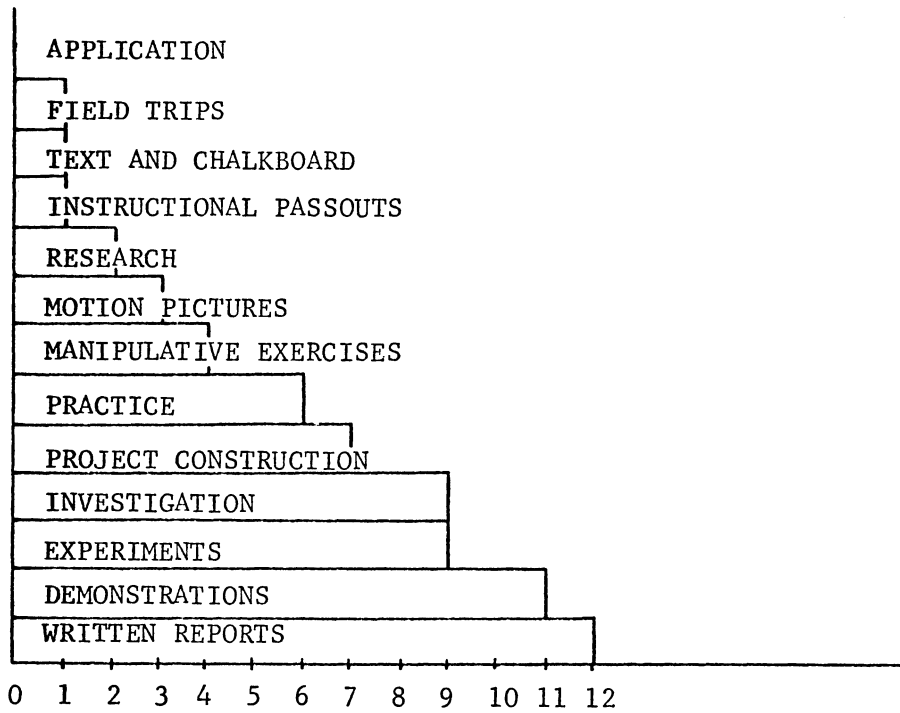


Figure 22. Distribution of laboratory techniques - Knowledge of Criteria

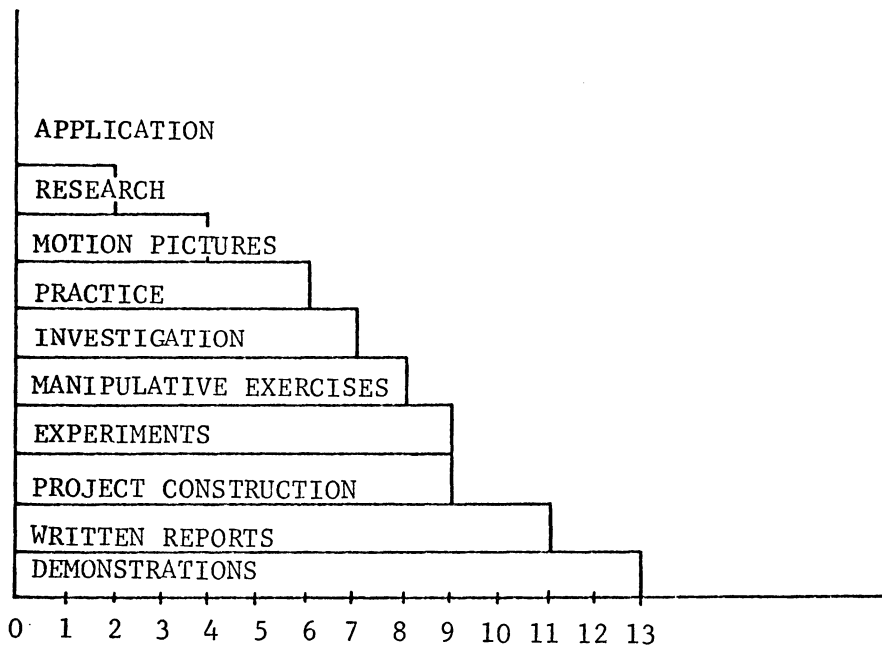


Figure 23. Distribution of laboratory techniques - Knowledge of Methodology

were more frequently used than any of the other listed techniques. The total utilization count for this technique was 11. Written reports with ten followed and the breakdown order was: project construction and experiments each with eight; practice with seven; investigation six; manipulative exercises five; motion pictures four; research three; and field trips one. Application was not used.

Knowledge of Theories and Structure. Figure 25 records a total of 36 reports. These reports show the utilization of the listed laboratory techniques in assisting the laboratory method to achieve the educational objective, "Knowledge of Theories and Structure." Written reports, experiments, demonstrations, and investigation were used more frequently than the remaining techniques with respective usage of eight, six, five and five times each. Motion pictures were used four times; manipulative exercises three, research two, and project construction, practice, text and chalkboard were used one time each. Application was not used.

#### VI. Ratio of Lecture Hours to Laboratory Hours

Respondents reported that eight informal lecture courses were taught without the application of laboratory instruction. (See Table II.)

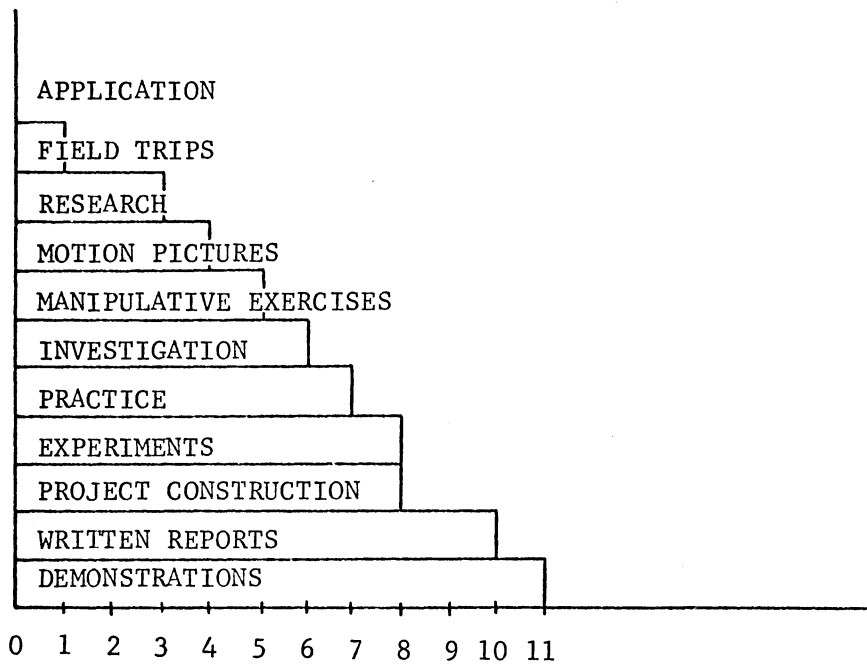


Figure 24. Distribution of laboratory techniques - Knowledge of Principles and Generalizations

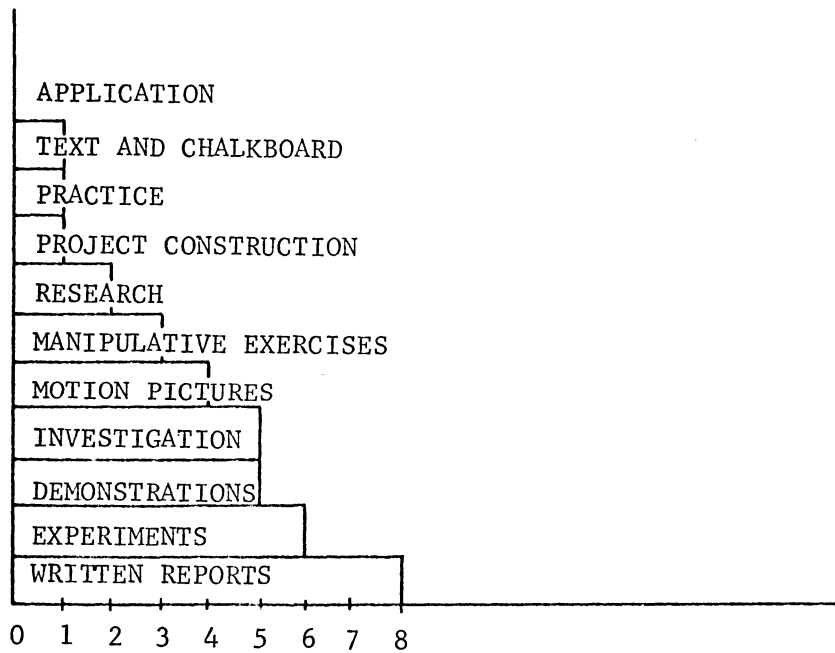


Figure 25. Distribution of laboratory techniques - Knowledge of Theories and Structure

Table II  
LECTURE COURSES - NO LABORATORY

Courses	Lecture Hours
3	67.5
2	45.0
1	90.0
1	30.0
1	48.0

Two 67.5 hour laboratory courses were reported. These reports did not include any lecture time.

Table III and Figure 26 present the ratio of lecture hours to laboratory hours reported by the respondents. The most popular ratio according to the frequency of occurrence was .67 with 12 courses reported. Seven courses were reported with a ratio of one which was second in order of frequency used. Three courses were reported with a ratio of .33 and three with a ratio of .75. Two courses were reported with a .43 and two courses reported a .5 ratio. One course each was reported with a ratio of .167, .2, and 1.33.

#### VII. Time Applied to Basic Concepts

Time is a relative factor and therefore should be related to the individual colleges before an average analysis may be drawn. Time applied to each concept would be a function of:

The lecture hours per section

The number of sections usually offered

TABLE III

## RATIO OF LECTURE HOURS TO LABORATORY HOURS

Courses	Ratio	
	Lecture	Laboratory
7	1	1
3	1	3
3	3	4
12	2	3
1	4	3
2	1	2
1	2	1
1	1	6
2	3	7

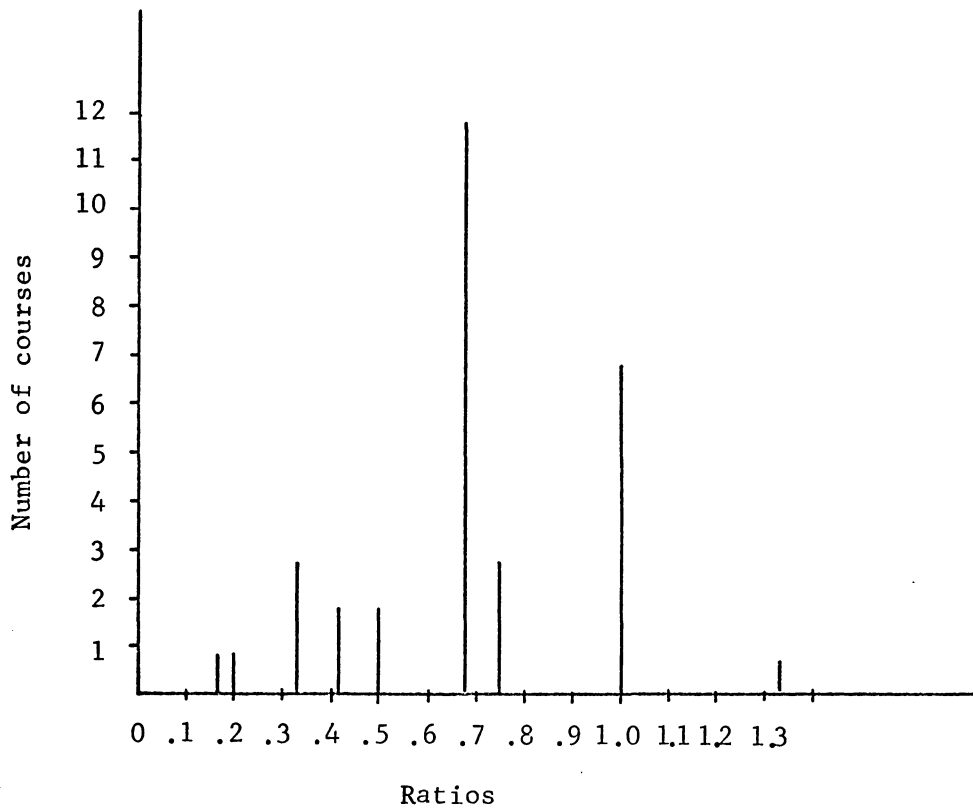


Figure 26. Ratio of lecture hours to laboratory hours

The laboratory hours per section

The credit hours of manufacturing processes courses required

Lecture Hours Per Section. Figure 27 indicates that 45 hour lecture sections are more popular than any other with 12 reports of this time period. There were eight reports of 67.5 hour lecture sections, six reports of 30 hour lecture sections, four reports of 32 hour lecture sections, three reports each of 125, 20, and 22.5 hour lecture sections; one section each offering 12, 27, 48, and 90 hour lecture sections.

Number of Sections Usually Offered. Many colleges offered more than one section of each course as represented in Figure 28. Seven colleges offered two sections of the same course, five colleges offered three sections of the same course, three colleges offered six sections of the same course, two offered four sections and one offered five sections of the same course. Seven colleges offered a single section of manufacturing processes courses. Two colleges did not respond to this question.

Laboratory Hours Per Section. Figure 29 reveals that the more popular laboratory section was made up of 67.5 hours with 12 reports of this time period. The second most popular section was made up of 45 hours with six reports of this time period. There were three reports of 30 hours, two reports of 28 and 60 hours each, and one report each of 16, 18, 22.5, 33, 35, 40, 42, and 135 laboratory hours per section.

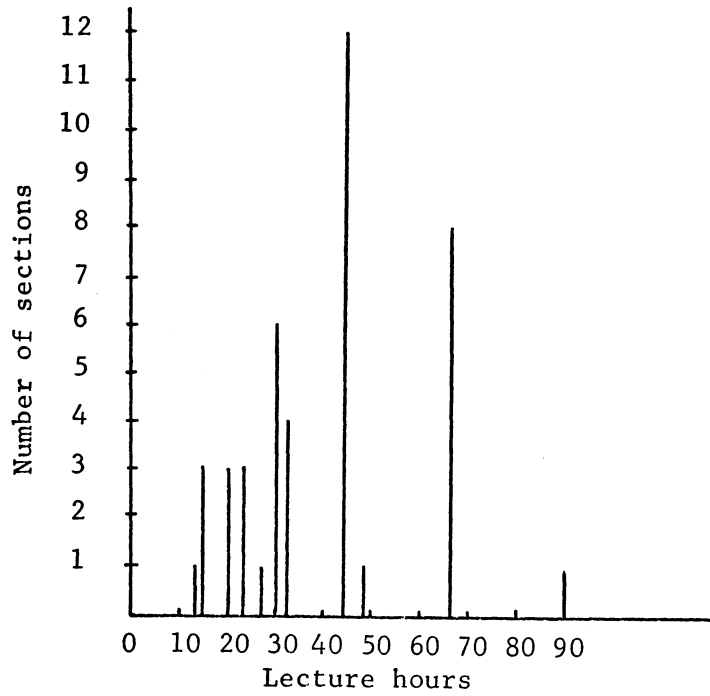


Figure 27. Number of sections offering the same lecture hours

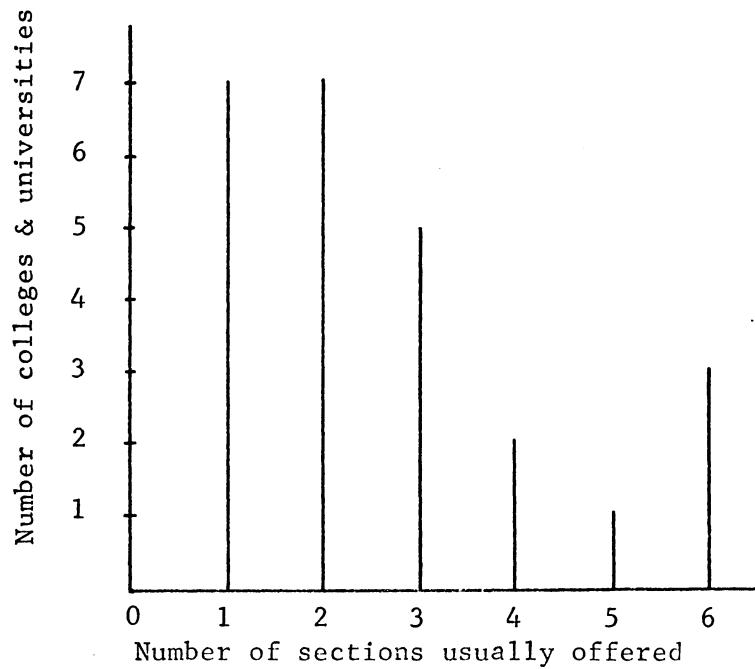


Figure 28. Number of sections of same course usually offered (greatest)

Credit Hours of Manufacturing Processes Courses Required Per

College. Total credit hours of manufacturing processes courses required by each college varied from college to college as indicated in Figure 30. All of the credit hours are based on the quarter system. Seven colleges required 4.5 credit hours of manufacturing processes courses for an undergraduate degree. Six colleges required three credit hours; four colleges required 13.5 credit hours. Two colleges each required six, seven and one-half, and nine credit hours. One college each required two, four, five, and 10.5 credit hours for an undergraduate degree.

Distribution of Basic Concepts. The number of different manufacturing processes courses offered by the different colleges reporting this type of instruction is represented in Figure 4. The basic concepts which are fundamental to manufacturing processes are fluidity, fusability, plasticity, and divisibility according to Ekey and Winter<sup>10</sup> and therefore were utilized in the questionnaire to sample the time applied to each area.

Figure 31 represents the average time applied to the basic concepts of manufacturing processes in an average manufacturing processes course. Fluidity involves the casting processes such as sand, centrifugal, investment, permanent molding, shell molding, die and plaster molding as listed in "M." of the questionnaire. A tally of all the fluidity reports averaged 18.1% of the average course time. Fusability represents the welding processes and averaged 13.4% of the average course time.

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<sup>10</sup>David C. Ekey and Wesley P. Winter, Introduction to Foundry Technology (New York: McGraw-Hill Book Company, 1958), p. 6.

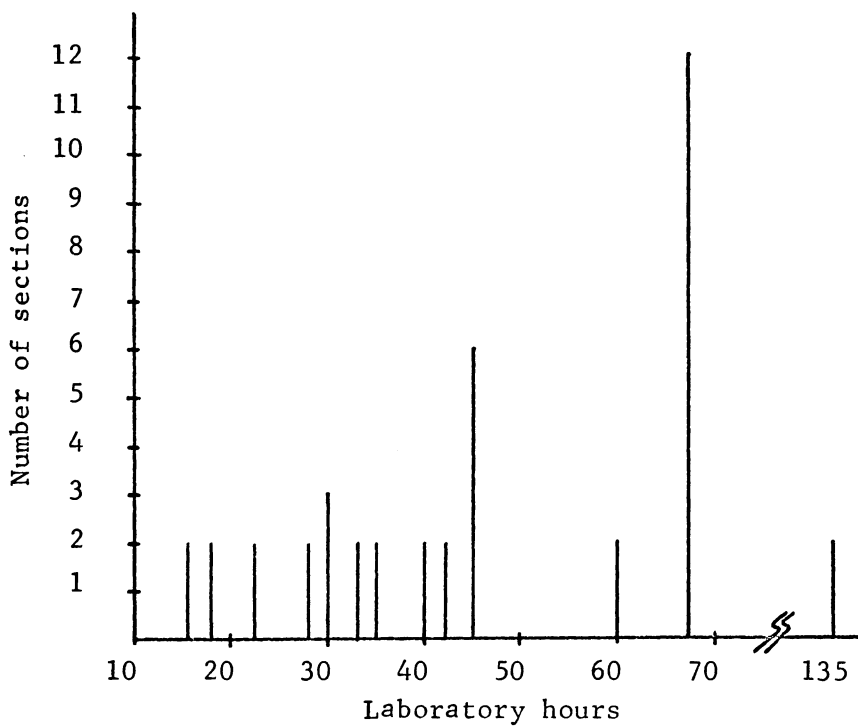


Figure 29. Number of sections offering same laboratory hours

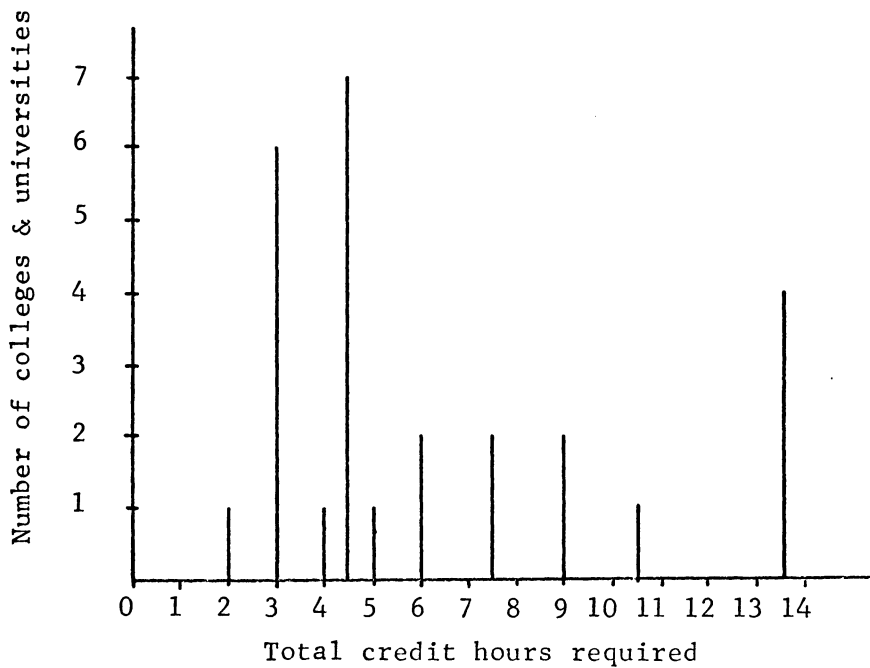


Figure 30. Total credit hours of manufacturing processes courses required in curriculum

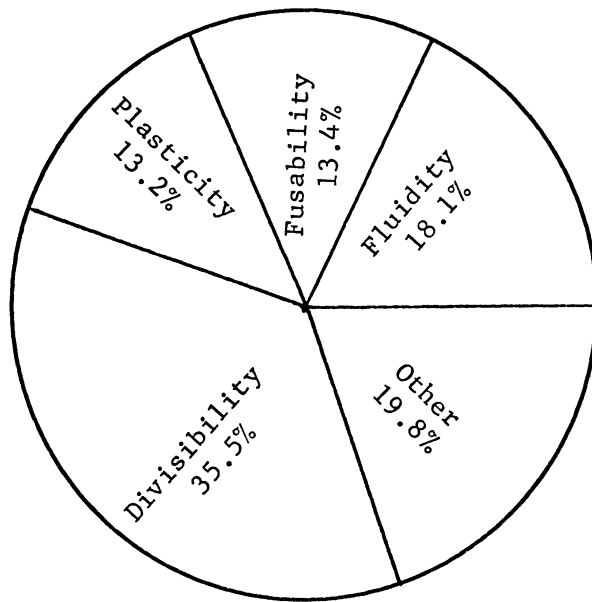


Figure 31. Distribution of basic concepts

Plasticity represented the forging, extruding, spinning, and stamping processes which averaged 13.2% of the average course time. Divisibility, the machining processes which are used to shape, size, and surface finish materials, make up the largest portion of the average course with 35.5%. Other processes received 19.8% of the average course.

#### VIII. Rating of Informal Lecture Effectiveness

The informal lecture method was most often used by the respondents in attaining educational objectives as has been previously indicated. Each respondent using the informal lecture method was requested to rate the effectiveness of this method in attaining each specified educational objective. The divisions on the rating used were: Excellent, Good, Fair, Poor, and Zero. No respondents rated the method "Zero" and very few rated it "Poor".

Knowledge of Specifics. Figure 32 reveals the ratings of the informal lecture effectiveness by the respondents for the educational objective, "Knowledge of Specifics. Of the 21 ratings, ten raters felt the method was "Excellent" in attaining this objective, seven rated it "Good", and four rated it as "Fair".

Knowledge of Specific Facts. Figure 33 records the Knowledge of Specific Facts. Seven raters reported the method was "Fair" and seven reported the method as "Good". "Excellent" ratings for this method consisted of three. Seventeen ratings were made for this objective.

Knowledge of Conventions. Respondents rated the use of the informal lecture method in attaining the "Conventions" objective a

collective total of 18 times. The method was rated as "Good" 11 times; "Fair" four; and as "Excellent" three times.

Knowledge of Trends and Sequences. The informal lecture method was rated as "Good" by 11 raters in attaining "Trends and Sequences" as shown in Figure 35. The "Fair" rating was applied six times, and the "Excellent" was applied three times. A total of 20 ratings were reported.

Knowledge of Criteria. Attainment of the "Criteria" objective by using the informal lecture method was rated a total of 16 times. (See Figure 36.) The method was rated "Good" nine times; "Excellent" four, and three times as "Fair".

Knowledge of Methodology. The effectiveness of the informal lecture method, in attaining "Methodology", was rated a total of 16 times. The "Good" rating was applied nine times, the "Excellent" four, and the "Fair" rating was applied three.

Knowledge of Principles and Generalizations. Figure 38 reveals the effectiveness, as reported by participating respondents, of the informal lecture method in attaining the "Principles and Generalizations" objective. Eleven of the ratings were "Excellent"; seven "Good", and one "Fair".

Knowledge of Theories and Structure. The informal lecture method was rated as "Poor" for attaining only one objective, "Knowledge of Theories and Structure", (See Figure 39.) The "Poor" rating was applied three times for this objective, "Fair" three times, "Good" four, and "Excellent" seven times. A total of 17 ratings were reported.

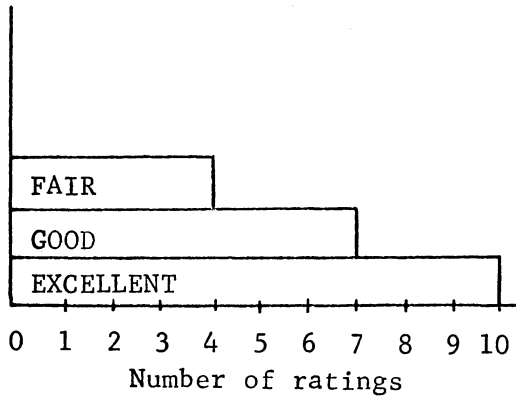


Figure 32. Informal lecture effectiveness - Knowledge of Specifics

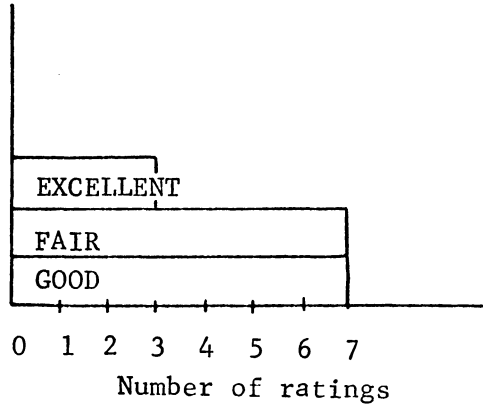


Figure 33. Informal lecture effectiveness - Knowledge of Specific Facts

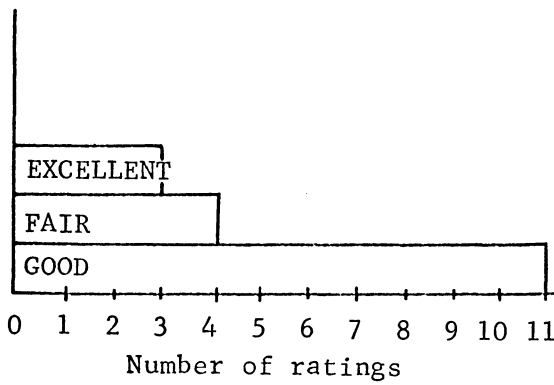


Figure 34. Informal lecture effectiveness - Knowledge of Conventions

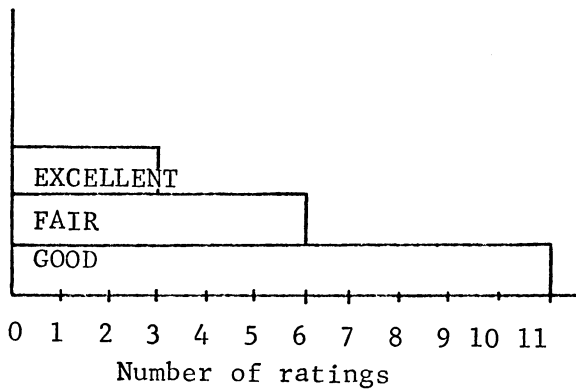


Figure 35. Informal lecture effectiveness - Knowledge of Trends and Sequences

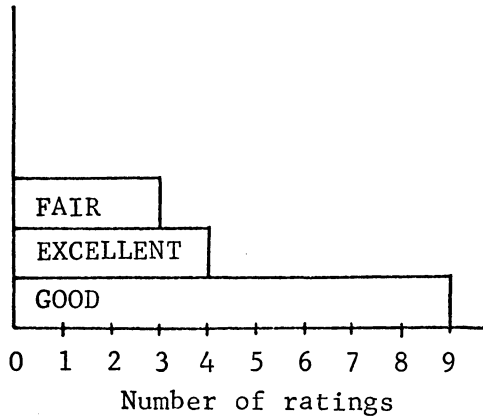


Figure 36. Informal lecture effectiveness - Knowledge of Criteria

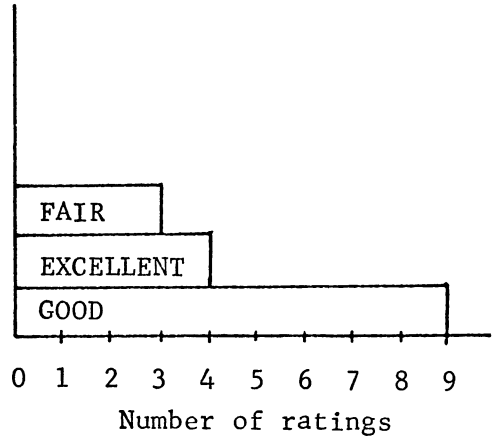


Figure 37. Informal lecture effectiveness - Knowledge of Methodology

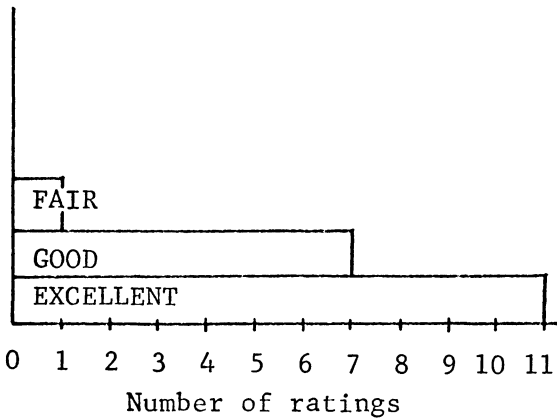


Figure 38. Informal lecture effectiveness - Knowledge of Principles and Generalizations

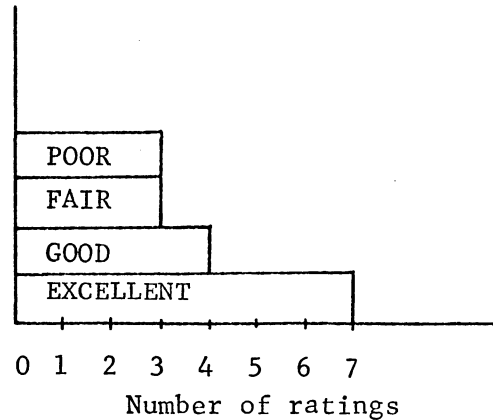


Figure 39. Informal lecture effectiveness - Knowledge of Theories and Structure

### IX. Rating of Laboratory Effectiveness

Each respondent using the laboratory method was requested to rate the effectiveness of this in attaining each specified educational objective. The rating scale suggested five responses: Excellent, Good, Fair, Poor, and Zero. "Zero" was not used by any respondent.

Knowledge of Specifics. Figure 40 contains data showing that the laboratory method was rated as "Excellent" 11 times in attaining the objective, "Knowledge of Specifics". The method was rated as "Good" four times, and as "Fair" two times. A total of 17 ratings were applied.

Knowledge of Specific Facts. The laboratory method was rated as "Excellent" in attaining this objective eight times. (See Figure 41.) The "Fair" rating was applied seven times, and "Good" was applied one time. A total of 16 ratings were made.

Knowledge of Conventions. The laboratory method was rated "Good" five times in attaining the objective, "Knowledge of Conventions". (See Figure 42.) "Excellent" and "Fair" ratings were applied four times each. Thirteen ratings were reported.

Knowledge of Trends and Sequences. (See Figure 43.) The laboratory method was rated as "Fair" nine times for attaining the objective, "Knowledge of Trends and Sequences". The method was rated three times each as "Poor" and "Good". A total of 15 reports were applied.

Knowledge of Criteria. Attainment of the "Knowledge of Criteria" objective by the laboratory method was rated six times each with "Excellent" and "Good". (See Figure 44.) The "Fair" rating was applied four times. A total of 16 ratings were reported.

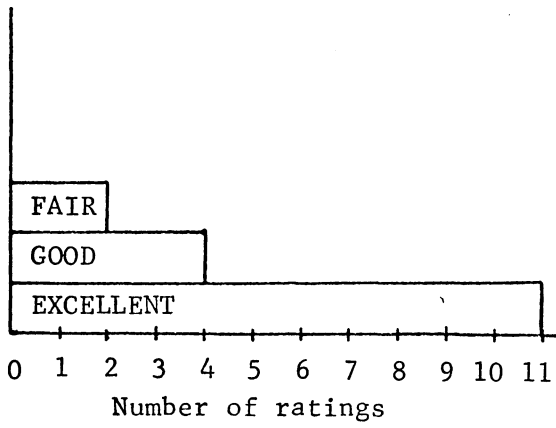


Figure 40. Laboratory effectiveness - Knowledge of Specifics

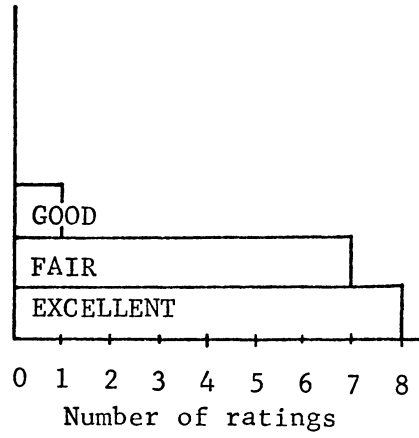


Figure 41. Laboratory effectiveness - Knowledge of Specific Facts

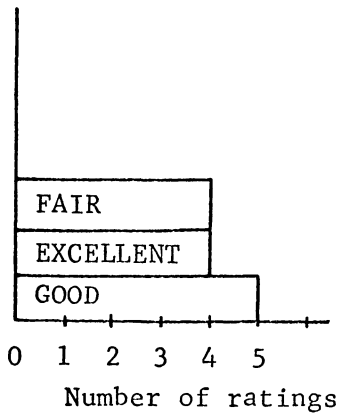


Figure 42. Laboratory effectiveness - Knowledge of Conventions

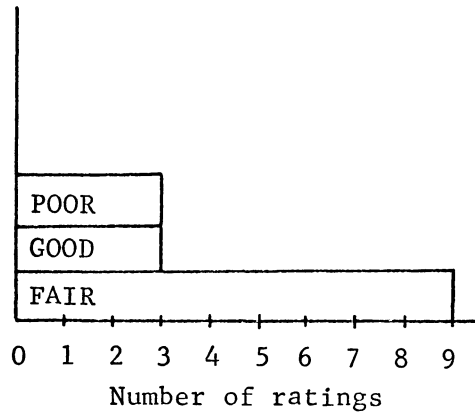


Figure 43. Laboratory effectiveness - Knowledge of Trends and Sequences

Knowledge of Methodology. The educational objective, "Knowledge of Methodology", Figure 45, was rated a total of 16 times as to the effectiveness of the laboratory method. The "Excellent" rating was applied ten times, "Good" four times, and "Fair" two.

Knowledge of Principles and Generalizations. The "Excellent" rating was applied ten times to the effectiveness of the laboratory method in attaining a "Knowledge of Principles and Generalizations". (See Figure 46.) The "Good" rating was applied four times and the "Fair" rating three. A total of 17 ratings were applied.

Knowledge of Theories and Structure. Figure 47 illustrates the effectiveness of the laboratory method in attaining the "Knowledge of Theories and Structure" objective. Of the 14 total ratings received, "Good" was applied six times; "Poor" five times, and "Fair" three times.

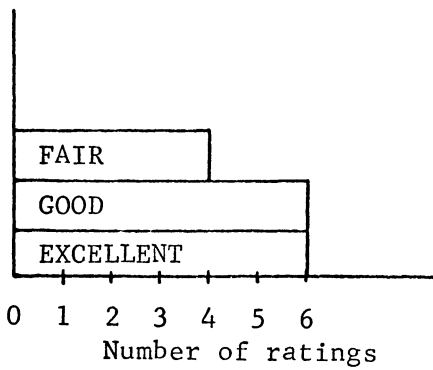


Figure 44. Laboratory effectiveness - Knowledge of Criteria

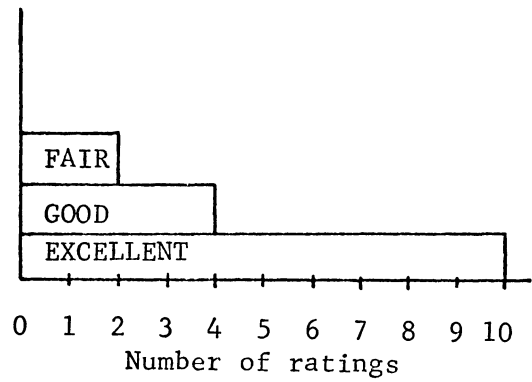


Figure 45. Laboratory effectiveness - Knowledge of Methodology

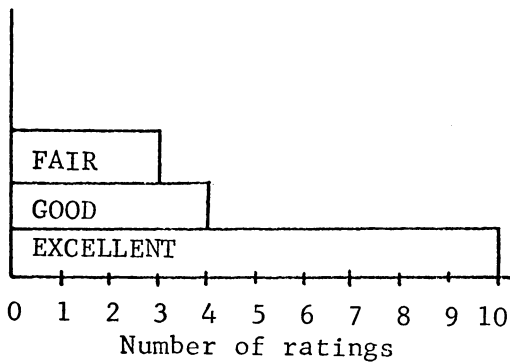


Figure 46. Laboratory effectiveness - Knowledge of Principles and Generalizations

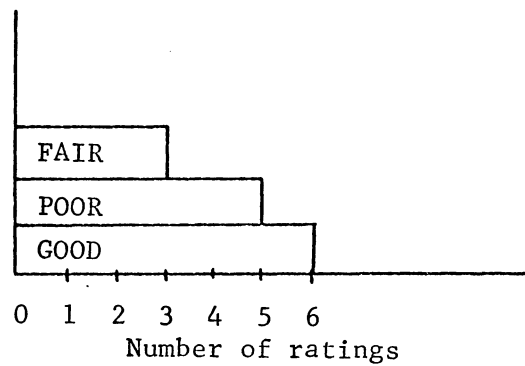


Figure 47. Laboratory effectiveness - Knowledge of Theories and Structure

## CHAPTER IV

### SUMMARY

The data presented in Chapters II and III provide detailed information concerning the subjects which were examined in this study. A summary of the basic findings in each major area are presented in the following paragraphs.

#### I. Academic System

The semester system was reported more frequently than any of the others and was used by 63% of the respondents. The quarter system followed with 26% utilization. The term used by one university was similar to the quarter in weeks but consisted of individual 75 minute time periods. The trimester system was reported by one university.

#### II. Course Level

The sophomore level of instruction was used more frequently than any of the other four levels with the junior and senior levels following. The freshman level was used by one college. Instruction was provided on the graduate level by six colleges.

#### III. For Whom Offered

The major areas surveyed in this study were made with respect to manufacturing processes courses only. Although one or more such courses were required for many Industrial Engineering undergraduates, they were also offered to Mechanical Engineering undergraduates at the same time.

Combined sections made up of Mechanical and Industrial Engineering students were more frequently used than those comprised of Industrial alone or any other combination.

#### IV. The Number of Courses Required

The majority of the Industrial Engineering curricula require one manufacturing processes course. Others required as many as five.

#### V. Sections Offered

Two sections of the same course were more frequently reported than any other number.

#### VI. The Total Credit Hours Required

Four and one-half hours credit for manufacturing processes courses were required more frequently for graduation (seven colleges). Four colleges require 13.5 credit hours. All credit hours were based on the quarter system.

#### VII. Required Time

The 30 to 60 class hour range (includes laboratory time) was reported more frequently than any other. This represented the total number of manufacturing processes class hours required of the undergraduate for degree completion. The 45-hour lecture section (excludes laboratory time) in particular was reported most (12 sections). There were three 125 hour lecture sections.

#### VIII. Class Size

The majority of the manufacturing processes classes consisted of from ten to 20 students. The maximum size reported was 100 students.

### IX. Laboratory Class Size

The majority reported a laboratory class size made up of from ten to 20 students. The respondent at one college reported 50 students in one laboratory.

### X. Laboratory Group Size

The more popular group size consisted of from three to four students. The respondent at one college reported an 18 student group size.

### XI. Basic Concepts

More course time was applied to the divisibility area (machining) than fusability, fluidity, plasticity, or any other area in the average manufacturing processes course. Plasticity received the minor amount of the total time applied to the basic concepts.

### XII. Educational Methods Used

Seven educational methods were reported to be used in the instruction of manufacturing processes courses. Of the seven, the informal lecture method was the more frequently used. Student design projects were the most infrequently used.

### XIII. The Support for Educational Objectives-Informal Lecture

The following is a list of the eight educational objectives with the corresponding number of total material reports marked on the check-list-form by the 27 respondents. The list is in descending order of

total reports received per objective. The rank indicates the position of the educational objective with respect to the total number of reinforcing materials.

Rank	Educational Objectives	Total Lecture Materials Reported
1	Knowledge of Specifics	109
2	Knowledge of Principles and Generalizations	76
3	Knowledge of Methodology	69
4	Knowledge of Conventions	65
5	Knowledge of Theories and Structure	62
6	Knowledge of Specific Facts	61
7	Knowledge of Trends and Sequences	59
8	Knowledge of Criteria	56

#### XIV. The Support for Educational Objectives - Laboratory

The following is a list of the eight educational objectives with the corresponding number of total technique reports marked on the check-list-form by the 22 respondents. The list is in descending order of total reports received per objective.

Rank	Educational Objectives	Total Laboratory Techniques Reported
1	Knowledge of Specifics	72
2	Knowledge of Methodology	69
3	Knowledge of Criteria	66
4	Knowledge of Principles and Generalizations	63

Rank	Educational Objectives	Total Laboratory Techniques Reported
5	Knowledge of Specific Facts	54
6	Knowledge of Conventions	42
7	Knowledge of Theories and Structure	36
8	Knowledge of Trends and Sequences	22

#### XV. The Educational Method Effectiveness - Lecture

Since the informal lecture method was used more frequently than any of the other instructional methods, a breakdown of the data submitted by those 22 respondents reporting on the effectiveness of each educational objective follows.

The informal lecture method was rated as "Excellent" in attaining the following educational objectives:

	Ratings		Total Ratings
Knowledge of Specifics	10	of	21
Knowledge of Principles and Generalizations	11	of	19
Knowledge of Theories and Structure	7	of	17
Knowledge of Criteria	4	of	16
Knowledge of Methodology	4	of	16
Knowledge of Specific Facts	3	of	17
Knowledge of Conventions	3	of	18
Knowledge of Trends and Sequences	3	of	20

The "Excellent" response was used for all eight educational objectives.

"Excellent" responses make up 31.1% of total responses.

The informal lecture method was rated as "Good" in attaining the following educational objectives:

	Ratings		Total Ratings
Knowledge of Conventions	11	of	18
Knowledge of Trends and Sequences	11	of	20
Knowledge of Criteria	9	of	16
Knowledge of Methodology	9	of	16
Knowledge of Specific Facts	7	of	17
Knowledge of Principles and Generalizations	7	of	19
Knowledge of Specifics	7	of	21
Knowledge of Theories and Structure	3	of	17

"Good" responses were used in all eight of the educational objectives.

"Good" responses make up 44.4% of total responses.

The informal lecture method was rated as "Fair" in attaining the following educational objectives:

	Ratings		Total Ratings
Knowledge of Specific Facts	7	of	17
Knowledge of Trends and Sequences	6	of	20
Knowledge of Specifics	4	of	21

	Ratings		Total Ratings
Knowledge of Theories and Structure	4	of	17
Knowledge of Conventions	4	of	18
Knowledge of Criteria	3	of	16
Knowledge of Methodology	3	of	16
Knowledge of Principles and Generalizations	1	of	19

"Fair" was used for all eight educational objectives.

The "Fair" rating makes up 22.2 per cent of the total responses.

The informal lecture method was rated as "Poor" for only one educational objective: "Knowledge of Theories and Structure" - 3 of 17.

The "Poor" rating made up only 2.1 per cent of the total responses.

#### XVI. The Educational Method Effectiveness - Laboratory

The laboratory method was rated as "Excellent" in attaining the following educational objectives:

	Ratings		Total Ratings
Knowledge of Specifics	11	of	17
Knowledge of Specific Facts	8	of	16
Knowledge of Criteria	6	of	16
Knowledge of Methodology	10	of	16
Knowledge of Principles and Generalizations	10	of	17

Four respondents rated the laboratory method as "Excellent" in attaining "Knowledge of Conventions".

"Excellent" was used for six out of eight educational objectives.

"Excellent" responses make up 39.5% of total responses.

The laboratory method was rated as "Good" in attaining the following educational objectives:

	Ratings		Total Ratings
Knowledge of Theories and Structure	6	of	14
Knowledge of Conventions	5	of	13
Knowledge of Criteria	6	of	16
Knowledge of Methodology	4	of	16
Knowledge of Specifics	4	of	17
Knowledge of Principles and Generalizations	4	of	17
Knowledge of Trends and Sequences	3	of	15
Knowledge of Specifics	2	of	17

The "Good" response was used for eight out of eight responses.

"Good" responses make up 22.6% of the total responses.

The laboratory method was rated as "Fair" in attaining the following educational objectives:

	Ratings		Total Ratings
Knowledge of Trends and Sequences	9	of	15
Knowledge of Specific Facts	7	of	16

	Ratings		Total Ratings
Knowledge of Criteria	4	of	16
Knowledge of Conventions	4	of	13
Knowledge of Principles and Generalizations	3	of	17
Knowledge of Theories and Structure	3	of	14
Knowledge of Specifics	2	of	17
Knowledge of Methodology	2	of	17

"Fair" rating was used in all eight educational objectives.

The "Fair" rating was used for 19.5% of the total responses.

The "Poor" rating was used for only two educational objectives, "Knowledge of Theories and Structure" - 5 of 14; "Knowledge of Trends and Sequences" - 3 of 15.

#### XVII. Informal Lecture Materials Check-List

The informal lecture materials check-list illustrations represent the number of colleges using the same materials in attaining each educational objective.

When one compares the instructional materials used by the different colleges for all eight educational objectives he will find that the relative position of each material does not vary significantly from educational objective to educational objective in most cases. The lack of variation in relative position of instruction materials from objective to objective allows one to rank the materials on a

total use basis for attaining educational objectives in general as specified by respondents.

Relative Positions	Instructional Materials	Rank
1,1,1,1,1,1,1.	Text and References	1
2,2,2,2,2,2,2,2.	Chalkboard	2
5,3,3,5,3,4,4,5.	Instructional Passouts	3
4,8,4,3,6,3,3,4.	Motion Pictures	4
6,4,5,6,4,7,8,3.	Charts, Graphs, and Posters	5
3,7,-,7,7,5,5,-.	Objects, Models, Mock-ups	6
7,5,6,4,5,8,6,6.	Overhead Projection	7
8,6,7,8,8,6,7,7.	Slides and Filmstrips	8
9,9,8,9,9,9,9,8.	Opaque Projection	9
10,0,0,0,0,0,0,0.	Tape Recordings	10
	Respondent Added	
1,1,1,1.	Closed Circuit TV	
1,1.	Demonstrations	

XVIII. Laboratory Technique Check-List

The laboratory instructional technique check-list is similar to the informal lecture materials check-list and therefore the same analogy may be made.

Relative Positions	Laboratory Technique	Rank
1,2,1,2,2,1,1,2.	Written Reports	1
2,1,2,1,2,1,1,3.	Demonstrations	2
2,1,2,1,2,1,1,3.	Experiments	3
3,3,3,4,3,4,4,2.	Investigation	4
7,4,5,5,5,3,4,8.	Project Construction	5
6,7,4,-,6,7,5,9.	Practice	6
4,6,6,-,7,5,7,6.	Manipulative Exercises	7
8,-,9,6,9,9,7,9.	Research	8
0	Application	---

## Respondent Added

9,8,8,7,8,8,8,5.	Motion Pictures
-,10,11,8,11,-,-,10.	Text and Chalkboard
-,9,10,-,10,-,-,-.	Instructional Passouts
-,,-,-,-,12,-,10,-.	Field Trips

## CHAPTER V

### CONCLUSIONS

The findings of this study have been presented in the preceding chapters. These findings were based on the questionnaires returned by the respondents who replied from the selected institutions. These institutions offered Industrial Engineering curricula and required the undergraduate to have manufacturing processes course instruction.

The data in this study indicate that there is a wide variation in the instruction of manufacturing processes courses. The variation in the method of instruction is not as pronounced as other factors involved in the presentation of course content. The informal lecture method of instruction was more frequently used than any other method. The fact that this method was used more than the formal lecture method indicated that participating instructors encouraged some discussion in their classes. Perhaps the purpose was to stimulate the interest of their students.

Respondents reported that variations existed for the length of time applied to the instruction of manufacturing processes courses since the academic system varied from institution to institution in many cases. The semester system was the most frequently used of the four academic systems reported. The total class hours ranged from 30 to 337 with the 30 to 60 range reported most frequently. The courses were usually designed for the sophomore level of instruction. Manufacturing processes instruction was required for all engineering students at one institution and only Industrial Engineers at others,

but the majority of courses were offered to integrated classes of Mechanical and Industrial Engineering students.

The number of manufacturing processes courses offered by the institutions ranged from one to five with one course offered by the majority of those reporting.

The number of students per lecture class ranged from less than ten to a maximum of 100. A class size of from ten to 20 students was more frequently reported than any other. This range was also most frequently reported for the laboratory even though laboratory section sizes were reported to range from less than ten students to as many as 50. The laboratory sections were sub-divided into groups which ranged from a single student per group to as many as 14 to 15 students per group. The three to four student group was the most common.

The ratio of lecture hours to laboratory hours varied from one-one to three-seven. The most commonly used ratio was two hours of lecture to three hours of laboratory. More time was applied to the basic concept "divisibility" than any other area.

Although the lecture time devoted to manufacturing processes varied from a total 12 to 90 hours, the majority of the lecture sessions consisted of a total of 45 hours. The number of sections of the same course offered at one institution varied from one to as many as six. One or two sections of the same course were usually offered by a single institution. Sixty-seven and one-half hours of laboratory instruction were usually offered with the lecture. Although the required credit hours varied from two to 14, the typical curriculum required five

credits of manufacturing processes courses.

The effectiveness of the informal lecture in attaining the eight prescribed educational objectives have been presented. The outstanding objectives attained by the informal lecture methods were the "Knowledge of Specifics" and the "Knowledge of Principles and Generalizations" ones along with "Knowledge of Conventions" and "Knowledge of Trends and Sequences". The laboratory method excelled in attaining the education objectives, "Knowledge of Specifics", "Knowledge of Specific Facts", "Knowledge of Theories and Structure" and "Knowledge of Convention".

Respondents used one or more of 12 different types of instructional materials when lecturing. Of these 12, text and references, chalkboard, instructional passouts and motion pictures were more frequently used than the others.

Respondents used one or more of the 13 different laboratory techniques when using the laboratory method of instruction. Written reports, demonstrations, experiments, and investigation were more frequently used than the others which were listed.

A typical manufacturing processes course may be constructed by using the most frequently reported factor found in each major area undertaken in this study. The most frequently reported outcome of an individual area would represent the current mode and therefore the typical manufacturing processes course in current use. The typical course would be based upon the frequency of reports with emphasis on the extremes rather than the median. A median would indicate a

neutral response with respect to relative position in frequency of occurrence and therefore indicate that the subject in question is neither weak nor strong. Therefore, one could assume that the subjects reported more frequently would be the most popular in current use.

Such a course would be useful to curricula designers, facilities planners, and those who are considering renovation of existing facilities or a modification of instructional procedures. The data are also useful for forming a comparative analysis of existing manufacturing processes courses accredited by the Engineers' Council For Professional Development, not only as presented in this study, but on a statistical basis. Either method would serve as a basis for comparison of existing courses in an individual curriculum to those presented in this study.

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## APPENDICES

## APPENDIX A

COVER LETTER

September 29, 1967

Professor (Name)  
Department of Industrial Engineering  
(College or University)  
(Address)

Dear Professor (Last name)

As an educator who teaches or is responsible for the teaching of manufacturing processes, you probably are aware of some of the interesting variations existing in instruction in these courses throughout the United States. The enclosed combination questionnaire-check list form is an attempt to secure information from colleges and universities pertaining to the present scope of instruction in manufacturing processes courses offered in the Engineers' Council for Professional Development approved curricula of Industrial Engineering. The information which results from the completed questionnaires should prove to be helpful to those educators who are interested in some of the current modes of instruction in the manufacturing processes field.

To answer the questions which follow should entail no more than a few minutes of your time, and yet your contribution will be valuable to others and rewarding in that you may receive a copy of the results if so requested on the questionnaire-check list form.

Sincerely yours,

T. Donald Adams, Instructor  
Virginia Polytechnic Institute

TDA/cjh

## APPENDIX B

FOLLOW-UP LETTER

November 1, 1967

Professor (Name)  
Industrial Engineering Department  
(College or University)  
(Address)

Dear Professor (Last name)

We know that you are busy, but we hope that you will still take time from your schedule to complete our questionnaire as our results will be incomplete without representation from your college.

Please note that all instructional forms do not have to be completed. Fill in only one form if this will represent your major method of instruction. Note also that if you do not engage in Manufacturing Processes instruction a statement of No! is all that is necessary.

In the event that the original questionnaire was lost in the mail, I am enclosing another. Your attention to this matter will certainly be appreciated.

Sincerely yours,

T. Donald Adams, Instructor  
Virginia Polytechnic Institute

TDA/jbg  
Enclosure

## APPENDIX C

QUESTIONNAIRE

## QUESTIONS OF RELEVANCY

- A. Do you teach a course related to materials and processes of manufacture? YES \_\_\_\_\_. NO \_\_\_\_\_.
- B. If NO, please place questionnaire in enclosed envelope and return to sender.

If YES, Please respond to the following questions. Decide whether each question is applicable to your situation; if not applicable, place NA in space provided.

## QUESTIONS RELATING TO OPERATION OF COURSE

- A. Underline the academic system used at your college or university: Quarter, Semester, Trimester.

THE FOLLOWING QUESTIONS PERTAIN TO MANUFACTURING PROCESSES COURSES IN YOUR CURRICULUM.

- B. Underline the course level or levels: FRESHMAN, SOPHOMORE, JUNIOR, SENIOR, GRADUATE.
- C. For whom offered: Underline applicable response - Required of all engineering curriculums, required of Industrial Engineering, required of Mechanical Engineering, list other major curriculums if not included above:

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- D. Number of different Manufacturing Processes courses required in your curriculum \_\_\_\_\_.
- E. Total class hours (include laboratory if utilized) of all manufacturing processes courses required in your curriculum \_\_\_\_\_.
- F. Total credit hours earned for all Manufacturing Processes courses (include laboratory if utilized) required in your curriculum \_\_\_\_\_.

G. Largest number of sections of the same Manufacturing Processes course usually offered during a single quarter, single semester, or other single period \_\_\_\_\_.

H. Lecture hours per section of each individual course taught

Course Title	Total Number of Lecture Hours
_____	_____
_____	_____
_____	_____

I. Laboratory hours per section of G. listed above

Course Title	Total Number of Lecture Hours
_____	_____
_____	_____
_____	_____

J. Average number of students per lecture class as in H. above

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

K. Average number of students per laboratory section (session) as in I. above

\_\_\_\_\_

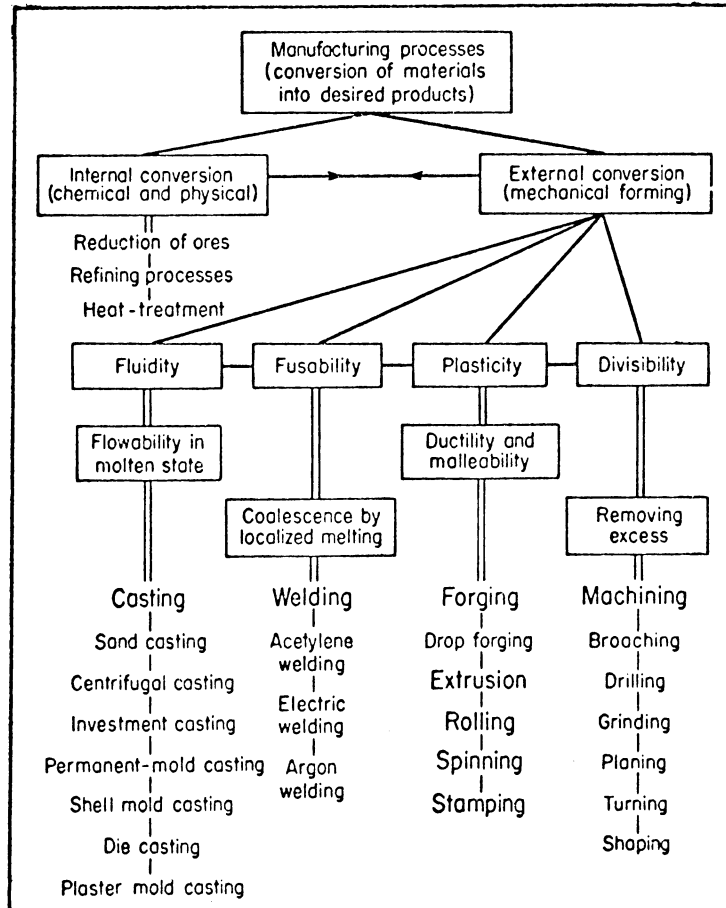
\_\_\_\_\_

\_\_\_\_\_

L. Are laboratory sections subdivided into groups?  
Underline YES or NO.

If YES, average number in each group \_\_\_\_\_.

M. Using the following flow chart as a guide, indicate the percentage of time devoted to the fundamental processes listed. (Approximate these percentages on a combined basis if more than one.)



FUNDAMENTAL PROCESSES TO BE CHECKED

FLUIDITY

Casting processes \_\_\_\_\_%.

FUSABILITY

Welding processes \_\_\_\_\_%.

PLASTICITY

Forging processes \_\_\_\_\_%.

DIVISIBILITY

Machining processes \_\_\_\_\_%.

Chart from INTRODUCTION TO FOUNDRY TECHNOLOGY, 1958, McGraw-Hill Book Company, Figure 1 - 1, page 6. Used by permission of McGraw-Hill Book Company.

## INSTRUCTIONS - RATING GUIDE AND CHECK LIST FORM

Select the method or methods of instruction which you use, in your Manufacturing Processes courses, from the following list.

- FORMAL LECTURE (uninterrupted)
- INFORMAL LECTURE (questions, comments,  
discussion allowed)
- GROUP PROJECTS AND REPORTS
- STUDENT REPORTS AND DISCUSSION
- PANEL (informal, planned presentations)
- RESOURCE PERSONS - PRESENTATIONS (guest speakers  
from the field)
- FIELD TRIPS AND REPORTS
- OTHERS

Place your selected method in the blank space located under the diagonally indicated METHOD OF INSTRUCTION which appears at the top center of the form. After this space has been filled with your choice you can proceed onward in completing the rating guide and checklist. Should you use more than one method, you may complete the additional forms provided by utilizing the procedure stated above for each additional method used. You will notice that the above list of instructional methods does not include laboratory since a laboratory form is included and supplied with different responses as to techniques used in this method of instruction. If you do not use the laboratory method at all, then do NOT complete the laboratory form.

The objectives stated on these forms are selected from a condensed version of the Taxonomy of Educational Objectives - The Classification of Educational Goals by Krathwohl, Bloom, Masia and are therefore used as a standard. Your method should be rated as to the effectiveness of satisfying specified course objectives.

An example form is provided for simplification purposes. The example indicates the way a college may choose to respond. Please note that if a technique, material, or objective is not used, the space is left blank. Note also that response E, G, F, P, Z, is used only in the column under your method of instruction and the rest is merely a check list to be marked where appropriate.

EXAMPLE: ONE COLLEGE MAY  
RESPOND THIS WAY.

E = Excellent  
G = Good  
F = Fair  
P = Poor  
Z = Zero

RATING GUIDE AND CHECKLIST

RATE THE EFFECTIVENESS OF METHOD OF INSTRUCTION IN  
ACHIEVING EDUCATIONAL OBJECTIVES.

CHECK THE MATERIALS USED IN ATTEMPTING TO REACH  
EACH EDUCATIONAL OBJECTIVE.

OTHERS:  
PLEASE SPECIFY  
OTHER MATERIALS  
USED IN THE BLANK  
SPACES PROVIDED AND  
CHECK THE APPROPRIATE  
OBJECTIVES.

COURSE OBJECTIVES --- KNOWLEDGE		METHOD OF INSTRUCTION											OTHERS:	
		LECTURE - FORMAL	TEXT AND REFERENCES	INSTRUCTIONAL PASSOUTS	CHALKBOARD	OBJECTS, MODELS, MOCK-UPS	CHARTS, GRAPHS, POSTERS	OVERHEAD PROJECTION	MOTION PICTURES	SLIDES AND FILMSTRIPS	TAPE RECORDINGS	OPAQUE PROJECTION		VIDEO TAPE
KNOWLEDGE OF SPECIFICS - TERMINOLOGY: Casting-cope, drag, draft; Machining- turning, facing, necking; etc.	E	/	/			/						/		
KNOWLEDGE OF SPECIFIC FACTS: Properties of Materials; Alloying Characteristics; etc.	F	/												
KNOWLEDGE OF CONVENTIONS: Processes Language; Classification Schemes; etc.	G	/	/			/								
KNOWLEDGE OF TRENDS AND SEQUENCES: Technological transitions from the past to the present.	G	/	/			/								
KNOWLEDGE OF CRITERIA: Units or tests by which materials are judged; Rockwell, psi, etc.	E	/				/								
KNOWLEDGE OF METHODOLOGY: Major operations which lead to finished product; shell molding, brazing, etc.	G	/	/							/		/		
KNOWLEDGE OF PRINCIPLES AND GENERALIZATIONS: Basic concepts which separate major processes (casting, forging, machining, welding).	E	/	/							/				
KNOWLEDGE OF THEORIES AND STRUCTURE: Lattice structures, dislocation theories, heat treating, etc.	P	/												

CLASSROOM

E = Excellent  
 G = Good  
 F = Fair  
 P = Poor  
 Z = Zero

RATING GUIDE AND CHECKLIST

COURSE OBJECTIVES --- KNOWLEDGE	METHOD OF INSTRUCTION													RATE THE EFFECTIVENESS OF METHOD OF INSTRUCTION IN ACHIEVING EDUCATIONAL OBJECTIVES.			
	TEXT AND REFERENCES	INSTRUCTIONAL PASSOUTS	CHALKBOARD	OBJECTS, MODELS	CHARTS, GRAPHS, MOCK-UPS	OVERHEAD PROJECTION	SLIDES AND POSTERS	MOTION PICTURES	TAPE RECORDINGS	OPAQUE PROJECTION	FILMSTRIPS	OTHERS:	PLEASE SPECIFY OTHER MATERIALS USED IN THE BLANK SPACES PROVIDED AND CHECK THE APPROPRIATE OBJECTIVES.				
KNOWLEDGE OF SPECIFICS - TERMINOLOGY: Casting-cope, drag, draft; Machining- turning, facing, necking; etc.																	
KNOWLEDGE OF SPECIFIC FACTS: Properties of Materials; Alloying Characteristics; etc.																	
KNOWLEDGE OF CONVENTIONS: Processes Language; Classification Schemes; etc.																	
KNOWLEDGE OF TRENDS AND SEQUENCES: Technological transitions from the past to the present.																	
KNOWLEDGE OF CRITERIA: Units or tests by which materials are judged; Rockwell, psi, etc.																	
KNOWLEDGE OF METHODOLOGY: Major operations which lead to finished product; shell molding, brazing, etc.																	
KNOWLEDGE OF PRINCIPLES AND GENERALIZATIONS: Basic concepts which separate major processes (casting, forging, machining, welding).																	
KNOWLEDGE OF THEORIES AND STRUCTURE: Lattice structures, dislocation theories, heat treating, etc.																	

LABORATORY

E = Excellent  
 G = Good  
 F = Fair  
 P = Poor

RATE EFFECTIVENESS WITH RESPECT TO OBJECTIVES.

CHECK TECHNIQUES USED IN PRESENTATION WITH RESPECT TO OBJECTIVES.

RATING GUIDE AND CHECKLIST

COURSE OBJECTIVES --- KNOWLEDGE	METHOD OF INSTRUCTION											OTHERS: PLEASE SPECIFY OTHER TECHNIQUES USED IN THE BLANK SPACES PROVIDED AND CHECK THE APPROPRIATE OBJECTIVES.		
	LABORATORY	DEMONSTRATIONS	MANIPULATIVE EXERCISES	PROJECT CONSTRUCTION	WRITTEN REPORTS	APPLICATION	EXPERIMENTS	RESEARCH (MAINTENANCE)	INVESTIGATION	PRACTICE				
KNOWLEDGE OF SPECIFICS - TERMINOLOGY: Casting-cope, drag, draft; Machining- turning, facing, necking; etc.														
KNOWLEDGE OF SPECIFIC FACTS: Properties of Materials; Alloying Characteristics; etc.														
KNOWLEDGE OF CONVENTIONS: Processes Language; Classification Schemes; etc.														
KNOWLEDGE OF TRENDS AND SEQUENCES: Technological transitions from the past to the present.														
KNOWLEDGE OF CRITERIA: Units or tests by which materials are judged; Rockwell, psi, etc.														
KNOWLEDGE OF METHODOLOGY: Major operations which lead to finished product; shell molding, brazing, etc.														
KNOWLEDGE OF PRINCIPLES AND GENERALIZATIONS: Basic concepts which separate major processes (casting, forging, machining, welding).														
KNOWLEDGE OF THEORIES AND STRUCTURE: Lattice structures, dislocation theories, heat treating, etc.														

CLASSROOM

- E = Excellent
- G = Good
- F = Fair
- P = Poor
- Z = Zero

RATING GUIDE AND CHECKLIST

RATE THE EFFECTIVENESS OF METHOD OF INSTRUCTION IN ACHIEVING EDUCATIONAL OBJECTIVES.

CHECK THE MATERIALS USED IN ATTEMPTING TO REACH EACH EDUCATIONAL OBJECTIVE.

METHOD OF INSTRUCTION

- TEXT AND REFERENCES
- INSTRUCTIONAL PASSOUTS
- CHALKBOARD
- OBJECTS, MODELS
- CHARTS, GRAPHS, MOCK-UPS
- OVERHEAD PROJECTION
- MOTION PICTURES
- SLIDES AND FILMSTRIPS
- TAPE RECORDINGS
- OPAQUE PROJECTION

OTHERS:  
PLEASE SPECIFY OTHER MATERIALS USED IN THE BLANK SPACES PROVIDED AND CHECK THE APPROPRIATE OBJECTIVES.

COURSE OBJECTIVES --- KNOWLEDGE	METHOD OF INSTRUCTION										
KNOWLEDGE OF SPECIFICS - TERMINOLOGY: Casting-cope, drag, draft; Machining- turning, facing, necking; etc.											
KNOWLEDGE OF SPECIFIC FACTS: Properties of Materials; Alloying Characteristics; etc.											
KNOWLEDGE OF CONVENTIONS: Processes Language; Classification Schemes; etc.											
KNOWLEDGE OF TRENDS AND SEQUENCES: Technological transitions from the past to the present.											
KNOWLEDGE OF CRITERIA: Units or tests by which materials are judged; Rockwell, psi, etc.											
KNOWLEDGE OF METHODOLOGY: Major operations which lead to finished product; shell molding, brazing, etc.											
KNOWLEDGE OF PRINCIPLES AND GENERALIZATIONS: Basic concepts which separate major processes (casting, forging, machining, welding).											
KNOWLEDGE OF THEORIES AND STRUCTURE: Lattice structures, dislocation theories, heat treating, etc.											

CLASSROOM

- E = Excellent
- G = Good
- F = Fair
- P = Poor
- Z = Zero

RATING GUIDE AND CHECKLIST

RATE THE EFFECTIVENESS OF METHOD OF INSTRUCTION IN ACHIEVING EDUCATIONAL OBJECTIVES.

CHECK THE MATERIALS USED IN ATTEMPTING TO REACH EACH EDUCATIONAL OBJECTIVE.

OTHERS:  
PLEASE SPECIFY  
OTHER MATERIALS  
USED IN THE BLANK  
SPACES PROVIDED AND  
CHECK THE APPROPRIATE  
OBJECTIVES.

COURSE OBJECTIVES --- KNOWLEDGE	METHOD OF INSTRUCTION												OTHERS:			
	TEXT AND REFERENCES	INSTRUCTIONAL PASSOUTS	CHALKBOARD	OBJECTS, MODELS	OVERHEAD GRAPHS, MOCK-UPS	MOTION PICTURES	SLIDES AND FILMSTRIPS	TAPE RECORDINGS	OPAQUE PROJECTION							
KNOWLEDGE OF SPECIFICS - TERMINOLOGY: Casting-cope, drag, draft; Machining- turning, facing, necking; etc.																
KNOWLEDGE OF SPECIFIC FACTS: Properties of Materials; Alloying Characteristics; etc.																
KNOWLEDGE OF CONVENTIONS: Processes Language; Classification Schemes; etc.																
KNOWLEDGE OF TRENDS AND SEQUENCES: Technological transitions from the past to the present.																
KNOWLEDGE OF CRITERIA: Units or tests by which materials are judged; Rockwell, psi, etc.																
KNOWLEDGE OF METHODOLOGY: Major operations which lead to finished product; shell molding, brazing, etc.																
KNOWLEDGE OF PRINCIPLES AND GENERALIZATIONS: Basic concepts which separate major processes (casting, forging, machining, welding).																
KNOWLEDGE OF THEORIES AND STRUCTURE: Lattice structures, dislocation theories, heat treating, etc.																

N. Do you desire a summary of the findings of this study?  
If YES, give name and address. YES \_\_\_\_\_ or NO \_\_\_\_\_.

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## APPENDIX D

The following is an extraction from the Knowledge area of the TAXONOMY OF EDUCATIONAL OBJECTIVES - The Classification of Educational Goals, Handbook I: Cognitive Domain by Krathwohl, Bloom, and Masia. Used by permission of David McKay Company, Inc.

## A Condensed Version

of the Cognitive Domain of the

TAXONOMY OF EDUCATIONAL OBJECTIVESKnowledge1.00 Knowledge

Knowledge, as defined here, involves the recall of specifics and universals, the recall of methods and processes, or the recall of a pattern, structure, or setting. For measurement purposes, the recall situation involves little more than bringing to mind the appropriate material. Although some alteration of the material may be required, this is a relatively minor part of the task. The knowledge objectives emphasize most the psychological processes of remembering. The process of relating is also involved in that a knowledge test situation requires the organization and reorganization of a problem such that it will furnish the appropriate signals and cues for the information and knowledge the individual possesses. To use an analogy, if one thinks of the mind as a file, the problem in a knowledge test situation is that of finding in the problem or task the appropriate signals, cues, and clues which will most effectively bring out whatever knowledge is filed or stored.

1.10 Knowledge of Specifics

The recall of specific and isolable bits of information. The emphasis is on symbols with concrete referents. This material, which is at a very low level of abstraction, may be thought of as the elements from which more complex and abstract forms of knowledge are built.

1.25 Knowledge of Methodology

Knowledge of the methods of inquiry, techniques, and procedures employed in a particular subject field as well as those employed in investigating particular problems and phenomena. The emphasis here is on the individual's knowledge of the method rather than his ability to use the method.

Knowledge of scientific methods for evaluating health concepts.

The student shall know the methods of attack relevant to the kinds of problems of concern to the social sciences.

1.30 Knowledge of the Universals and Abstractions in a Field

Knowledge of the major schemes and patterns by which phenomena and ideas are organized. These are the large structures, theories, and generalizations which dominate a subject field or which are quite generally used in studying phenomena or solving problems. These are at the highest levels of abstraction and complexity.

1.31 Knowledge of Principles and Generalizations

Knowledge of particular abstractions which summarize observations of phenomena. These are the abstractions which are of value in explaining, describing, predicting, or in determining the most appropriate and relevant action or direction to be taken.

Knowledge of the important principles by which our experience with biological phenomena is summarized.

The recall of major generalizations about particular cultures.

1.32 Knowledge of Theories and Structures

Knowledge of the body of principles and generalizations together with their interrelations which present a clear, rounded, and systematic view of a complex phenomenon, problem, or field. These are the most abstract formulations, and they can be used to show the interrelation and organization of a great range of specifics.

The recall of major theories about particular cultures.

Knowledge of a relatively complete formulation of the theory of evolution.

### 1.21 Knowledge of Conventions

Knowledge of characteristic ways of treating and presenting ideas and phenomena. For purposes of communication and consistency, workers in a field employ usages, styles, practices, and forms which best suit their purposes and/or which appear to suit best the phenomena with which they deal. It should be recognized that although these forms and conventions are likely to be set up on arbitrary, accidental, or authoritative bases, they are retained because of the general agreement or concurrence of individuals concerned with the subject, phenomena, or problem.

Familiarity with the forms and conventions of the major types of works; e. g., verse, plays, scientific papers, etc.

To make pupils conscious of correct form and usage in speech and writing.

### 1.22 Knowledge of Trends and Sequences

Knowledge of the processes, directions, and movements of phenomena with respect to time.

Understanding of the continuity and development of American culture as exemplified in American life.

Knowledge of the basic trends underlying the development of public assistance programs.

### 1.23 Knowledge of Classifications and Categories

Knowledge of the classes, sets, divisions, and arrangements which are regarded as fundamental for a given subject field, purpose, argument, or problem.

To recognize the area encompassed by various kinds of problems or materials.

Becoming familiar with a range of types of literature.

### 1.24 Knowledge of Criteria

Knowledge of the criteria by which facts, principles, opinions, and conduct are tested or judged.

Familiarity with criteria for judgment appropriate to the type of work and the purpose for which it is read.

Knowledge of criteria for the evaluation of recreational activities.

### 1.11 Knowledge of Terminology

Knowledge of the referents for specific symbols (verbal and nonverbal). This may include knowledge of the most generally accepted symbol referent, knowledge of the variety of symbols which may be used for a single referent, or knowledge of the referent most appropriate to a given use of a symbol.

To define technical terms by giving their attributes, properties, or relations.

Familiarity with a large number of words in their common range of meanings.<sup>1</sup>

### 1.12 Knowledge of Specific Facts

Knowledge of dates, events, persons, places, etc. This may include very precise and specific information such as the specific date or exact magnitude of a phenomenon. It may also include approximate or relative information such as an approximate time period or the general order of magnitude of a phenomenon.

The recall of major facts about particular cultures.

The possession of a minimum knowledge about the organisms studied in the laboratory.

### 1.20 Knowledge of Ways and Means of Dealing with Specifics

Knowledge of the ways of organizing, studying, judging, and criticizing. This includes the methods of inquiry, the chronological sequences, and the standards of judgment within a field as well as the patterns of organization through which the areas of the fields themselves are determined and internally organized. This knowledge is at an intermediate level of abstraction between specific knowledge on the one hand and knowledge of universals on the other. It does not so much demand the activity of the student in using the materials as it does a more passive awareness of their nature.

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<sup>1</sup> Each subcategory is followed by illustrative educational objectives selected from the literature.

## APPENDIX E

II. RESPONDENTS

University of Alabama  
Tuscaloosa, Alabama

Arizona State University  
Tempe, Arizona

University of Arkansas  
Fayetteville, Arkansas

University of California  
Berkeley, California

University of Houston  
Houston, Texas

University of Illinois  
Urbana, Illinois

University of Iowa  
Iowa City, Iowa

Iowa State University  
Ames, Iowa

Oregon State University  
Corvallis, Oregon

Pennsylvania State University  
University Park, Pennsylvania

University of Pittsburgh  
Pittsburgh, Pennsylvania

Purdue University  
Lafayette, Indiana

Rutgers - The State University  
New Brunswick, New Jersey

San Jose State College  
San Jose, California

Lamar State College  
Beaumont, Texas

Lehigh University  
Bethlehem, Pennsylvania

University of Massachusetts  
Amherst, Massachusetts

University of Missouri  
Columbia, Missouri

Montana State College  
Bozeman, Montana

North Carolina State University  
Raleigh, North Carolina

Ohio State University  
Columbus, Ohio

Oklahoma State University  
Stillwater, Oklahoma

Stanford University  
Stanford, California

Syracuse University  
Syracuse, New York

Texas Technological College  
Lubbock, Texas

Virginia Polytechnic Institute  
Blacksburg, Virginia

West Virginia University  
Morgantown, West Virginia

The ten institutions listed below did not qualify to participate in the study because manufacturing processes courses of instruction were not offered.

Columbia University  
New York, New York

Northeastern University  
Boston, Massachusetts

The University of Florida  
Gainesville, Florida

Northwestern University  
Evanston, Illinois

Georgia Institute of Technology  
Atlanta, Georgia

Southern Methodist University  
Dallas, Texas

University of Miami  
Coral Gables, Florida

Texas A & M University  
College Station, Texas

New York University  
Bronx, New York

University of Toledo  
Toledo, Ohio

No response to the questionnaire was received from six institutions.

## APPENDIX F

INDIVIDUAL REPORTS

	<u>Classifications from Questionnaire</u>					
	A	B	C	D	E	F
University of Alabama	S	Soph	IE ME	1	5	3
Arizona State University	S	Soph	All Engr	1	2	2
University of Arkansas	S	Soph	IE ME	1	3/wk	2
University of California at Berkeley	Q	Jr	IE ME	1	5/wk	3
University of Houston	S	Soph	IE ME	1	5	3
University of Illinois	S	Soph Jr Sr Gr	IE ME	3	15	9
University of Iowa	S	Soph Sr Gr	IE ME	2	10	5
Iowa State University	Q	Soph	IE ME	1	55	3
Lamar State University	S	Soph Jr Sr	IE ME	3	11	7
Lehigh University	S	Jr Sr Gr	IE	3	15	9
University of Massachusetts	S	Soph Sr Gr	IE ME	1	4	2
University of Missouri	S	Soph Jr	IE	3	15	9

Montana State College	Q	Soph	IE ME	2	9	5
North Carolina State University	S	Soph	IE	1	2	3
Ohio State University	Q	Jr	IE ME	2	150	9
Oklahoma State University	S	Fr Jr	IE ME	2	2	5
Oregon State University	Q	Soph	IE ME	1	3	3
Pennsylvania State University	Term (Q-75 min per)	Soph Jr Sr Gr	IE ME	4	180	6
University of Pittsburgh	Tri	Soph	IE	1	3/wk	3
Purdue University	S	Jr Sr	IE ME	2	9	6
Rutgers - The State University	S	Soph	IE ME	1	3	4
San Jose State College	S	Soph Jr Sr	IE	1	7	3
Stanford University	Q	Soph	IE ME	1	5/wk	2
Syracuse University	S	Jr	IE	5	15	9
Texas Technological College	S	Jr Sr Gr	IE	1	5	3
Virginia Polytechnic Institute	Q	Jr Sr	IE ME	1	60	4
West Virginia University	S	Jr	IE	1	5	3

	G	H	I	J	K	L
University of Alabama	3	1	1	16	12	-
Arizona State University	2	2	-	50 60	50 60	-
University of Arkansas	3	3	-	15	-	-
University of California at Berkeley	2	2	3	40	16	4
University of Houston	3	2	3	18	9	3
University of Illinois	6	32 32 32	45 45 45	40 30 30	24 20 20	4 4 4
University of Iowa	1	4 2	- 4	40 20	- 20	- 5
Iowa State University	-	22	33	24	12	3-4
Lamar State College	3	12 48 32	36 0 16	16 15 15	16 0 15	- - -
Lehigh University	4	2 0 4	3 3 3	25 0 20	25 14 15	- 2 -
University of Massachusetts	5	1 2 3	3 - -	50 - -	10 - -	4 - -
University of Missouri	30	30	45	30	30	-
Montana State College	2	3	6	40	20	3
North Carolina State University	1	30	42	42	14	3
Ohio State University	6	20 30	60 40	18 18	18 18	- -
Oklahoma State University	2	2 2	- -	18 10	25 10	- -
Oregon State University	1	3	-	30	-	-

Pennsylvania State University	6	12.5	18	100	25	4
		12.5	28	100	25	4
		12.5	28	100	25	4
		45	45	30	30	4
University of Pittsburgh	1	3	-	35	-	-
Purdue University	4	2	2	37	25	18
		2	3	75	35	18
Rutgers - The State University	3	3	3	24	16	3-4
San Jose State College	2	1	6	24	12	-
Stanford University	1	2	3	40	8	-
Syracuse University	2	3	3	20	10	3-4
		3	3	20	10	3-4
		-	3	-	10	3-4
Texas Technological College	1	2	3	18	18	4
		2	3	10	10	4
		3	-	5	5	4
Virginia Polytechnic Institute	1	30	30	60	20	5
West Virginia State University	2	2	3	20	20	5

	<i>Fluidity</i>	<i>Fusability</i>	<i>Plasticity</i>	<i>Divisibility</i>	<i>Other</i>
University of Alabama	10	12	8	20	50
Arizona State University	-	-	-	-	-
University of Arkansas	20	10	30	40	0
University of California at Berkeley	-	-	-	-	-
University of Houston	10	15	20	25	30
University of Illinois	40	10	20	30	0
University of Iowa	30	30	10	30	0
Iowa State University	25	30	15	30	0
Lamar State College	8	4	3	45	40
Lehigh University	5	5	5	85	0
University of Massachusetts	0	0	20	80	0
University of Missouri	25	25	25	25	0
Montana State College	25	25	10	40	0
North Carolina State College	20	16	13	27	24
Ohio State University	20	30	10	40	0
Oklahoma State University	30	10	30	30	0
Oregon State University	30	30	10	30	0
Pennsylvania State University	20	20	10	40	10
University of Pittsburgh	27	13	27	33	0
Purdue University	15	7	3	75	0
Rutgers - The State University	30	10	10	50	0

San Jose State College	0	15	5	80	0
Stanford University	12	9	12	15	52
Syracuse University	15	5	30	35	15
Texas Technological College	20	20	20	40	0
Virginia Polytechnic Institute	20	20	20	40	0
West Virginia University	12	12	0	70	6

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the scanned document**

A SURVEY OF METHODS AND MATERIALS OF  
INSTRUCTION USED TO ATTAIN EDUCATIONAL  
OBJECTIVES SET FORTH FOR MANUFACTURING  
PROCESSES COURSES

Thala Donald Adams

ABSTRACT

Engineering educators are constantly striving to stay abreast of the technological advancements of our time. These technological changes have influenced course instruction to the extent that many of the traditional courses which were offered in the past have all but disappeared from the curricula which are currently prescribed. Those courses which remain in the curricula should undergo reevaluation from time to time in order to appraise the educational objectives and the effective use of instructional methods and materials used in attaining these objectives.

This study is a survey of methods and materials of instruction used to attain education objectives set forth for manufacturing processes courses. The findings were derived from data submitted by instructors who were responsible for manufacturing processes course instruction at many of the leading colleges and universities located throughout the United States. These courses were required for completion of degree requirements in Industrial Engineering curricula which were accredited by the Engineers' Council for Professional Development during 1967.

The investigation disclosed the variations that existed in the utilization of educational methods, instructional materials, and laboratory techniques which occurred in the instruction of manufacturing processes throughout the 27 institutions surveyed. Variations existed in the total class hours, the ratio of lecture to laboratory hours, the class size, and the required credits for corresponding curricula.

The effectiveness of the informal lecture and the laboratory methods in achieving specified educational objectives were rated by the instructors who were in charge of manufacturing processes instruction. These findings are included in the report of the investigation.