CONSIDERATIONS IN THE ASSIGNMENT OF HOMEWORK IN HIGHER ENGINEERING EDUCATION

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Introduction

The purpose of this paper is to present some considerations of various types of homework assignments in higher engineering education. In order to promote more effective teaching in this area, a review of the methods in use at present is required. In the author's opinion, the type or style of homework in higher engineering education, such as in the junior, senior and graduate school years should differ from that in the elementary, Freshman-Sophomore years, or perhaps the junior year in a technical institute or engineering college. The type of homework should depend on the type of subject which is being taught. Homework for the courses in fundamental engineering should differ from assignments in the practical or applied engineering courses.

Types of engineering homework can be classified into the following two categories: the drill-type homework [1] and the creative-type homework [2][3]. The drill-type homework [4] should be given for the purpose of developing fundamental engineering skill. In this type of homework, application of the same engineering fundamental principles to many different problems are required until the student masters the use of engineering fundamentals. Most assignments in mathematics, mechanics, and computer programming courses belong to this category. The creative-type homework should be given to the student to develop imaginative and creative ability. In this type of homework, problems are generally either the synthesis type or of the analysis type. Design problems are included in this category. The problems are designed in such a way that students must use many diffferent principles to attack the problem instead of repetitious applications of the same simple fundamental principles to attack the problem instead of repetitious application of the same simple fundamental principle to many different problems. In this type of homework, students learn for themselves the technique of attacking the problems using their imaginative creativity. Creativity like any other talent or ability, can be developed only by frequent practice and exercise. The instructor's role in this type of homework would be that of directing the student's thought in the right direction. The driving power

itself must be provided by the student. The instructor should, however, motivate the student's interest and should give the student every possible opportunity to exercise his creative ability. In other words, for development of creative engineering ability among highly educated engineers, creative-type homework should be given as often as possible while they are still students.

Drill-Type Homework

Students often find drill-type assignments boring. The boredom may kill the student's interest and close the door to his imaginative and creative mind. Drill-type homework should be kept at a minimum in the senior and graduate school years. Too much drill-type homework will change the student into a slave of "teaching machines". He would not have the time to spend on creative and imaginative problems which usually take more time than the drill-type problems. Most likely his preoccupation with the drill problems will prevent him from thinking creatively. In short, drill-type homework problems are definitely necessary for the training of technicians but should be limited in higher engineering education.

Currently, there is a problem in the university engineering education system in this respect. A young man entering a college of engineering must first learn many engineering fundamentals and naturally, the homework assigned him will be mostly of the drill-type. It will be fortunate if this current situation does not discourage the young man's imaginative engineering mind. Generally, it can be be said with a few exceptions that a young mind is more creative and imaginative than an old one. The boyish engineering imagination without a firm theoretical background might look foolish to an experienced engineer, but who can say that the "firm theory and experience" on which the experienced engineer bases his impression is inaubitable? It was not too long ago that the "old mind" thought the earth was flat and absolutely stationary. There should be some way to keep this young man's imaginative mind alive before it is suppressed by excess of drill-type assignments. Since the time allocated to fundamental engineering courses is limited, educators try to instill fundamental engineering principles as quickly and firmly as possible. This is the probable cause of the great amount of drill-type homework in the early stages of engineering education. Is it actually necessary to give this amount of drill-type homework? Probably not. Since engineering fundamentals will appear over and over again during the entire course of engineering education and in engineering practice after graduation, it is not necessary to give the student too

much drill in the early stages of his engineering education. This situation is analogous to learning to drive a car. One must learn the fundamentals of driving to obtain an operator's license. Real driving skill will develop later after years of driving under various conditions. Drill is important but it should be kept at a necessary minimum. Instead of using excessive drill, a teaching method which motivates the student's creative mind and stimulates the student's interest in engineering should be used. This might have the side effect of lessening the number of engineering dropouts. Every possible means should be executed to protect a tiny light which was enkindled in the young engineering mind and to help it to become brighter.

The imaginative and creative engineering mind is expected of most graduate students. If drill-type homework is given to the graduate student often, the student cannot have the time to think. Time is needed for imaginative and creative thinking. If the student is kept busy by drill-type problems all the time, the student will become merely an advanced technician instead of a creative engineer. Technicians know how but engineers know how and why. Furthermore, engineers should be able to propose new and better solutions.

Creative Homework

Creation will follow imagination. In order to develop the student's imagination, he should be afforded the necessary time, as well as necessary motivation and inspiration. To educate creative engineers, what is needed is an inspired instructor. It is an important responsibility for engineering educators to inspire their students to utilize their creative engineering minds. Just like learning to swim, the creative ability must be developed within the students themselves. No one can teach another how to swim unless the student is in water and willing to try. No one can teach creativity unless the student is in the water of motivation and stimulation. Once students are in the water, one can coach them from poolside yet the swimming ability itself must be developed within the student himself.

It is unfortunate that in the current method of student evaluation, such as grade point average one cannot determine too well the student's creativity. Yet most students are, with little exception, evaluated by their grade point averages. Again, except a few special cases, most students with good grades are merely advanced technicians. Creativity is seldom found in a student with good grades if the author is not mistaken. Creative engineering minds are often discovered amount "not-so-good-

grade earners". Of course, "not-so-good-grade earners" are not necessarily creative engineers. But the mass production of advanced technicians who call themselves engineers should be avoided. The ideal case is the student who earns good grades and also becomes a creative engineer. All engineering educators should make every effort to realize this goal.

Many types of assignments can be conceived in advanced engineering education with the purpose of developing the student's creativity. Weekly assignments which require much imagination and creativity can be assigned. One of the most effective methods of developing and also evaluating the student's imagination, creativity and his critical mind is the assignment of a term praper, providing proper guidance is given to the student. Frequent conferences between the student and the instructor are needed and effective guidance and inspiration should be given at that time for better results. A side effect of a term paper assignment is development of ability in scholastic engineering writing. It is not unusual to find some students among seniors or graduate students, who do not know how to write a scholastic engineering report.

Open ended term project, problem identification, problem definition, creative design, and a type of editorial work in library study belong to this creative-type homework category. Cookbook style design practice is not considered to be creative-type homework. Cookbook style design practice belong to the drill-type homework [4]. In actual Engineering practice, the defining the problems is often more important than solving of the given problems. Open ended type homework helps develop such capability if carefully monitored, guided, and inspired. How to manage the instruction of defining the engineering problems is the problem itself to be solved. Creativity, like any other talent or ability, can be developed only by frequent practice and exercise. The instructor's role in this type of homework would be that of directing the student's thought in the right direction. The instructor should also try to or assist to provide an environment to generate creative and imaginative thought by suggestions and, if possible by his inspiration. But, the driving force itself should be provided by the student himself. The instructor should motivate the student's interest and should give the student every possible opportunity to exercise his creative ability. In other words, for development of creative engineering ability among highly educated engineers, creative-type homework should be given as often as possible while they are still students.

The homework assignment should be designed so that the student will develop a skill for defining the engineering

problems and solving the problems. The problem solving is only a half of the engineering education.

Need of Society

Perhaps, a great number of "advanced technicians" are needed in the engineering profession. A great deal of drill-type homework in higher education is certainly helpful in producing highly educated "advanced technicians." Drill-type homework in higher engineering education, however, is not very helpful in producing creative engineers. In creative engineering education, drill-type homework should be kept to a necessary minimum and creative-type homework should be assigned as often as possible.

Plug-In Type Homework

In creative engineering education, what is the value of the substitution type problem or "plug-in type" problem? If this type of problem is assigned excessively, then this is actually the case of the drill-type homework and the same criticism of drill-type homework applies to the plug-in problem. However, lest the plug-in type homework problem be too lightly regarded in higher engineering education for creative engineers, the attitude should be corrected. The "plug-in" type problem is important in producing a solid practical and quantitative concept of the subject matter. If the plug-in type problems are not given at all, the student may have the concept of the theory in a generalized nature, but he cannot conceive a realistic, practical, and solid picture of the engineering problem. The imaginative nature is important in the higher engineering education. The imaginative nature, however, should be distinguished clearly from the simple "imagination" or "dream". The engineering imagination must be based on a concrete fundamental engineering understanding. The simple "imagination" could be like a sort of science-fiction and does not have any realistic and practical numerical engineering concept. The realistic practical engineer must practice with numbers. The practical application of the theory or concept which he has must be examined by numerical examples. Therefore, students must learn for themselves, by plugging some realistic numerical quantity into the theoretical equations. The practical application of the theory and how to use it to solve engineering problems, or to create something new in engineering can only be learned with the help of such practical problems.

Therefore, the plug-in type problem and homework in higher engineering education must be designed in such a way

that the homework produces a practical numerical concept in the engineering students and gives realistic understanding of the application of the theory. Engineering imagination must be based on a concrete concept of practical theory. The assignment of plug-in type homework should be, however, kept at a necessary minimum for creative-engineering education. Too much plug-in type homework will have the same effect on the student's interest and imagination as the drill-type problem. Design of good plug-in type problems is the engineering educator's responsibility.

Conclusion

In conclusion, it can be said that homework in higher engineering education must be the kind of homework which will help develop the student's imagination and creativity. However, this imagination and creativity must be based on solid engineering principles. Although it is necessary to provide this foundation with a teaching method which includes the assignment of drill-type problems, but these assignments should be kept at a minimum.

Acknowledgement

The author would like to thank Louis J. Rutigliano for assistance in preparation of this manuscript.

References

[1] Louis A. Hill, "Homework for Theory and Practice" Engineering Education, Vol. 60, No. 2, pp. 120-122; October 1969.

[2] George M. Prince, "A Method of Creative Thought" Engineering Education, Vol. 58, No. 7, pp. 805-810; March 1968.

[3] Felix Y. Yokel, "A New Experience in Creative Thinking" Engineering Education, Vol. 58, No. 7, pp. 810-811; March 1968.

[4] Stephen L. Rice, "Objectives for Engineering Laboratory Instructin" Engineering Education, Vol. 65, No. 4, pp. 285-288; January 1975.