PROBLEMS OF CO- ORDINATION
IN
ENGINEERING TEACHING

BY

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INTRODUCTION

Undoubtedly every teacher of engineering subjects is more or less frequently faced with questions from his engineering students which indicate a definite inadequacy of understanding of the fundamentals he is supposed to have mastered in his earlier courses of introductory engineering and supporting subjects. Vagueness in regard to the selection and integration of a system of units; an inability to use the slide rule for needed operations, and a lack of understanding of the conditions under which its accuracy is inadequate; an inability to use the mathematics he has studied in application to engineering problems -- these, and countless other examples can be drawn to illustrate the time-consuming interruptions to steady progress in the classroom.

Since it is the purpose in the classroom to ever forge ahead into ideas and principles new to the student, it is certainly to be expected that some slow and painstaking attention will be required at times to refresh the memories with forgotten fundamentals or inform the individual student on a matter he has somehwere missed or failed to absorb. Nevertheless, when these difficulties are frequent, and reach upward into, and through, the junior and senior classrooms, it behooves the teacher to ask of himself questions, and to seek plausible answers. Are our engineering students properly selected; are they effectively oriented; are we permitting unsuited candidates for the profession to remain too long under the curriculum; and have we omitted from our schedule of teaching any of the fundamentals we later require or expect a mastery of?

This paper endeavors to study several such vital questions. To allow the study such a broad range is to limit on the outset the possibility of delving deeply into any particular problems. To choose such a course is dangerous to the effectiveness of any study, and therefore must be supported by very good reasons. It is felt that when the fundamentals of engineering principles and of supporting scientific subject matter have been sorted and divided into subjects or courses for convenience of specific treatment, that something may have been lost in between. Specialists are in continous study as to the best methods of presenting their course material, and educational journals and conventions devote a considerable amount of attention to problems arising within the different branches of engineering and of course much attention also to general problems of engineering education. Nevertheless it is difficult to find any extensive treatment of the problems that arise from the lack of co-ordination between subjects of the curriculum. It would seem that the engineering schools are so busy fighting down proposed new courses and curriculum, and finding time and places for those new developments which must be given some attention in the curriculum, that anything like a constant vigil for lagging effectiveness of the basic courses may often be under attended.

In order to study a problem of this nature, it would seem quite necessary to initially include a very broad range of investigations. After the essential difficulties have been determined, then the study may be narrowed down to these.

Thus this initial study was designed to investigate those media such as orientation classes, guidance, aptitude examinations, etc., which function to select, introduce, and adapt the new student, and also to cover some aspects of the beginning technical courses which form the foundation for the more advanced work.

Since personal contact with any sizeable number of engineering teachers was out of the question, the most valuable sources of information remaining were considered the published articles on educational problems, and the results of a circulated questionnaire.

The preparation and circulation of a questionnaire was undertaken under considerable handicaps. Since some of these handicaps need to be appreciated in order to properly weigh the results of the questionnaire, they will be mentioned briefly. With all engineering staffs smarting under the impositions of heavy enrollments and inadequate assistance, it could be expected that a great many questionnaires would not be returned, and many that would be returned could not be given the attention essential to their effectiveness. Of probably more importance, it did not seem fair to ask more than a bare minimum of assistance in the preparation of the questionnaire. Consequently, ambiguities, instances of incompleteness, and other noticeable faults have arisen from the admitted inexperience of the writer. Furthermore, it is virtually an impossible task for even a large group of vitally interested and more experienced persons to develop a questionnaire embracing questions of such general nature which would be free of most of the inherent faults. Nevertheless, it is considered that valuable results were attained by the questionnaire, and an honest effort will be made to interpret these and to point out the weaknesses as they are seen to exist.

It was recognized that the response to the questionnaire would not be complete enough upon which to base an accurate tabulation of existing courses, course material, or official departmental opinion, and its purpose was therefore restricted to the gathering of individual opinions and expressions of attitude.

Believing from the outset that much could be done to improve the selection and guidance of students and to better co-ordinate the various courses of the curriculum, the writer has for a long time tried to concieve of some plan whereby a department or school could organize to accomplish such improvement. As in most problems there are a variety of ways to make an approach. The ideal means of assuring the student of a full and deep educational experience is to maintain a staff of teachers who are outstanding in good-teacher qualities; who both have a broad and abundant knowledge and a real zeal in their teaching. This type of staff, if working in real harmony, and keeping abreast of the entire program of the department, would need little by way oforganization and program in order to produce outstanding professional students. But to hope for the assembling of such a staff is idealism, as talent and funds throw us for short. It is a recognition of this that has caused organization and development of segregated courses and curriculums and which also suggests the possibility of attaining further improvement through further organization and supervision, when and if the best efforts to provide excelling teachers has been made.

It was decided to include in the questionnaire a number of questions in regard to an organized program which might help to better coordinate the general courses and lead to a better understanding and improved scholarship by the student.

It was not possible to preface each question in the questionnaire by an explanation of the full meaning of, and reason behind, the question. It is evident that many individuals selected the most non-committal choice of answer to the objective type questions and left many questions unanswered, where with a more complete explanation they would have been more decisive.

It seems in order, before discussing the results of the questionnaire, to give a more complete explanation of the question than it was possible to include on the questionnaire itself. To this purpose, a brief section will follow the listing of results of the questionnaire.

SECTION I OF THE QUESTIONNAIRE

A reproduction of Section I of the questionnaire follows with results indicated in percentages of the total number of answers. A key to the tabulation will be given at the beginning of the discussion of results.

1. Consideration of topics of instruction.

Please mark the items listed below in accordance with the following:

(1) Place a check-mark (✓) in the first space before the topic of instruction to indicate that it is now being treated in a regularly scheduled course of the curriculum.

(2) Place a cross-mark (x) in the first space before the topic of instruction to indicate that it is now being treated in a somewhat adequate and satisfactory manner within the subject matter of the general courses of the curriculum.

(3) Place in the secondspace before each topic the letter best describing your attitude toward the topic.

(a) This topic could well be given more attention than at present.

(b) This topic, although of importance to the student, can be given adequate attention within regular courses without undue loss of time.

(c) This topic is relatively unimportant to the student of engineering and deserves no formal attention.

	Parts 1 and 2 mark with (✓) or cross (x)			Part 3 mark with (a), (b), or (c)		
	Percentages			Percentages		
Ans.	Small Schools	Large Schools	Ans.	Small Schools	Large Schools	
✓	64	73	a	25	23	Orientation, directed to ______________
x	19	7	b	29	33	
—	17	20	c	0	0	
✓	53	57	a	32	23	Introduction to engineering profession
x	29	23	b	31	43	
—	18	20	c	1	0	
✓	46	37	a	38	37	
x	22	10	b	11	20	Aptitude examination
—	32	53	c	2	0	
✓	22	24	a	41	47	
x	41	33	b	21	17	Vocational guidance
—	37	43	c	3	7	
✓	31	23	a	20	17	Problems solving techniques
x	51	50	b	50	50	
—	18	27	c	1	3	
✓	47	33	a	16	20	
x	46	37	b	49	40	Slide rule instruction
—	7	30	c	1	3	
✓	23	17	a	19	7	Study of systems of units
x	53	53	b	57	50	
—	29	30	c	2	3	
✓	20	17	a	15	7	
x	57	50	b	53	53	Dimensional analysis
—	23	33	c	3	0	
✓	35	43	a	27	27	
x	51	30	b	37	30	Inspection trips
—	14	27	c	2	0	
✓	10	13	a	27	40	Visual aids, motion pictures, etc.
x	60	47	b	42	27	
—	30	40	c	7	0	

	Percentages			Percentages		
Ans.	Small Schools	Large Schools	Ans.	Small Schools	Large Schools	
✓	35	50	a	29	20	
×	30	7	b	20	13	Seminar, covering ___
–	35	43	c	4	7	________
✓	23	20	a	26	17	General examinations
×	35	30	b	34	30	to test progress and
–	42	50	c	9	13	indicate deficiencies
✓	32	33	a	21	17	Laboratory report writ-
×	57	57	b	52	40	ing, curve plotting
–	11	10	c	0	3	
✓	32	30	a	22	27	Application of mathe-
×	58	53	b	47	40	matics to engineering
–	10	17	c	0	0	
Total No. of replies included	96	30		96	30	

Explanation of Section I of the Questionnaire

In the above section of the questionnaire, a check mark before an item was to indicate that the item is at present being given specific attention within some regularly scheduled course devoted only to topics such as those listed. For example, if systems of units are given attention in a physics course, it would not be checked, whereas if systems of units are given attention in a problem, slide rule, or orientation course, it would be checked.

A cross before an item was to indicate that it is at present being given adequate attention within a regular course of the curriculum, such as physics, mathematics, or other.

A space left blank before an item would then be interpreted to mean that, in the judgment of the person filling in the questionnaire, the item is not at present included in any course of the curriculum.

In the second answer-column, an (a) placed before an item was to indicate that the item should have additional attention in order that a prevailing deficiency might be removed or that the students might progress more rapidly and smoothly. It was not intended that at this point the desirability of additional attention be weighed against the time required or other opposing factors.

A (b) placed before an item was to indicate that it could be, or is being, taught satisfactorily, or to better advantage, within a regular science or engineering course, and that attention within a problem, orientation, or other such course was unnecessary or undesirable.

A (c) placed before an item was to indicate that the consequence of omitting the item from the course of instruction would be so little compared with the many topics of greater importance, that the subject could best be ignored.

It was not possible to find terms which would have a sufficiently universal meaning to avoid all confusion. Thus the kind of orientation and seminar being offered was left to be specified by the person filling in the questionnaire. Also, it was not asked that the several items given in a common course be grouped or otherwise identified. By "general examinations" was meant examinations that cover most of the principles of the science and mathematics taken up to the time the examination is given. "Comprehensive" or "of broad coverage" might be more properly descriptive.

Key to Tabulated Results for Part I

The figures given before each item are in percentages of the total number of answers included in the tabulation, as given at the bottom of each column. The percentage not indicating either choice of answer (check or cross) in column one is significant and is given. The percentage not answering with (a), (b), or (c) in the second column is not significant and is not listed. The answers from faculty members of large schools are given separately for comparison with those from smaller schools since the opinions of the two groups would be expected to differ considerably in some instances. Large schools were arbitrarily selected by including those having a freshman enrollment of more than four hundred in 1940, according to the Journal of Engineering Education tabulation for that year.

Results of Section I of the Questionnaire

It should be noted in examining the results of this section that, as explained before, it was not designed to collect quantitative data on specific courses offered in the various schools. In many cases there are several replies from the same school, and quite often there is considerable disagreement among members of a faculty as to which topics are provided for in the teaching schedule, and in what courses of the curriculum they are included. Therfore, as explained before, the results are qualitative, and are a canvas of opinions as to what topics are provided for and how.

It would seem unlikely that a difference of less than ten percent in the results reported from large schools and from small schools would be significant. The most notable differences of this magnitude in the first column of the tabulation are in the number of spaces that were left blank when the questionnaire was filled out. A blank was meant to indicate that the topic was not given attention either in a special or a regular course. There was, however, considerable indication that failure to mark an answer in a space of this column was a result of desiring to remain non-committal or from incomplete understanding of the information desired. The tendency to be non-committal was most pronounced in replies from large schools. This fact has resulted in weakness in the results of the first column of Section I of the questionnaire. This attitude was manifest to some extent throughout the questionnaire, but the nature of the questionnaire is such that it did not affect the results of other parts adversely.

The most clear cut trends of the results are listed below under the individual topics. The reader will wish to make interpretations of his own regarding the results, therefore the writer's interpretations are reserved for a section of the paper so labeled.

Orientation

Teachers in both large and small schools report that orientation is provided for in a special class in about two-thirds of the cases. Opinion as to whether additional attention should be given to orientation was about equal to opinion that it is satisfactorily provided for in present courses, either special or regular.

Introduction to the Engineering Profession

Of those expressing opinions, the report is two to one that this topic is provided for within some special introductory course rather than within regular courses. Larger schools report greater satisfaction with the present treatment of the topic than do the smaller schools.

Aptitude Examination

With 53 percent of the results from large schools failing to indicate any provisions for aptitude examinations against 32 percent from smaller schools, it is indicated that the smaller schools are making more use of such examinations. As pointed out before, however, the percentages giving no answer are not too reliable as an indication that provisions are not made.

It can be noted that 47 percent from the large schools and 68 percent from the smaller schools report provisions for aptitude examinations, and that measurements of aptitude are handled through special arrangements in the majority of cases rather than within regular courses.

Both large and small schools report by considerable majority that more attention should be given to the matter of aptitude examination.

Vocational Guidance

From both large and small schools the report is about equal that vocational guidance is not provided for at all, or is provided for within regular courses of study. About 20 percent report special effort or facilities. It is therefore very significant that a notable majority feel that more vocational guidance is needed.

Problem Solving Technique

About 50 percent of the teachers in both large and small schools report that problem solving techniques are taught along with the theoretical courses. Roughly one quarter of the total report problem solving instruction in special classes. Both large and small schools indicate by notable majority that problem solving instruction should be, and is now satisfactorily done within the regular courses rather than separately. Roughly 20 percent of the total number feel a need for more attention to the matter.

Slide Rule Instruction

There appears to be more provision for slide rule instruction in special courses than for problem solving techniques. A notable majority indicate a preference for and satisfaction with instruction within theory courses.

Study of Systems of Units

About 50 percent consider this topic provided for in regular courses and 20 percent in special courses. Few express a need for more instruction, and there is an overwhelming opinion that the subject should be treated within the theory classes as encountered.

Dimensional Analysis

The same results reported under systems of units apply here.

Inspection Trips

Over 75 percent of the replies indicate that inspection trips are provided for. Smaller schools indicate a tendency to provide these trips within the framework of regular courses (probably laboratory courses) while larger schools indicate a tendency toward special provision for the trips. About 25 percent express a need for additional stress and above 30 percent express satisfaction with the present attention.

Visual Aids, Motion Pictures, etc.

Smaller schools report a greater present provision for visual aids than larger schools, while both large and small schools report that visual aids are geared almost entirely to regular courses. The larger schools report a greater need for increased use of visual aids than do the smaller ones. More significant figures on the desire for increased use of visual aids will be found under Section II of the questionnaire.

Seminar

A larger percentage of small schools report provision for some type of seminar (65 to 57), whereas the larger schools tend more toward special classes for the subject than do smaller schools. Opinion is about evenly divided that present attention is sufficient or that more attention is needed.

General Examinations to Test Progress and Indicate Deficiencies

About 50 percent of the total returns report provision for this type of examination. Opinion leans toward satisfaction with present attention.

A larger percentage from small schools feel the need of more attention than from large schools (26 to 17).

Laboratory Report Writing, Curve Plotting

About 90 percent of the total returns report provision for instruction in report writing and curve plotting, handled very largely within regular courses, presumably laboratory classes. Opinion indicates that instruction within regular courses is desirable and at present satisfactory.

Application of Mathematics to Engineering

About 85 percent report adequate provision for instruction in application of mathematics to engineering. About 25 percent express a need for additional training but a majority of those answering feel that it is adequately covered in regular courses, without the necessity of a separate course.

SECTION II OF THE QUESTIONNAIRE

The following is a reproduction of Section II of the questionnaire as sent out, except that the tabulated results have been inserted. A key to the tabulation is given later.

II. General information

This study includes the consideration of what might be termed a "co-ordination course" to deal specifically with the topics under discussion. Such a course might be initiated with the freshman class, and consist of one or two 2-hour periods per week devoted to the topics important to beginners. As methods, material, and instructors were developed, it might be extended gradually throughout the four years to cover other of the topics as they become of importance.

Many important questions arise in connection with this idea, and your opinion on a few of them is sought.

Please underline the word or words that cause the sentence to express most nearly your opinion.

		Total Number of answers:	
		Small Schools	Large Schools
1.	I think that (5-3 all, 50-59 nearly all, 44-35 very few, 2-3 none) of the existing courses devoted to these topics could be effectively conducted within the framework of a co-ordination course.	84	29
2.	I think that frequent reports to the co-ordination instructor by other teachers and resulting in special assignments and tutoring would be of (35-36 great, 43-48 moderate, 22-16 little) benefit to the student who is having difficulty.	86	31
3.	Certain courses of the curriculum, often in a department outside the major field, serve to filter out weak beginners. I believe that active and judicious guidance within a co-ordination course (35-32 would be a much more efficient method, 11-13 would represent unnecessary effort, 54-55 would merely be helpful).	81	31

	Total Number of answers: Small Schools	Large Schools
4. Many mathematics departments are endeavoring to meet engineering needs with courses designed on the "engineering mathematics" or "mathematical analysis" basis. I believe these are rather (59-50 effective, 41-50 ineffective) in giving the student the required facility in engineering usage, and that speical attention by the engineering school (82-65 is, 18-35 is not) also needed.	87 78	26 20
5. I (52-63 believe, 48-37 do not believe) a co-ordination course could be kept workable and efficient.	90	27
6. I believe that orientation and other subjects which are required without credit (88-82 are, 12-18 are not) branded as unimportant, and (87-79 are, 13-21 are not) made hard to administer effectively.	84 90	28 28
7. When slide rule courses are offered, I believe intermittent instruction within a co-ordination course as new operations are required to be learned would be (52-56 superior, 48-44 inferior) to a unit course for beginners.	77	27
8. I favor the use of a standard form for problem solutions for (22-42 beginners, 27-10 all students). I do (51-48 not) favor its use.	86	29
9. I consider that inspection trips to industrial plants would be (45-31 considerable, 40-50 little, 15-19 wasteful) assistance to a freshman in selecting a branch of engineering.	94	32
10. I believe that visual aids, if designed for the college level of instruction, deserve (59-74 a much greater application, 32-29 only moderate application, 9-0 very limited application) in engineering teaching.	93	31
11. I believe that a (22-48 more interesting, 45-33 equally interesting, 33-19 less interesting) seminar program of the type we now give, or would like to give, would result if given within a co-		

		Total Number of answers:	
		Small Schools	Large Schools
11.	ordination course.	54	21
12.	I believe that the teaching of systems of units in a co-ordination course would be (17-23 more, 83-77 less) effective than in regular physics and engineering courses.	76	26
13.	I believe that pre-junior year examinations of wide technical coverage are (70-67 indicative, 30-33 not indicative) and 71-59 should, 29-41 should not) be given in addition to the piece-meal course examinations.	83 79	30 27
14.	I think such a course (38-37 would, 28-16 would not, 34-47 would only partially) justify the necessary time and effort by keeping the student well grounded and by absorbing present classes now devoted to one or more of the topics.	73	30
15.	I believe that the possibilities of a co-ordination course (83-89 are, 17-11 are not) worthy of careful study and consideration, and I(85-92 would, 15-8 would not) be interested to see it given a trial somewhere.	75 78	28 24

III Course material

Please list the name and publisher of the text material used in your school for instruction in any of the topics listed in Part I. If your school or department uses a standard problem sheet, please enclose a copy.

____

____

IV. Discussion:

A discussion or criticism of any parts of this questionnaire will be welcomed and will be of much greater assistance to the writer in giving him an insight into <u>why</u> your institution treats these matters as it doesthan can possibly be drawn from the questionnaire alone.

Name________________________________

Title________________________________

Thank you sincerely for your interest and cooperation.

s/ Newton H. Barnette

Newton H. Barnette
Department of Electrical Engineering
Virginia Polytechnic Institute

Results of Section II of the Questionnaire

In the objective statements of Section II of the questionnaire reproduced above, the first figure before each choice of answer is the percentage of the total number of answers from small schools and the second number shows the percentage of the total number of answers from large schools who made that particular choice of answer. The total number of answers to each question from small and large schools is given in the column on the right.

The significance of the tabulated results for each objective statement is evident from a glance for most of the statements. A brief discussion of what was behind the question and a statement of the significance of results is given below for those parts needing further clarification. Numbers refer to statement numbers in Section II of the questionnaire.

1. The first objective statement was designed to measure the opinions of teachers as to how much of the attention required for orientation, problem solving technique, and all of the items listed under Section I of the questionnaire could be effectively woven into a single course. The purpose would be to remove or reduce the necessity of dealing with these topics within regular classes, and to place them under the guidance of a smaller staff where they might be better provided for.

The results indicate that a majority of the teachers believe that nearly all the existing attention to the topics could be effectively conducted within a co-ordination course.

2. The thought behind question two was that perhaps a better vigilance for the deficiencies of students might be maintained by having a part of a coordination course devoted to special work assignments resulting from reports of deficiencies by various of the student's instructors.

The majority of opinion was that from moderate to great benefit could result from such effort.

3. Students are often eliminated from the curriculum largely by specific courses such as chemistry or descriptive geometry, sometimes referred to as filtering courses. The third question asks whether this might not be more effectively done through the vigil and counsel of a co-ordination staff.

Majority opinion on this idea was that such effort would merely be helpful in effecting judicious filtering. A sizable minority believed it would be a much more efficient method.

4. The effort of mathematics departments to provide engineering students with an early and thorough facility for applying mathematics to engineering problems has led in some cases to courses described as "engineering mathematics" or "mathematical analysis". Question four asks to what extent this effort has been effective in giving the required facility.

Opinion is about evenly divided as to whether such courses are effective or not. However, majority opinion is that additional attention to the application of mathematics is required by the engineering staff above that given by the mathematics departments. Smaller schools were more emphatic in this matter than larger ones.

5. Question five asks an opinion on whether a co-ordination course to embrace all the topics listed under Section I of the questionnaire could be kept workable and efficient.

The majority opinion from large and small schools was that such a course could be kept workable and efficient. Large schools were more favorable on this point than were small schools.

6. Orientation and some other scheduled classes with required participation by the student are often non-credit bearing. Question six inquires as to whether such courses, required without credit, are branded as unimportant and are made hard to administer.

A very notable majority of teachers questioned feel that such courses are branded as unimportant and are made hard to administer.

7. In many schools, no formal instruction in slide rule use is given, and where such instruction is given, it is usually given rather briefly and at a rather early position in the curriculum. Question seven asks whether instruction in the use of the slide rule for needed operations might not be better given intermittently as the need for such operations arises.

Amnarrow majority opinion is that such instruction would be superior.

8. Some institutions make use of a standard problem sheet for use with homework problems. Question eight seeks opinions on the desirability of the use of such a sheet.

About 50 percent of the opinions were against the use of such a sheet. The remaining 50 percent from small schools was about evenly divided between use for beginners and use for all students, while from large schools a majority of the 50 percent favoring its use preferred that it be restricted to use with beginners.

9. A great number of students beginning a course in engineering are not familiar with what the profession embraces. Question nine asks if inspection trips for freshmen might not be a valuable aid to guidance of beginning students.

Majority opinion from teachers from the larger schools felt such trips would be of little or wasteful assistance. A somewhat smaller majority from the smaller schools took the same view.

10. The question of the extent to which visual aids may be used to advant-

age in engineering teaching is currently of great interest. Question ten asks opinion on the extent to which such aids can be effectively used if designed for college level instruction.

A sizable majority believes visual aids deserve a much greater application. This opinion is most pronounced with large schools.

11. Question eleven asks opinion as to whether a more interesting seminar program could be conducted within a co-ordination course. The idea here is that more timely seminar programs might be arranged and that time might more often be available when exceptional opportunities for an outstanding speaker present themselves.

Majority opinion was divided between an equally interesting and a more interesting program. Larger schools gave a notably larger opinion that a more interesting program would result, while smaller schools gave a notably larger opinion that an equally interesting program would result. A fairly small minority felt that such a program would be less interesting.

12. In the writer's experience, students of some schools are not provided with a concise presentation of the most used systems of units and an explanation of why so many systems are necessary. Question twelve was meant to inquire as to whether a treatment within a co-ordination course might not be superior to the piecemeal presentation that is received in various courses. It is believed that this idea was not expressed clearly enough in statement twelve of the questionnaire to be fully understood.

Majority opinion, as the question was presented, was that units are best studied as necessary along with the regular courses of physics, electricity, etc.

13. Question thirteen seeks opinion on the desirability of comprehensive examinations at the end of the sophomore year.

Majority opinion was that such examinations are indicative and should be used.

14. Question fourteen asks opinion as to whether a co-ordination course embracing the topics already mentioned would justify the time and effort it would require. The principle justifications would be the absorption of existing courses devoted to one or more of the functions listed under Section I, and a possible increased efficiency and rate of progress in all courses.

Opinion was rather divided between justification and only partial justification for the time and effort required. A rather small minority felt that it would completely fail to justify itself. Of the minority, reports from smaller schools were notably more dubious of its justification. Reports from larger schools might have been expected to be more favorable toward complete justification, but opinions here were very similar between the larger and smaller schools.

15. Question fifteen seeks opinions as to whether the idea of a co-ordination course has possibilities.

An overwhelming majority opinion is that the idea is worthy of careful study and consideration and that it would be interesting to see it given a trial.

COMMENT AND CRITICISM RETURNED

The following are excerpts from letters and notes returned with questionnaires. The questionnaire was regarded as informal, and it seems proper not to divulge the source of the comment. The number following the quotation is a key to the source and will remain confidential. The attitude of cautiousness exhibited by many participants makes this policy seem wisest.

> The Engineering School at Oregon State College requires a common freshman year of all students, registered in Civil, Electrical, Industrial, and Mechanical Engineering. In this freshman year two sequence courses are required in General Engineering. One called Engineering Problems, GE 101, 102 and 103 carries two credits per term and includes one hour of lecture and four hours of computation per week. This course might easily be called a 'coordination course' and includes most of the topics included in the first part of your questionnaire in a satisfactory way. It is a regular course with a mimeographed textbook and is coordinated with the work in mathematics and physics. Typical problems from civil, mechanical, and electrical engineering fields are used in the computation periods. The lectures may or may not be technical, they are intended to help orient the students and introduce them to the engineering profession.
>
> Aptitudes and vocational guidance are generally taken care of before college registration. Provisions are made for individual students who need additional help. Entering freshmen are expected to report one week in advance of the rest of the classes. During this week they are given orientation lectures and classificatory examinations, and the opportunity for personal conferences with advisors.
>
> These features have been used for a number of years and have proven their worth. We are reasonably well satisfied with the procedures outlined. Changes have been made from time to time and will undoubtedly be made in the future. No radical changes are indicated, however, unless the number offreshmen becomes so large that the staff is unable to meet the requirements. (96)

I am somewhat skeptical about the introduction of a so-called 'co-ordination course'. I think it might very likely lead to confusion rather than co-ordination. It is my opinion that one of the principal difficulties at present in engineering instruction is to impress the student that everything he learns is a part of the entire picture and that the difference in the courses is merely a convenient means of discussion of the topics and does not indicate any essential difference of subject matter. I feel strongly that the way to co-ordinate material is in each course to show the application of material studied in other courses (the use of mathematics in mechanics, for example) and that to try to do this co-ordination in separate courses is certainly a step in the wrong direction. If such a course were introduced in the curriculum I still feel that every effort should be made to do the 'co-ordinating' in the other courses and I therefore believe that there would be a considerable amount of unnecessary duplication, if not worse. (124)

It would be fine if some of this material could be substituted for one of the five 'Basic College Core Courses' which first and second year students in this institution are now required to take. (141)

Competent men could not be obtained to teach it (co-ordination course). (26)

Since we are training for leadership our training should not be too mechanical. (33)

Our curricula now are crowded with courses deemed essential. What would we drop to provide time for co-ordination courses, general examinations, etc.?

The key to education at colleges and universities is the <u>individual instructor</u>. What he is and how he teaches and inspires is reflected in the graduation product. In meeting and studying under a variety of good instructors, the average student should get the necessary co-ordination, orientation, guidance, etc. (23)

Could the co-ordination course be kept workable and efficient? "Ideally, yes; but practically, no." (37)

If we had plenty of teachers of a very superior quality. (56)

There are some parts which I do not know how to answer, primarily for the reason that my philosophy seems to be entirely different from yours. Stated in a nutshell, my theory can be stated thus: It is a waste of time to coddle weak and incompetent students, and it is definitely to the interest of the engineering profession and to the general public to get rid of such students as promptly as possible. Just why State Funds or private beneficence should be dedicated to the hopeless task of trying to salvage a lot of incompetents is more than I can understand. In short, I believe in the sink or swim method. Those who do not have what it takes ought to do something else.

The kind of co-ordination course that you seem to have in mind seems to me to be a device to give somebody a job which can be done much better by thoroughly competent instructors, each in his own field of work. (141)

Over a period of 30 years, I have seen a lot of these (co-ordination courses) tried in whole or part. So far none has justified its general acceptance. (9)

I feel that such a (co-ordination) course should be limited to the freshman year. (19)

I am very strongly in favor of a better type course as an introduction to engineering to help freshmen understand what it is all about, to help them choose their branch of engineering, and to show them correlation of subjects taken. (21)

Certainly a great need exists for co-ordination of the various courses of instruction in the curriculum, and the larger the institution, the greater is the need ordinarily. However, conditions differ so much among institutions that the reasons why things are done one way at one institution and another way at another institution usually involves a long story. A plan workable at one institution might not be suitable at another institution. My general answer is that the idea sounds interesting enough, but a concrete plan should be developed and tried out somewhere. (131)

I am in sympathy with the general idea of a co-ordination course but few professors could teach this type of course effectively. (56)

The choice of answers listed in the questionnaire is not always sufficiently complete and seems to generally 'beg the question' too much in favor of the 'co-ordination course'. (71)

I may not understand the intent of the co-ordination course but it is difficult to teach co-ordination until the student understands what he is trying to co-ordinate - Senior year, maybe. (80)

This type of course (co-ordination) is given at the University of Washington. (91)

Note: This statement did not come from Washington.

General Comment on Section I of the Questionnaire

The list is faulty because it mixes subject matter with methods, therefore, not valid. (67)

This section should have more careful wording and organization before extended use. (57)

General Comment on Section II of the Questionnaire

This entire set-up is confused and not clear. It would have been helped had such a course as you envisage been outlined. (67)

—— I cannot envisage how such a course could be set up. And then I do not see how it could be administered. (67)

I do see some sense to a senior problems course which would tie together much if not all of the subject matter in the curriculum. It would have to deal in 'cases'. (67)

As far as Part 2 of the questionnaire is concerned, the questions which you raise are, of course, the things that plague instruction in general. We feel that these are the problems that are of concern to every instructor, and that methods should be set up to make this coverage adequate in the various courses. (72)

Orientation

Orientation to problem solving technique, use of the slide rule, system of units, laboratory report writing, application of mathematics to engineering, etc., seems best done in connection with the regular courses. We feel that to institute such courses which require one to create artificial situations involving the use of these various tools in engineering study is much less effective than when required in several courses, ---. (91)

Our work in orientation for freshmen is confined to freshman week and the first four or five weeks of college, when the students meet for an hour a week for orientation lectures. This work has been very helpful. It enables us to introduce them to the engineering profession, to gain some information about the various branches of the profession and the qualifications needed for succes in them, and to learn about the University regulations and activities. We give aptitude examinations in English and Algebra, and all new students must take what amounts to intellegence tests. (107)

All freshmen engineering students at the University of Tennessee take the same course regardless of the department in which they intend to major. In this uniform freshman year we give a course entitled 'Engineering Problems' which is actually a combination of Engineering Problems and Introduction to Engineering and which involves a certain amount of orientation. While this course is certainly not perfect we believe that it does accomplish, to a considerable extent, a number of the objectives which you mention and it does this at a time which will be of greatest value to the student. At the same time, we continue our discussion of most of these matters throughout the students' curriculum by incorporating proper material in practically all of the engineering courses contained in that curriculum. This is particularly true, for example, with reference to problem solving techniques. In our senior seminars we also discuss numerous topics of current interest to members of the engineering profession. (124)

<u>Introduction to Engineering</u>

This course consists of a series of lectures by faculty and by practicing engineers covering the engineering professional fields. The purpose of the course is to assist the freshman in selecting the particular field of engineering for which he is best adapted. We bring to the students outstanding practicing engineers in the State of Maryland, as well as those located in Washington, D.C. The period extends for 50 minutes and usually 10 or 15 minutes at the end are allowed for questions from the students. Many of the talks are illustrated by various means.

The student takes notes and is required to submit a written report after each lecture, which is graded and returned to the student with a criticism of English and sentence structure.

Due to the practical and interesting nature of this series of lectures, we find the freshmen are eager to attend and look forward with much interest to hearing the speaker. We consider the course as offered a very successful one. (81)

Aptitude Examination

Such tests are given. Their value is very doubtful. (8)

Given through - "a thoroughly organized and expertly administered procedure under University Department of Student Personnel Study". (18)

Vocational Guidance

Should come in Sophomore year. (4)

Given and - "directed by Division of Psychiatry, Department University Health and by Department of Personnel Study." (18)

Problem Courses

I am not so strong for special co-ordination or problem courses, as I feel that their objectives can be accomplished within the framework of the regular courses. (80)

We had considerable experience with problem courses under A.S.T.P. and to us the results seemed doubtful. I imagine this was general because the course was taken out of the curriculum after a short time. (80)

I believe that the approach to problem solving techniques in terms of a basic engineering attitude, not in terms of a bag of special tricks, is a highly important item which can be approached profitably apart from any particular course of instruction. (131)

We gave an Engineering Problems course this semester and I was one of two instructors handling the course. It is probably too early to judge results accurately but frankly I am skeptical whether the time could not have been spent to better advantage on regular course material. (16)

Our engineering courses are certainly not all that are to be desired. I feel certain that we are not now training engineers adequately to do straight thinking of an analytical character. I am somewhat in favor of vigorous training if some can be and is done on carefully planned practical problems not just on problems for problems sake. There is now too much 'atmosphere' type of course and not enough of the functional type. (35)

Slide Rule Instruction

My feeling is that the teaching of the slide rul has been sadly and greatly neglected with the result that most of our engineering students and practicing engineers do not know how to use their slide rules efficiently. In fact most of them never get beyond the use of the D- and C- scales. (28)

It seems to me that instruction in slide rule could well be standardized and included in every engineering curriculum in view of the usefulness of the slide rule to the engineering students and graduates. The medical schools include instruction in minor surgery or even formal courses in bandaging. The law schools require a course in legal bibliography to enable lawyers to find their way among the archives. But engineers let their students shift for themselves in learning the slide rule. (28)

There should be a very short formal introduction. (4)

I believe that two or three hours of instruction in the basic operations of the slide rule, and some of the more commonly used short cuts, is entirely adequate. I believe that students who use special rules such as the vector slide rule or who use special operations very frequently should be expected to pick up facility in such use largely by themselves. I believe that a prolonged course in the use of a slide rule in order to learn a lot of elegant tricks, most of which might rarely ever be used again, is a waste of time. (131)

Systems of Units

I believe that the study of systems of units is best done along with the physics and engineering courses. (131)

Dimensional Analysis

If by dimensional analysis merely the idea of dimensional homogeneity as applied to checking the correctness of equations is meant, no special course of instruction should be necessary.

I believe that a comprehension of dimensional analysis with its application to the model theory and its supposed philosophical implications is beyond the scope and needs of most undergraduate students. (131)

There should be a formal analytical course at the beginning of graduate work. (4)

Inspection Trips

With regard to Question nine, I feel that inspection trips are of much benefit to upper classmen if they are given information in advance as to what to look for and if the trip is carefully arranged to include material of definite instructional value. I feel that such trips are of little value when the student merely gets a general impression of a lot of bustle and unrelated activities and does not understand the meaning or sequence of the processes which he sees going on around him. I believe that freshmen have not reached the stage where they can derive much profit from inspection trips and that scheduling such trips for freshmen, because of the large numbers involved, would be quite difficult and not worth the time and effort involved. (214)

I believe that inspection trips to industrial plants, construction work, engineering offices, and so on, are valuable experiences all through the undergraduate course of study. (131)

This is impractical for freshmen and sophomores because of age and number of students. (93)

Visual Aids

--- it is easy to use too many visual aids, such as moving pictures. --- all students should be trained to be able to visualize things and processes from written descriptions. An engineering student, especially, should have abundant practice in so doing. His calling is changing and improving rapidly, and he cannot expect after graduation to have moving pictures available from which to learn of these many developments. He must be able fully to understand things and processes described in magazines and books. (107)

Do visual aids deserve a much greater application in engineering teaching? I believe before that question can be answered visual aids must be developed to the point of proving that they offer advantage for instruction at the engineering level. Thus far, almost all of the development has been at the vocational level. I am highly in favor of encouraging its development. (131)

Comprehensive Examinations

We used the sophomore comprehensive examinations several years before the war and I believe they have a place in the educational field. (80)

I am highly in favor of comprehensive examinations that test the comprehension of the student, not only his knowledge, of his entire field of study instead of course by course in the usual piecemeal fashion. (131)

Should come at end of sophomore year. (4)

Laboratory Report Writing

—— we have found it possible to give sufficient emphasis to this important subject in the laboratory course. The advantage has seemed to us to consist chiefly in the fact that the motive to write the report and the material to put in the report was already included in the requirements of the laboratory work. (91)

Application of Mathematics to Engineering

I believe that mathematics should be applied by use of engineering examples in the mathematics classes and by use of mathematics in the engineering courses. (131)

The curriculum is now over crowded. The deficiencies in Mathematics and Physics may perhaps be corrected by more allotment of time to experimental Physics and to the Mathematics Department. At present the time of the Mathematics Department is devoted to fundamental, formal methods which the average student cannot obtain by unaided use of textbook. (4)

Application to engineering should be taught in engineering courses, not mathematics courses. (110)

Standard Problem Sheet

Standard forms often waste the able students time with details. They may be helpful to the student who learns best from formalized procedure. This is not usually the most brilliant student. (103)

GENERAL DISCUSSION

Even a brief study of the questionnaire's results and of comments from contributors is convincing of these things: that there is wide agreement that there is always considerable room for improvement by removing deficiencies and weaknesses that exist in our teaching system; that in some cases, two groups of persons who believe they have the right answers, have diametrically opposed views; and that there is a most encouraging open-mindedness and progressive attitude exhibited by a large majority of the teachers contributing to this study.

The appearances of these factors causes one to feel immediately that some medium of increased exchange of viewpoints would stimulate our progress almost immeasurably. The activities of our A.S.E.E. and the pages of its Journal cannot be praised too highly in their accomplishments along this line. However, most of these activities and writings deal with big problems of the general educational program. There exists a need for an exchange of viewpoints on the smaller problems that are met daily in the classroom, or that at most are often considered of importance only to the local institution. For example, a multitude of various purposes are hidden under the terms orientation and seminar. One school orients the students to the profession, another to local facilities, another to college life, etc., etc.

One school conducts a seminar of lectures, another has the student prepare papers which are graded from a standpoint of use of English and technical content, another makes seminar a matter of participation in student professional societies, etc.

Why should one faculty feel the need of this kind of orientation and another of a completely different kind? Of course, both schools could profit by both types in question but time not permitting, a pattern is laid out best suiting the institution. But it is important to know the reason an institution does as it does, without dismissing the matter by simply saying, "their needs are different from ours".

Too often in this connection, a staff member is hesitant to give his opinion because it probably does not represent the official attitude of the school, while all the time, the school does not have an "official attitude." The attitude of the faculty is the attitude of the school, but these diverse attitudes too often fail to fit together sufficiently to form a policy.

Surely by approaching the problems as engineers are able to approach problems, continued and increased improvement can be realized.

What are some of the things that need to be improved in our program? Where is there evidence of need of improvement? Undoubtedly each teacher has his list of answers to these questions tucked back in his mind. Some lists are longer than others, some are tucked farther back than others, but always there is a recognition that this thing or that thing can be improved, and there is usually an opinion as to how to do it.

The discussion in this section of this paper will unavoidably be based on the personal experiences and opinions of the writer. The other sections of the paper have been kept as free as possible of individual opinion, but this will not be attempted in this section, but will rather be considered one of its purposes.

The writer admits a very short experience in the educational and professional engineering fields, and a serious lack of experience of administrative nature. This study has been undertaken for the primary reason of gaining experience and of trying to reach some conclusions on questions and ideas which have arisen up to this point.

Orientation

Most schools recognize that a problem of adjustment faces the college freshmen, and various orientation courses or programs are set up for the purpose of making the transition period easier for the new student. The extent of success of such programs is a difficult thing to measure. From the standpoint of the school, perhaps the student can, during freshman week and an additional few weeks of a tapered program, become sufficiently familiar with the program of the college that he can be considered oriented. Nevertheless, from the students point of view the period of adjustment has just begun, and the whirl of activity has left him somewhat confused.

His adjustment to college living and to the many problems that arise is carried with him into the classroom, and should become vital concern of his early teachers. Many teachers feel that their only commitment to the profession is to teach that which is to be found between the covers of the text. High school seniors are lectured to the effect that when they enter college, it will all be up to them; that the college teacher has no time for council, no interest in his personal problems, etc. The summer vacation between high school graduation and the opening of college does not make men out of boys. Actually, the uprooting from home grounds brings many problems more serious than the student has ever before had to face.

The policies of our schools are such that totally unqualified students far too often are able to struggle through to the junior or senior year, or even to graduation. To witness this is one of the most discouraging experiences of teaching. Nevertheless, if an unsuited student could be guided into another profession, or shown in the proper way his unsuitability for any type of college work, it stands to reason that the public funds or private beneficence have served the state better than if possibly a few dollars and a temporarily, at least, broken life and crushed spirit have been passed back to the state. It is the function of the engineering teacher to teach his student the requirements for engineering study and how to meet them, and it would seem that near perfection in our teaching methods would need to exist before we are justified in subscribing unqualifiedly to a principle of "sink or swim" as is professed in a letter of the previous section.

If a student is so constituted that he cannot learn to swim, then he should be rescued for land duty before he drowns or fouls the ppol. Usually, the drowning student will welcome and cooperate in his rescue, as drowning is not his pleasure. This is true unless he is allowed to go too far before being diverted to a better pursuit.

Orientation could be improved by two methods of attack. First by a program directed toward a unification of the faculty behind a study of the problem, and their serious cooperation in presenting a uniform and purposeful attitude to the student. Certain aspects of this will be further discussed presently. The second approach is through better organization to effect orientation. The idea of a program herein termed "co-ordination course" is one possible direction such organization might take. With a designated class period maintained as far into the curriculum as later would prove profitable, the door would be open to orienting the student to new situations and phases of instruction as they arise. This continous thread of orientation would be only one of several functions envisaged for the co-ordination program, and of course would not alone justify such a program.

Inconsistencies in Our Programs

The students progress could be made much more smooth by better uniformity of policy throughout the class rooms. Many astounding discrepancies arise because a teacher's classroom is his private sanctuary[1]

Unlike almost any other position where people should work in a close unit, the teacher is most often not under the guiding scrutiny of the department heads and deans as supposedly is provided. The teachers degree of freedom is one of his most cherished compensations. However, the competent teacher would have nothing to fear and little of freedom to lose by having his superior and his colleagues observe his teaching, work closely with him on course outlines, and reach mutual conclusions on such matters as grading schedules, extent of completeness required in laboratory reports and other such important policies.

The refreshing variety resulting from having teachers with different backgrounds, personalities, and philosophies is to be diligently sought as highly desirable. However, if these differences are not judiciously controlled and channeled into a unified program, they readily become the seat of dissatisfaction among faculty members, and the source of permiscous sins against the students.

One is led to believe such circumstances are very general, and perhaps cyclic in occurance. Examples have been cited to the writer by students and faculty members from many schools.

Some things that may arise from such a condition are as follows: One instructor may feel that he is justified in exacting very lengthy laboratory reports requiring upward of six hours of the student's time outside the laboratory class, while another feels that the small credit carried by a laboratory course justifies only the most brief, informal report to be required. One instructor gives extremely hard examinations, grades severely, and finds at the end of the semester that the grades have been drastically suppressed. Padding of grades and guessing must be resorted to, and the students have been kept in utter confusion the full term. Another instructor may grade too easily and be lenient in all work required. One instructor may lecture solidly the entire term while another teaches very similar or identical work as a problem course. Some instructors monopolize the students time, apparently forgetting he has other courses. Some teachers, on the way up, teach themselves instead of the student. All teachers are often totally blind to their own failures and weaknesses.

Another type of situation resulting from a non-integrated program is the gradual change of course content, a certain amount of which is desirable and stimulating to the teacher, but which soon may result in a student's failure to be taught principles that are pre-requisite to his future work.

With such occurrences, it is to be expected that courses that were once divided from general knowledge into a well matched set which would knit together into an integrated program of instruction will soon lose their pattern and much will be lost between courses. Close supervision, to a much greater degree than usually exists, not only seems justifiable, but seems most essential.

It seems unfair to expect worthy performance from a student who must work under a number of these serious conditions.

Unfortunately, the avoidance of these irregularities is not entirely a matter of vigilance and good administration of those immediately in charge. The non-uniform requirements for engineering teachers and the limitations imposed by the state and institutional policies are serious sources of trouble. Low salary attraction for good men is one cause. The inability of a department to hire good men <u>when</u> they are available is another. No teacher can hold a position in the usual state supported school without he and all other staff members are carrying full student load and above. Therefore, a choice man cannot be added to the staff when he is available, but when a vacancy arises, it must be filled on short notice, and often in desperation. Another limitation is imposed by inability to discharge incompetents. Unwritten law, and tenure principles which are very beneficial in some respects, often leave a staff burdened with an undesirable member for years. Furthermore, engineering teachers are usually hired totally on a basis of industrial experience or good scholastic standing and seldom have any background of teacher training or any test of aptitude for the profession.

As previously stated in the introduction, if the obstacles just mentioned can be largely eliminated and kept out of the school, then the need for organized co-ordination is greatly reduced, or ideally, is eliminated.

Since perfection in staff and organization is not possible, co-ordination of some nature must be pushed diligently, and constantly. Of course, co-ordination cannot attain perfection and thereby eliminate the necessity of great effort and vigilance to hold up the quality of every phase of the program. One must have a good program before it can be co-ordinated, and a program cannot be good unless it is co-ordinated.

The discussion to follow will attempt to state some of the needsfor improvement in the coverage of the topics listed under part one of the questionnaire and the possible advantages and disadvantages of coverage within a special co-ordination course.

Aptitude Examination

A large percentage of beginning college students have not decided what they wish to study and if they have decided, the choice is most often based on associations with people doing the type of work the student feels he wishes to do. Whether the student has a particular aptitude for the profession of his dreams is often not taken into account. If it is his aptitude which has led him unknowingly to his choice, then he has been fortunate. Often, however, it is the attractiveness of a good salary, or of prestige, or a matter of what his parents, in their wisdom, have decided that he shall be.

For inept students to pursue a course of study for a few terms and then discover that probable failure lies ahead is a very expensive proposition to everyone involved. The price of traveling the wrong road is high enough to justify the use of every reasonable preventive means.

The use of certain courses to eliminate weak students must be relied on to a certain extent as a means of preventing unsuited students to remain under the curriculum. Extreme care should be used in selecting a course or in allowing a course to contribute to this function. Descriptive geometry, requiring an analytical and flexible mind, is accepted by many as a suitable elimination course for general engineering students. Many others feel that a student can have a very satisfactory aptitude for the various branches of engineering and yet not be apt for descriptive geometry, or perhaps quite often also, have a great dislike for the subject.

Several other supporting courses have been known to fail many capable engineering students and cause others serious, and sometimes, undue, worry. Although such courses are entirely essential to the engineers education, they are not always good criteria for aptitude in engineering. Our regulations for scholastic probation and dismissal have been developed with sufficient laxity to prevent only one, or a few, of these courses from removing the student from the curriculum. It is usually possible for totally unsuited students to take advantage of this laxity, and by passing easier courses under the easier teachers, he can struggle along almost indefinitely. Uniformity in course requirements, coupled with more rigid rules and compliance with rules, is the only answer to this serious problem.

Courses that are introductory to the major field are certainly the ones to be preferred for the function of filtering. The first opportunity to test the student in his chosen field, is here. Of course, there are dangers here also. For example, there is something more than just a tendency for senior members of a department to teach junior and senior work and leave the introductory work to the less experienced teachers. If a single course is to have a great bearing on the quality of students admitted to advanced work, then this course deserves the very best teacher available. Another danger lies in a teacher's <u>trying</u> to make a course difficult. The course should be designed with utmost care to cover material typical of the curriculum and of a level proven suitable for separating good students from the poor. Once the course has been so designed, the outline should be carefully adhered too.

Aptitude examination is, then, not a matter of one test on the first day of school. Nevertheless, if unit aptitude tests can be developed so as to do a reasonably efficient job of preliminary sorting, they are certainly desirable. It is probably the rule rather than the exception, however, that the student set in pursuing a given curriculum is not willing to follow the indications given by such examination. This is undoubtedly the reason that many schools give such examinations only upon the students request.

Another difficulty in developing dependable tests is the finding of talent sufficiently trained in psychology and engineering to supervise their design. In many schools the education and engineering departments are not able to work together satisfactorily in such a matter for precisely the reason mentioned. At least two instances are recalled from replies to the questionnaire where members of the engineering department were highly pleased with the expertly administered program of aptitude examination and student guidance carried on through the department of psychology or education. Such examples are worth close study so that this important assistance may not be lost to the engineering school.

Introduction to Engineering

The results of the questionnaire would indicate that about fifty percent of the teachers answering consider Introduction to Engineering specifically provided for in some orientation or problems course. The nature of the course most often appears to be a series of talks and lectures by faculty members and professional men, and in some cases assigned library study from some of the excellent books, several rather recent, that have been written as an introduction to the engineering profession. A few of these books are listed at the end of the paper.

The degree of success of such a series of lectures and library assignments depends entirely on the diligence of the staff in making the series interesting. Many schools located away from industrial areas, lose the most vital part of the program in not being able to secure outstanding professional engineers to participate.

The letter reproduced under the previous section, "Comment and Criticism Returned" and bearing the number (81), gives an excellent description of a very successful course in introduction to the engineering profession. Obviously, the success of the program results from the interest that has been instilled in it through careful and continuous planning.

When a certain number of lecture periods are turned over to a staff member to be used for such lectures without the backing of an alert staff, the teacher has to do most of the lecturing and calls in other faculty members occasionally to assist. The interest of the staff and of the students deteriorates, and the project is a dismal failure. When such a course cannot be given in a really dynamic manner, it is best not given at all. The class is better off if dismissed on a day when a period of doubtful interest is in the offing.

The question in the freshman's mind gradually changes from a question of whether he is suited to engineering to what branch of engineering he wishes to pursue, and finally, to a question of what type of work he will wish to do upon graduation. By the time the student has reached the senior year, this latter question becomes of great importance. How better can he make a choice than to hear talks by successful men in industry concerning their phase of engineering work and through inspection trips and films. Quite often, the exact same lecture which will help the freshman decide his branch of engineering would be helpful to the senior in deciding the type of job he wishes to seek within his chosen branch.

Some types of seminar programs are directed to this end and often have the further function of providing the senior with information concerning current developments.

If both introduction to the engineering profession and seminar were planned as part of a general co-ordination program embracing the four year curriculum, a very interesting and practical series should result.

Vocational Guidance

Vocational guidance is the end purpose of a major part of the orientation program, including aptitude examination and introduction to the engineering profession. Upon entrance, and during the freshman year, the primary function of guidance is to weed out those not suitable for engineering. During the sophomore year, the main function becomes that of aiding in the selection of a curriculum. Thus the greatest effort in true vocational guidance needs to be placed with the sophomores.

Small schools, in which the department heads and instructors can work very closely with individual students have much less need for an organized program of guidance, but of course a much greater need for high quality teachers. Schools participating in cooperative programs with industry will also have many of its guidance problems automatically solved.

Means of coping with the guidance problem divide into two parts, as does virtually every phase of the co-ordination problem. An understanding and cooperative faculty working within a planned and purposeful program is the combination required. Successful guidance at the freshman and sophomore level can avoid many wasteful and unpleasant experiences in the junior and senior years.

Problem Solving Techniques

A great proportion of the engineering students work is the setting up and solving of problems. A proper introduction to techniques of problem solving, with sufficient drill to fix these techniques in the student's mind is an important phase of early training. A majority of schools leave this important matter to be dealt with along with the individual courses of instruction. Recently, more schools are instituting a course in engineering problems in the hope that these techniques can be better established than when piecemeal instruction is given within regular classes. Although some instructors report skepticism as to the success of such courses, these courses seem to be remaining in an increasing number of schools where tried. These courses seem to be convincing many educators that problem solving techniques is a very important phase of instruction which can be very profitably conducted apart from regular courses.

The principle objection to such courses is the danger of introducing artificial circumstances whereas material of a direct and practical nature is already available within regular courses.

Actually, the conducting of such a course independently of theory courses affords an excellent opportunity to present an integrated picture of the use of mathematics in solutions of engineering problems. There is the entire field of engineering from which to draw practical problems for illustrating techniques of solution and for preparing the student for the more advanced work.

Such a course successfully conducted offers the possibility of speeding up the students problem solving to an extent that will pay great dividends in later technical courses. Also, the time saved the instructor through receiving a finer type of homework paper should be quite noticeable.

Some letters were received pointing out that a problem course being used in those particular schools was designed and conducted in such a way as to serve several of the functions listed under Section I of the questionnaire. Certainly such a course could be made to serve some of the purposes of orientation, introduction to engineering, measurement of aptitude, et al. Such a course should prove ideal as the backbone of a program of co-ordination.

The question of the desirability of using a standard problem sheet arises in connection with a problem course. Although the use of such sheets does not seem to be a very wide practice, several were returned with questionnaires. Only two distinct types were received. One type is unruled on the side to be used except for lines dividing the top margin into blank spaces for nomenclature, and the marginal lines down the sides. The back side is ruled, five squares to the inch. This ruling shows through to the working side only very faintly, not quite well enough to be used with ease as guide lines for sketching and writing. Horizontal lines are to be drawn by the student between the sections stating the data given, what is required, a sketch, and the solution. Engineering lettering is to be used.

The second type received is ruled on the face with quarter inch cross section. The lines are very faint. Marginal lines are down the sides and the top of the sheet has blanks for nomenclature, that required being identified by titles in gothic type.

Both types of problem sheets are of good bond and have standard, three-ring punching.

Results from question eight of the questionnaire shows opinion about evenly divided as to whether a standard sheet should be used or not. Many favoring its use prefer to restrict such use to beginners.

Perhaps the strongest argument against the use of a standard sheet is the time it costs the student to rule off the paper, write the details of the problem, use engineering lettering, and fill out several spaces at the top of the sheet.

The advantages of using the sheet are to develop a habit of neatness in the student, remove the inaccuracies and errors that result when clear diagrams and statements are not used, and to make the problems easier for the teacher to grade and the papers easier to identify.

The second type of problem sheet described above definitely appears to be a compromise between the rigorous requirements of the first type and the complete freedom of the student to use any paper and organization he desires. The second type simply provides convenient spaces for clearly identified nomenclature, and a clearly visible, but not objectionable, ruling as a guide for sketching and maintenance of neat order. The work may be placed according to the judgement of the student or may have a specified arrangement. This sheet appears to retain most of the advantages of standardization both for the teacher, and the student, but does not require nearly as much of the student's time.

Slide Rule Instruction

Those schools which give a problems course make slide rule instruction a vital part of the course. Some schools have distinct and separate short courses on the slide rule. Many schools leave the student to pick up facility in the use of the rule upon his own initiative. In the writer's experience, the student seldom finds time to search out many of the useful and time saving operations, and as one letter puts it, often never goes further than the use of the C and D scales. As a matter of fact, there are teachers who fail to master the slide rule themselves and who actually go through operations before the class that could be performed in a fraction of the time. The use of the trig scales with complex notation is a good example. Direct use of the trig scales gives the power factor angle and resultant vector more quickly than taking the square root of the sum of the squares and then finding the angle after finding the tangent.

When no special provisions for slide rule instruction are made, the student is dependent upon individual instructors to bring new operations and applications to his attention. Usually the instructor and student are both too busy to investigate the student's facility with the rule, and if either brings up the subject it is rather by chance and may not occur until need for the operation has existed for some time. Furthermore, under such a condition, any instruction in the use of the rule is an interruption to the subject matter of the course and often has to be gone through more than once before most of the class members learn it.

In view of the usefulness of the slide rule to engineers and engineering students, it would seem highly desirable to give a thorough treatment of the theory behind it and its use. The freshman year is hardly the place for such a treatment since the student has not had sufficient mathematics to understand the construction and relationship of the scales, nor enough application to be able to retain an understanding of more than the simplest operations. A knowledge of the simple operations should suffice until the sophomore year, when a more thorough treatment could be given. For those operations that will still not be used regularly until more advanced work is studied, the initial instruction will serve as a foundation for a more detailed coverage when the operation is put into use.

Instruction in slide rule can readily be conducted independently from other courses, and more profitably. The total amount of time that would be required for thorough instruction in slide rule is not great; probably not great enough for a separate course. It would therefore seem that coverage in a problems course, supplemented by intermittent instruction within later phases of a co-ordination course when new operations are needed, would present an excellent means of instruction.

Systems of Units and Dimensional Analysis

Because so many different systems of units are required for various subjects, the opinions offered by the persons answering the questionnaire are almost wholly in accord that the particular system of units used in the subjects should, and must, be taken up with the subject and not separately. This is obviously true, and the question included in the questionnaire was not meant to ask opinion on this particular matter. The intent of the question was to ask, since there is no course in which a student is given an over-all picture of why many systems of units are required and how a system is based and built up, if it would not be advantageous to include such a treatment in some one of the general engineering courses. Once the total picture is understood, the additional necessary coverage in individual courses can have real meaning.

The fundamental concepts of dimensional analysis are like-wise usually not shown the student in one composite picture. The fact that formal and extensive consideration of dimensional analysis is required only for graduate level work is well pointed out in two of the letters of the previous section. The type of explanation essential to the student is given excellent attention in the first section of "Electrical Engineering Fundamentals" by Corcoran and Kurtz. It is this type of coverage which the writer feels should be specifically provided for. Whether the provision is made for general engineering students in one of the physics courses or is treated in a problem or co-ordination course would be immaterial as long as the total picture is somewhere given.

Inspection Trips

Practically all schools appear to provide to a certain extent for inspection trips. The degree of benefit derived from these trips is dependent upon the amount of planning and the discussions given before and after the trip. As pointed out in a letter of the previous section, the student stands to gain very little through observing a large number of noisy processes if he has not been given a prior knowledge of the meaning and order of the processes and does not enter a general discussion of them after the trip.

Some inspection trips could be worked in, to great advantage, with the lecture series offered by seminar or orientation. Under such a plan, an official of the plant to be inspected could offer the preliminary lecture.

More benefit of a direct technical nature can be derived from inspection trips by advanced students than by those below junior level. The larger numbers involved in the beginning classes makes inspection trips for them impractical in most cases. Beginning students could undoubtedly derive considerable benefit from planned trips for a school located where such trips are practical. Schools in industrial areas need less of this type of introduction to engineering for its beginners than does a school drawing students from an area in which the young people are not familiar with industry. Unfortunately, the school needing examples of industry the most are in the poorest position for them, and vice versa.

Moving pictures could be put to much greater use as an excellent substitute for inspection trips for beginning students, to help familiarize them with industry and the jobs it offers in the various fields of engineering.

Visual Aids

The information gathered by the questionnaire indicates that the teachers in the smaller schools consider themselves more nearly adequately equipped with visual aid programs than those in large schools. A great majority of both groups of teachers feel that visual aids should be used more than at present.

One rather wide criticism of the visual aids now available is that most of them have been developed for instruction at trade school level. Development of films to accompany text material and to assist in the grasp of theoretical considerations has hardly begun.

One letter voices an objection to visual aids which is undoubtedly rather widely held. It states that learning to visualize mechanisms and processes from written and oral descriptions is a very important phase of the engineers training. Visual aids used too freely would, of course, affect this training very seriously. The question of training for thinking and visualization versus increased simplification and facility in teaching is a conflict which is currently under serious study by those vitally interested in the possibilities offered by visual aids, and probably will be a great factor in the rate of acceptance of new developments.

Visual aids cover a much broader field than moving pictures alone, of course, and development of the other forms may decrease their objectionable features to permit application to engineering teaching. Still pictures from slides, projection of book illustrations, stereoscopy, sets of charts, etc. are some of these. The advantages offered by most of these are more than offset by the time consumed, the poor selection of illustrations available, and the expense. The use of colored chart sets and enlarged drawings can be very helpful at times, but the usual teacher neither has the time or funds at his disposal to exploit their use.

The subjects of visual aids like many of the other subjects touched on by this study is too large to be gone into here further than to attempt to reflect the attitudes of thoseanswering the questionnaire and making comments.

Comprehensive Examinations

Although a majority of teachers reported that examinations to test general progress were not provided for outside of regular courses, a large majority feel that such examinations are indicative, and have a place in the teaching program.

Comprehensive examinations, when used, are generally given at the end of the sophomore year. They should be of such nature as to test the student's general comprehension and should be of value both to the student and the school in measuring progress. A similar examination at the end of the senior year is of value in classifying the graduates for employers, and checking the standards of the school's program.

Some teachers reported that their schools tried to develop and use comprehensive tests but found that the marks made by students on these examinations were very close to the over-all quality credit for previous work. Thus they were abandoned, not being any more indicative of the students general knowledge than regular course averages.

Laboratory Report Writing

The questionnaire has shown a general satisfaction with present handling of instruction in laboratory report writing. In the writer's experience, a very great number of students, most often coming in from other departments for electrical engineering laboratory courses, have turned in very poor experiments at first, showing a lack of understanding concerning the principles of good report writing. There seem to have been two major reasons for this difficulty, both of about equal proportion. The first was that they had no where been given a thorough coverage of even the more important points of report writing. The second reason was the widely varying requirements for reports in the various engineering departments, and in some cases between instructors of the same department. Answers to the questionnaire showed a great preference for giving report writing instructions within the regular laboratory courses where both the incentive and the material for the report already exist. This obviously is the place for such instruction if it is actually provided for. Whether it is provided for depends on whether a uniform policy toward reports exists within and between departments, and whether the first sophomore laboratory courses contain provisions within their outlines. It would therefore seem in the case of the writer's experience, that the second factor, that of a failure of standardization of requirements within and between departments, was possibly the basic cause for the students failing to receive adequate instructions, as well as being the cause of their confusion as to requirements.

Underlying the failure to standardize requirements are the attitudes of the individual instructors. Virtually all laboratory work is given the same rate of credit within a given institution. Yet one instructor will give quite long experiments and require countless hours of calculations and analysis for the report, while another will accept a bare minimum of report preparation, feeling that the credit given a laboratory is sufficient to cover only the laboratory hours and the time required to prepare a very short report. Obviously, at least one of the instructors is wrong, the variation in requirements not being just a legitimate difference of opinion. When the last overall curriculum study was made in an institution, and certain amounts of time alloted to individual courses and a certain rate of credit established for such work, each course was alloted the amount of time it deserved in comparison with other courses, and in accordance with guiding policy of the department. For one course to require one fifth the time another requires, or vice versa, is clear evidence that a new study of the course balance is needed, and a return to a standard policy very badly needed. Along with this unbalance naturally comes the variation in requirements for report contents and a variation of quality standards.

A set of detailed written standards passed out to the students at the first meeting, along with as much lecture attention as is required, is most effective within an individual course. This contributes little to overall improvement unless all laboratory classes cooperate in the matter. A set of standards containing instructions in curve drawing, the use of various types of graph paper, the standard symbols for wiring diagrams, requirements of the various sections of the report, a description of the laboratory and its equipment, etc. gives the student an invaluable guide, and the instructor a standard for grading and criticism.

The initial lecture or lectures on report writing, together with coverage of the set of standards, could be handled quite as well in a coordination class as in a laboratory course, and would have the advantage of making certain that a uniform laboratory policy is exhibited to every student.

Application of Mathematics to Engineering

Interesting results were obtained by the questionnaire in regard to the question concerning the effectiveness of "engineering mathematics" or "mathematical analysis" courses. Opinion as to whether these courses are successful in giving the required facility in application of mathematics to engineering problems was rather divided, with a small majority believing that they are. However, an overwhelming majority felt that additional attention is required by the engineering department. This may be taken to mean that there is an especially wide gap between pure mathematics, and its application to engineering problems; that even though the mathematics departments have stripped their courses as free of rigor as possible in order to give the maximum possible amount of attention to applications, that it is still necessary to give special attention to application in the engineering courses. If this interpretation is not made, then the fact that a small majority think the mathematical analysis courses are effective while a much greater majority feel the need of additional attention, can only be taken as contradictory. The former interpretation is borne out by the difficulty experienced by many engineering graduates in attaining the required facility with rigorous mathematical procedure that is essential to successful advanced work. They have not been trained rigorously, and must reach back for this important training. Certainly, a bare minimum of time has been alloted to mathematics courses and the desire voiced by some correspondents that more time be given the mathematics departments to deal with applications is well founded.

The attention given by the engineering department to applications of mathematics is divided between the problem course (if given) and the regular theory courses. After the elementary mathematics courses taken up to the time the problem course is offered have been correlated with engineering work in the problems course, the remainder must be done in the theory classes. Some schools do have advanced courses in engineering problems and advanced engineering mathematics courses offered by the engineering department. These schools seem to be rather few, and even in them, the advanced work is often optional.

The fact that engineering theory courses are already very crowded greatly hinders any attempt to spend appreciable time with mathematics application. It would appear that mathematics beyond algebra and trigonometry are actually avoided in many courses. Evidence of this lies in the fact that although calculus is used in derivations of equations in textbooks, an undergraduate textbook is rarely found that requires the use of any calculus in solving the drill problems provided. Often times, of course, after calculus is used to derive an equation, the final equation is all that is of value in actual usage. Nevertheless, there are a large number of cases where the setting up of the fundamental conditions and reaching a solution through calculus would be far better drill to the student than purely mechanical use of a formula. Considerable improvement in this condition could be realized.

General Discussion

Up to this point, all questions and discussion have been in regard to specific topics. The topics mentioned are quite varied in nature, and there are quite a number of them. If all these factors are to be examined with a view of coordinating the program of which they are a part, many other important questions arise. According to the results, every one of the topics listed under Section I of the questionnaire are important to the engineering student and require attention somewhere in the curriculum. If these topics are classified, they seem to fall into four general groups: (a) those which can for the most part be attended to by a short period of special attention (aptitude examinations, comprehensive examinations), (b) those which for the most part can be best covered within regular theory courses (systems of units, cebtain uses of visual aids, laboratory report writing, application of mathematics to engineering), (c) those which can most profitably be covered separately from regular courses (orientatioh, introduction to the engineering profession, problem solving techniques, slide rule instruction, introduction to dimensional analysis, certain uses of visual aids, seminar, and possibly inspection trips), (d) those which are very largely a matter of teacher-student contact, regardless of course structure (vocational guidance). To the group under (c), should be added: introduction to systems of units, and introduction to laboratory report writing. These topics can best be introduced in a separate course but then revert to coverage in theory classes. Some minor conflicts with questionnaire results arise from these classifications, but when the discussions within letters are taken into account and a brief study of the nature of the topics is made, the grouping given appears most logical.

Most present curricula specifically provide to a greater or lesser extent for those topics listed under (a), (c), and (d) through the entrance requirements, content of general courses, and the selection of good teachers. Certain possibilities for failure to maintain satisfactory treatment of these topics through the usual machinery have been pointed out. However, better treatment of these topics is largely to be gained through improvement of present methods.

Some or all of the items under group (c) above are usually considered to be cared for within existing courses, but because of their nature, improved treatment could probably be gained through a new point of attack.

The attack suggested is that these topics (orientation, introduction to the engineering profession, problem solving techniques, slide rule instruction, introduction to dimensional analysis, certain uses of visual aids, seminar, introduction to systems of units, introduction to laboratory report writing and curve plotting, and possibly inspection trips) be embraced in a co-ordination course, as a part of a co-ordination program to better integrate all work.

In any case where such a program is initiated, it should find its start within an existing course already devoted to one or more of these purposes, or within a newly established course having a self justification exclusive of giving birth to a co-ordination course (e.g., an engineering problems course). Progress from this point on should be through a slow process of evolution and planning.

Certain mechanical considerations will have to be met as a part of the gradual extension of the course. One of these is the fact that after the freshman year, it would be quite essential to separate students of the various branches of engineering and to always take care to compose classes from groups of students of equal standing and meeting common difficulties insofar as possible.

Courses already established under the name engineering problems courses, and partially devoted to other of the problems of co-ordination, are a definite step in the direction herein suggested. Some of the letters received attest the success of such programs.

The amount of time devoted to the co-ordination course and how far it finally extends into the curriculum are questions which could only be decided through actual administration of the program.

The co-ordination course might finally cover such matters as introduction to engineering, orientation, elementary slide rule instruction, etc. in the freshman year; engineering problems, introductions to report writing and dimensional analysis, vocational guidance lectures and picturesduring the sophomore year, and finally be comprised of scattered periods for inspection trips and seminar programs during the junior ~~and~~

and senior years. This is only one possible final pattern. The size of the school, its particular needs, and the manner in which the program pays off are the deciding factors of its final form and expanse.

Two questions posed in several letters and notes were: What one teacher can teach the many topics that are suggested for a co-ordination course? In view of the now crowded curricula, where could time be found for such a course?

To secure and maintain teachers of superior grade for all theory courses so that they are equal to the task of setting the student straight on the spur of the moment on points which could otherwise be settled in a co-ordination course is an infinitely more difficult matter than to carefully select one (or a few, in the case of a large school) instructor of exceptional broadness, and a keen interest in the co-ordination phase of the program. In addition, a teacher whose business it is to teach an introduction to systems of units, slide rule instruction, problem solving techniques, etc., and is provided time for preparation, could certainly attain a much better knowledge of these topics than the ordinary teacher can ever have.

Turning to the question of time, many schools are finding room for problems courses, and this course is justifying itself on a basis of increased efficiency throughout advanced work. It is not suggested that even the slightest amount of time be devoted to a co-ordination course unless it can clearly justify itself on the same basis. In order to provide room for the initial trial course, two sources of time suggest themselves. The first is through the elimination of seminar, orientation, and similar courses which have deteriorated to a point of uselessness because they have not been backed with sufficient organization and purpose. The second is through removal of duplication of instruction. Physics courses serve as an example of this possibility. The usual physics course required of all engineering students contains mechanics, light and sound, electricity and magnetism, and heat. The electrical engineer then takes a full course of dynamics, a full course of statics, a heat power course, and many electrical courses. The mechanical engineer takes dynamics, statics, an electrical engineering course, and many courses involving heat studies. Other engineering majors have similar instances of duplication. At the sophomore level, where physics is studied, it seems unlikely that the student can be given special concepts from the physicists viewpoint that are basically different from what he receives in engineering courses.

Statement of Purpose

The theme of this discussion, which is the result of a study of the questionnaire returns, letters, articles and limited interviews is that an inventory of our teaching effectiveness is over-due, and such corrective measures appearing necessary should be taken.

Greater vigor in the hard and relatively uninteresting matters of careful course outlining, intradepartmental and interdepartmental cooperation, and careful compilation of course records for determination of effectiveness is required as a basis for general improvement and must be done through supervised planning.

The objectives behind all of the suggestions made in this paper in behalf of efforts to improve teaching effectiveness may be summarized as follows:

> To channel unsuited students out of engineering as early as possible, and on a sound basis.
>
> To equip each student thoroughly with every tool and fundamental concept essential to rapid progress in advanced work.
>
> To maintain a cleancut, co-ordinated, program through tireless effort, and through closer cooperation of the staff.

The principal requirement for realizing these objectives is for greater planning and greater purpose in the teaching program. Individual teachers hold entirely too much independence and freedom in the conduct and coverage of classes. Should co-ordination of teaching effort be realized, then the overall pattern of study as seen by the student would take on a much clearer meaning. The more successful the co-ordination effort the less conscious the student will be of its existence and necessity.

A BRIEF SURVEY OF LITERATURE

In studying published literature for enlightenment on the problems being studied in this paper, one finds that his source of material is very largely limited to the "Journal of Engineering Education". In general, there are two types of articles to be found in the Journal. One is the report type, which is submitted by a committee having been assigned the responsibility of investigating a given subject. The second type of article is the expression of an individual of his views on a given subject either voluntarily or through suggestion. The report type of article, being the result of the efforts of several outstanding educators is most often confined to establishing facts on broad topics. The articles written by individuals very often treat matters of a more detailed and controversial nature. From these can be gleaned many interesting attitudes and arguments. However, the limited number of articles of this nature which are offered in each issue of the Journal does not permit much in the way of counter argument or rebuttal; as a result, a real cross section of opinion on controversial matters is hard if not impossible to obtain from this source.

The fact that little writing is done with respect to the particular problems of co-ordination being studied herein, and the fact that such information as is available has to be sought out piece-meal and at a great expenditure of time will cause this section of the paper to be limited in scope.

The writer has reviewed a large number of articles with two aims in view: (1) to obtain as broad a concept as possible of the ideas set forth in the more outstanding articles having been written on engineering education and (2) to find evidences and examples of lack of co-ordination in engineering teaching, and suggestions for improvement.

Although it is hard to find articles which deal specifically with the matters of co-ordination and correlation of engineering teaching, there are numerous references in articles to existing deficiencies in these matters. A few such references will be cited.

Teacher Selection and Teacher Attitudes

President Doherty has said, "Yet it always seemed incredible to me that the plan of progress in engineering studies is set according to the personal notions and understanding of individual instructors instead of according to the understanding and continuous growth of understanding of the student, for whom after all the entire plan is intended". [10]

The article in which this attitude is expressed is one calling for a better policy for teaching systems of units. He says, "I can think of no other educational front where such devastating confusion exists; nor yet one where understanding is more essential". [10] He favors the teaching of only one system of units in the introductory physics courses. The MKS system is given slight preference, but the matter of being more thorough with the one system and co-ordination of this system with the following mechanics and electricity course is stressed.

Recognition that the planning of courses and their co-ordination with other work is often very poorly done because of the freedom of the individual instructor is a scorching indictment when voiced by a man of President Doherty's position in the field of engineering education.

This same theme is present in the discussion[8] of the frequent rebuilding of a curriculum by a newly appointed department head without due consideration of the studies that have been made and the wise council available. The article referred to is by Gilbert E. Doan and is an excellent example of rebuttal to views expressed in earlier articles of the Journal. There are very few such articles to be found in the Journal, and the need for more of them is great.

There are of course many factors which contribute to loose, inefficient departmental structure and policy. Two such factors are pointed out by D.B. Steinman[38] as the practice of inbreeding and the employment of teachers without practical experience. He questions the teaching ability of a large proportion of the engineering teaching profession, and considers that undergraduate proficiency and degrees are the prime basis for selection of teachers.

Albert B. Newman[26] has given a partial list of reasons why men leave industry for teaching positions. The seven reasons he lists bear out that many teachers have come from industry into teaching to the detriment of the profession. He lists as the first reason the fact that the candidate for a teaching position has not advanced as rapidly in industry as he feels he should have. Another motive is that of reorganizing an engineering department on a time clock basis and in accordance with the fixed ideas of administration the applicant has learned in industry. Some applicants from industry are said to believe that success in teaching is much easier than success in industry, and are attracted by the prospect of easy hours and long vacations. Still others are attracted by higher salaries. The last reason suggested is that the applicant is leaving industry upon the insistence of his wife who dislikes the travel connected with the industrial position.

A.A. Potter[30] comments, "Those in executive positions in colleges and universities have had sad experiences when they added to their staffs engineers of wide practical experience, who knew nothing about teaching, who did not realize that teaching is an art and who merely imparted knowledge of a very specialized type."

George W. Dyson is critical[12] of the teaching ability of most engineering teachers and the selection of teachers on a basis of degrees and research ability. He stresses the need of engineering teachers for training in education.

Uniform Grading

Forrest C. Dana cites[6] actual results from experimentation to verify the broad discrepancies in grading between instructors and, indeed, between courses and classes under the same instructor. His article on the development of a grading system for a problems course describes a system which has virtually eliminated human inaccuracy from grading. Although this plan would not be adaptable to more advanced courses of varying nature, it does bear proof of the increased accuracy that can be attained in grading. It furthermore sets a shining example of the high degree of co-ordination which can be attained by a departmental staff. It is quite evident that the effectiveness of the course has been greatly strengthened by this co-ordination, in addition to the primary function of standardization of grading.

Slide Rule Instruction

Evidence of the need for increased instruction in the theory and use of the slide rule is borne out by this statement: "How many engineers can divide each of a group of numbers by a common divisor using one or at most two settings of the slide rule for the entire group? The answer is, fewer than one would expect".[19] This criticism is evidently directed at graduate engineers and teachers as well as to students of engineering.

Orientation and Guidance

A very large number of articles have been written concerning student selection and guidance. The number of articles on these subjects appear to be increasing considerably in recent years. One phase of the problem is the study of aptitude tests for student placement. The analysis of the reliability of such tests has been reduced to a rather scientific basis through use of the mathematically derived correlation factor. Certain inaccuracies will always occur in such evaluations, the one of greatest importance being the students _actual_ rating upon which the correlation of aptitude examination results must be based. Participation of large numbers of schools in a national study of aptitude and comprehensive examinations has made it possible to greatly reduce the seriousness of this and other inaccuracies by supplying data on vast numbers of students. _Journal_ articles report a very wide acceptance of aptitude tests as a valuable aid in sorting beginning students, and report an increasing acceptance of comprehensive examinations at the end of the sophomore year to eliminate large numbers of unsuited engineering students. One article[18] reports a "slowly widening interest" in comprehensive examinations accompanied with reduced emphasis on term examinations in individual subjects.

Another article[13] makes the following interesting observations. An investigation of the problem of comprehensive examinations led to the conclusion that either one of two capabilities could enable a student to do satisfactory work in engineering curricula. First, a superior ability to absorb and assimilate factual knowledge, or second, the ability to reason from a given set of facts and a reasonable knowledge of basic scientific principles to a logical and intellegent conclusion.

A comprehensive examination was developed as a test of the second factor, while the usual course examination served as a measure of the first capability.

By this double standard method it was reported that better than 90 percent correlation with failure to graduate on time was achieved. Thus it was possible to eliminate those students who failed to meet both standards with virtually no danger of dropping capable students.

Many other phases of the guidance problem are studied in various articles. A unique system of guidance is described by Professor A.D. Moore.[24] This plan is called the "Mentor System". It represents an extremely well organized yet completely voluntary guidance service to each student throughout his college career. Guidance council is with a staff member in the student's major branch of engineering. The content and effectiveness of a series of guidance lectures developed by Professor Moore is especially interesting. A very valuable bibliography is appended to his article as suggested reading material for Mentors. This impressive list should be studied by every engineering teacher.

Regarding the opposite concepts of "sink or swim" and judicious, serious guidance, this quotation is quite significant:[19] "It is hard for engineers to believe that a surprisingly large percentage of students do not know how to study and do not even know how to read properly. Many students who have sufficient mentality to become engineers are lost to to the institution and to the profession through inability to make the best use of their talents."

"Study habit courses should be a vital part of every first year curriculum."

D.B. Steinman[38] takes a somewhat varient view by insisting that present policy is one of enlisting students, or guidance <u>into</u> engineering, whereas there is a significant lack of guidance <u>out</u> of the curriculum.

Visual Aids

Great stimulus has been given to the study of visual aids in engineering teaching by George C. Tomlinson[39] who among other things suggests that "A general engineering orientation series might constitute a proper start in the selection of films for engineering educational purposes." He further says, "A number of engineering schools are at great distances from industrial centers. At these institutions the proper use of educational film will fill a real need in building up an industrial background for the students".

Two major faults with present film are given as their elementary nature and the large advertisement content of those supplied by industrial concerns.

Suggestions were made[3] as early as 1919 to have the basic industries filmed for the classroom. In 1928 Francis H. Roys suggested that the S.P.E.E. and founder societies "collect and edit films to educate students in choice of career".

H.J. Gilkey points out[15] some of the present temporary difficulties in using visual aids:

(a) Lack of suitable facilities
(b) Difficulties of overhead
(c) Question of subject matter
(d) Cost

Professor Gilkey concedes that all of the above difficulties might well be overcome by increased preparation for use of visualaids but feels their use will have even more serious objections of a lasting nature. He sees ~~the~~ the motion picture medium of teaching as very similar to the lecture system and with the added objection that notes can not be taken. He further feels that the projector forms a barrier between teacher and pupil, making it impossible for the teacher to prod the student with timely and thought provoking queries. Lastly, he points out that the student will not have his thinking brought to him on a silver screen after graduation, and should be trained to think, as a vital part of his education.

Interesting in this respect is comment by G.A. Olsen[27] to the effect that although leading the student to puzzle out answers to his own questions is unquestionably very <u>effective</u> it is also a very <u>inefficient</u> method of instruction. He feels that certain courses lend themselves best to the supervised study type of instruction. His article deals specifically with this type of instruction in beginning mechanics courses. A study has convinced him that one thorough coverage of mechanics in a supervised study class is superior to the usual method of partially teaching it several times as in physics, introduction to engineering and then mechanics.

He believes also that much less time is required for this superior type of instruction.

Problems Courses and Slide Rule Instruction

In a study of the educational system of Europe,[20] D.P. Krynine says, "I think, however, that in this country (United States) mathematics is not enough used in teaching technical subjects and that there is a gap to be filled between mathematics and engineering".

In addition to its valuable functions of developing a standard of neatness and a technique for problem solving in the student, a problems course is designed to help fill this gap between mathematics and engineering.

The University of Washington, Iowa State College, and Oregon State College have been pioneers in problem course development. Although these institutions have been criticized for certain results of the rigid specifications of some of these courses, these schools and many others attest the great benefits the students have derived through this training.[6, 28] Professor Moore of Washington University was especially unique in his theories of instruction and use of problems courses.

Regarding slide rule instruction, H.M. McCully makes this statement,[22] "It is indeed unfortunate that so many of our teaching colleagues have not kept themselves informed of the increased usefulness of such an essential element in the educational program of present-day students".

This comment was offered after a poll of the membership of honorary engineering societies of a large number of engineering schools. This large group was highly in favor of a formal slide rule course for freshmen students.

Professor McCully's article points out in great detail the tremendous psychological tool the slide rule is. The rule plays the role of the symbol of the engineering profession. The possesion of a rule is a cherished pleasure for the beginner not yet able to engage in more advanced engineering pursuits, and may be used as a great morale builder.

In addition to the suggested benefits to be obtained through slide rule instruction, the article points out that such instruction can be done in small units but should be continuous over a long period. The unnatural setting for such instruction in mathematics and other courses is pointed out and the advantages of instruction within a drawing course are cited.

Laboratory Instruction

Several studies have been made in an effort to make laboratory classes more effective. Professor Howard E. Degler,[7] and others, finds that for several reasons, laboratory work as a powerful tool is tending to become less effective. He cites the need for revision of laboratory courses and makes several suggestions toward this purpose. Other writers have pointed out that laboratory instruction is far more expensive than class instruction and that great effort should obtain to keep these courses effective. It is also pointed out that,as is generally evident, laboratory courses require far more time of the student than do regular courses for the credit given.

Co-ordination

As an example of departmental effort to coordinate the engineering studies, Professor Miller of the University of Michigan reports a practice of assigning men of the drawing department the responsibility of examining drawing work done in degree granting departments, and helping members of these departments with their drawing problems.

Professor Theodore H. Morgan[25] makes the following observations on the problem of unification and correlation of instruction:

"The interlacing of the courses of a single group should be so strong as to weave them together into one closely knit whole. All barriers should be broken down and the student should recognize before him a single, unified program. This program should commense with his first day of college and develop logically and consistently from day to day and from term to term right through to graduation".

The article outlines the work done in unification of an electrical engineering curriculum by close correlation between all theory courses and between laboratory and theory courses. It causes one to ask, "why hasn't the idea and method always prevailed?"

"To those who might think that the plan of unification of the curriculum is idealistic rather than practical, the reply is that to a limited extent it is now in operation in many engineering colleges throughout the country. In such institutions it would not be viewed as impractical gradually to extend the degree of co-ordination in order to obtain increased benefits. The sudden introduction of the complete program at any institution would probably have discouraging results at first. In a plan of this nature the details must be worked out and executed by the individual members of the staff who are directly concerned, and while enthusiastic leadership is necessary, it is not sufficient. There must exist a genuine appreciation of the benefits and enthusiasm for it on the part of the majority of the staff before it can be made to function effectively".

The above citations, although few, and not all - inclusive, are genuine evidence of the need of co-ordination in teaching, in course planning, and in all phases of engineering instruction. These expressions for need of co-ordination are usually somewhat incidental to the theme of the articles in which they are found, and most of the writings on engineering education problems are based on the premises that intradepartmental and interdepartmental co-ordination is already established as a strong foundation for further building. Obviously this is often not the case, and indications are strong that some of the larger problems might disolve upon the actual realization of a co-ordinated program.

CONCLUSION

Leadership, teamwork, common understanding, and common purpose are recognized essentials in any educational program. College teachers are supposed to be entirely competent, wise, and resourceful individuals, and are generally assumed to be. This assumption leads to a great degree of individual independence in teaching methods and class conduct. The direct result of this independence often is a very loose and purposeless educational organization and program. This is found due to the presence of many teachers of limited ability and vision. This part of the problem can be approached only through persistent efforts to improve the attractiveness of teaching positions and by being more critical in the employment of new men. However, another important reason for degenerate teaching programs is the failure of maintaining a backbone for the program.

This study has led to the following conclusions and recommendations.

I. Existing deficiencies

Immunity from weakness should never be assumed. The idealistic plan of maintaining strength and unity by virtue of the quality of the staff is subject to serious and frequent failure. Every teacher, every department, and every school should periodically examine itself critically through an organized procedure in an effort to detect and correct weaknesses.

II. Definition of aims

Every engineering school and every department within it should have a well defined set of aims to be used as a yardstick of effectiveness. It is concluded that many schools and departments do not have well defined aims.

At risk of oversimplification, the following aims are suggested:

A. Selecting the student

To restrict entrance to well suited students, and through reliable means to eliminate promptly those unsuited students who have gained admittance.

B. Equipping the student

To equip each student thoroughly with every tool and fundamental concept (both technical and non-technical) essential to rapid progress in advanced work, and to channel students into the phase of engineering they are best suited for.

C. Training the student

To maintain a clear cut, well defined program through co-ordination, correlation, and unification.

III. Suggestions for improvement

The following suggestions are offered for improving and maintaining a program which will meet these aims.

A. An improved selection and guidance program

(1) More honesty and more effort in picturing the exacting requirements of engineering study and the engineering profession to engineering aspirants.

(2) More strict adherence to existing entrance requirements and the establishment of more judicious entrance barriers.

(3) Use of well tested and scientifically correlated aptitude examinations.

(4) A program of education of faculty members to the importance and methods of orientation and guidance, and their active enlistment in a purposeful program.

(5) Use of comprehensive (general engineering aptitude) examinations of proved effectiveness, to be followed through completely with scientific correlation studies.

B. <u>Better training in basic fundamentals and techniques</u>

(1) <u>A co-ordination course</u>

Develop a co-ordination course to thoroughly treat those phases of training which do not fit naturally into theory courses, or which can be given superior treatment apart from theory courses. Such phases of training and/or topics are:

(a) thorough training in how to study
(b) general and specialized orientation
(c) introduction to the engineering profession
(d) problem solving techniques
(e) slide rule instruction (theory and use)
(f) introduction to dimensional analysis (homogeniety)
(g) films and lectures depicting industry and various engineering opportunities
(h) introduction to systems of units
(i) introduction to laboratory standards and report writing
(j) seminar and/or advanced problems course
(k) inspection trips and correlated lectures

(2) <u>Co-ordination of courses</u>

Plan the individual theory courses so that they will build directly on the basic principles developed in the co-ordination course and earlier theory courses. Continue the requirement of a high level of proficiency in the use of the tools mastered in the co-ordination course and of application of mastered fundamentals to the advancing work.

(3) <u>A co-ordination program</u>

(a) A stronger chain of responsibility- assign the responsibility of the co-ordination course, and an accompanying co-ordination program, to a group composed of one member from each departmental faculty. (If the school is large and the developed co-ordination course extends beyond the division of the general curriculum, the course should be divided departmentally).

(b) Establish basic agreement on fundamental policies within and between departments through frequent faculty discussions. Prepare printed copies of these standards. For example, uniform grading policy; uniform laboratory policies, such as outside work required and report standards; etc.

(c) A curricula study. Make a new and extensive study of curricula content and the extent of co-ordination existing between courses. Prepare and circulate master course outlines so that course content and points of emphasis may not drift. Any change in course content should result only from a judicious change of the master outline. (Since all engineering schools are training engineers for the same industrial market, it should be possible for the A.S.E.E. (S.P.E.E.) to establish outline standards for the courses of each major curriculum. Although these would have to allow some free interpretation, they should be very valuable as a standard of comparison, having been formulated by a group of men who are authorities in the field).

(d) A study of course effectiveness. Require a detailed course outline from each instructor at the beginning of a course. Keep records of text material used, homework assigned, and examination problems given in the course each term. Keep tabulated data of grades received each term. Study this data for improvement of teaching methods, uniformity of grading, and a measure of teaching effectiveness.

In offering this brief list of suggestions, it is not intended that the engineering teacher be deprived of his freedom. It is merely suggested that the minimum essentials of organization be retained and that active cooperation take the place of passive indifference and cross purposes. To a person outside college teaching work, the fact that many of the things suggested are not incorporated in every teaching program would undoubtedly come as somewhat of a shock. Surely they represent a minimum basis for a successful program.

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