PURDUE UNIVERSITY

STUDENT PREPARATION FOR GRADUATE SCHOOL THROUGH UNDERGRADUATE RESEARCH

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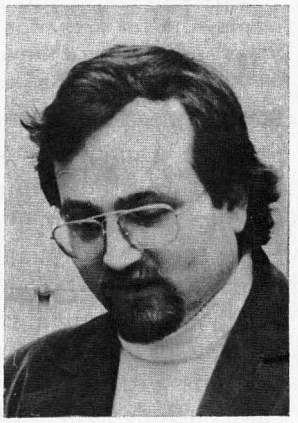

Nicholas Peppas undertook the responsibility of organizing this ASEE Symposium and editing the contributions presented in this issue. When not busy with polymer and biomedical research and teaching at Purdue, where he has been since 1976 after a 1973 Sc.D. from M.I.T. and a challenging experience in the Greek Army, he is occupied with operatic, linguistic and historical studies. Some of his published historical articles include essays on Aeschylus, Philocrates and Theocritos, a "History of the Albanians in Attica, 1200-1700," and a "History of Eleusis, 500 B.C.-1920."

THE PURPOSE OF THIS contribution is to summarize a three-year experience with undergraduate research in polymers at Purdue University and to discuss indications that undergraduate research participation is more likely to assist students in considering graduate studies in chemical engineering or other fields.

The recent increase in undergraduate chemical engineering enrollments [1] is viewed with scepticism by many educators who feel that chemical engineering departments are physically unprepared to handle the large number of new students. Schools which traditionally have had large undergraduate programs have introduced drastic measures to cope with these "numbers," as described in a sequence of papers edited by Houze [2]. However, I am afraid that the factor "undergraduate student" has been neglected. Despite the significant expansion of faculties and staff, the addition of recitation classes, and other measures, there is considerable concern that professor/undergraduate student interactions have weakened or become non-existent.

Under these circumstances undergraduate research may become an excellent way to improve professor/student interactions, to induce an intellectual framework for exchange of scientific and sociopolitical ideas and to retard the academic disorientation of undergraduate students. It is disturbing to note that although universities are expected to provide an *academic* atmosphere for education, (the word *academy* stemming from the philosophic school and the suburb of Athens where Plato and other philosophers used to gather *to discuss and think*), there are indications that many departments are merely concerned with graduating the "number of students" that will satisfy industrial demand for chemical engineers. Frankly, how many of us are able to identify by person *all* the graduating seniors of our departments?

In a recent report [3], Barker pointed out an additional problem in chemical engineering education; i.e. the alarming shortage of chemical engineering faculty. His survey shows that in the Spring of 1980 there were 83 chemical engineering schools reporting 172 vacant faculty positions. This number is up by 80% from 94 positions in 130 schools in 1977 [4]. The number of foreign graduate students has leveled off to about 47%. Since there were 309 Ph.D. degrees in chemical engineering in 1979 and since many of the foreign graduate students return to their countries [3], there may be as few as 200 Ph.D. chemical engineers available to fill 172 faculty positions and approximately 200 industrial positions.

These alarming statistics point out that the existing number of doctorate candidates is low and that this phenomenon is affecting not only the faculty renewal cycle but also chemical industries. Several industrial leaders have publically acknowledged the need for more advanced degrees in chemical engineering.

It is not the purpose of this contribution to analyze all the reasons that led to this shortage. The author does feel, however, that undergraduate students are in general misinformed about the functions and job market of Ph.D. graduates, the financial benefits, and the future careers they might pursue if they obtained a Ph.D. degree. The

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problem (and its possible solution) lies in the realization that undergraduate students are usually well informed about the immediate attractions (mostly financial) of a B.S. degree, but are poorly informed about the (not always financial) benefits of an advanced degree in chemical engineering or other areas. Through numerous discussions with undergraduate students the author has concluded that many of them are not aware that they get a stipend during their graduate studies period, or that a Ph.D. degree does not necessarily mean an academic career, or that knowledge obtained in their undergraduate program may not be sufficient for job opportunities in certain industrial sectors such as research and development.

Therefore, a program of independent undergraduate research may be a highly desirable system of exposing undergraduates to the research aspects of chemical engineering, and of inducing their creativity and other skills.

THE PURDUE URAP IN POLYMERS

The Undergraduate Research Activities Program (URAP) as applied to Polymer Science and Engineering at Purdue University has been discussed in a previous contribution [5]. Instead of describing again the logistics of this system, we will concentrate here on a possible correlation between past education and academic performance of participants, and their present job situation.

In a three year period (June 1977-May 1980) 37 undergraduate students participated in URAP in polymers under the direction of this author. Two students worked for a total of four semesters, two students worked for three semesters and eleven students worked for two semesters. The average graduating index of all students was 5.61/6.00 and their present positions are analyzed in Table 1. Further analysis in this paper refers to the 35 participants who have already graduated.

TABLE 1
Present Position of 37 URAP Participants

Undergraduates	2	5.4%
Graduate Students in ChE	12	32.4%
Medical School	3	8.1%
Business School	7	18.9%
Industry	13	35.1%

According to this Table, 42.8% of these 35 students continued towards a graduate degree in chemical engineering or Medical School as compared to 17.6% for a group of 1980 seniors from Purdue of similar scholastic caliber. To investigate whether this group of URAP students was biased towards research and graduate school *before* actually participating in this program, the author caried out an informal survey of 29 undergraduate students who participated in URAP in Polymers during the 1978-79 and 1979-80 academic years. Table 2 summarizes the answers to some key questions concerning the participants' evaluation of undergraduate research.

TABLE 2
"Yes" Responses of URAP Participants in Polymers (N=29)

	PRESENT POSITION		
QUESTION	Industry (N=11)	Grad. ChE/ Med. Sch. (N=13)	Business Sch. (N=5)
Did you have previous research experience?	5	2	0
Were you considering Grad school before URAP?	2	3	2
Did URAP affect positively your decision to go to Grad School?	NA	11	4
Had URAP a major influence?	NA	7	1
Did URAP affect negatively your intention to go to Grad School?	2	NA	1

As shown in this Table seven participants thought that undergraduate research had a major influence in their decision to continue their studies and four participants felt that URAP affected their decision to some extent. Since one cannot always be successful with such programs there were two students who had originally considered graduate studies but they were turned off by their undergraduate research experience. The author takes the blame for this failure.

Although these results may not be considered statistically important by some readers, they do show a general trend in the development of a research-oriented attitude, which is conducive to advanced studies in chemical engineering or medical school. There is no doubt that in his three-year URAP experience the author has encountered the same problems of time and space (funding was generous) that Fricke reported in his contribution in this issue [6]. Undoubtedly the URAP system is not new, and it cannot be applied as a requirement for all students in schools with large enrollments, such as Purdue. However, the research performed was in many cases of high caliber (although perhaps of limited scope). The thirty seven participants in this program contributed a total of nine original papers for student contests (resulting in four regional and national AIChE and SPE awards), and a considerable number of manuscripts for presentations in regular scientific meetings of AIChE and SPE and original publications for refereed polymer and related journals.

Some final general comments and realizations from my URAP experience may be helpful to other educators as well. Undergraduate students are usually very enthusiastic researchers, sometimes more enthusiastic than many graduate students. Generally, they do not like to serve as "assistants" to graduate students but they prefer to work independently and under the immediate direction of a professor. Class scheduling may be difficult to handle, especially with purely experimental projects. A possible solution here (which has worked for our research group) is to let the students work any time they wish, including weekends and evenings.

Although the comments presented here refer to the students directed by this author, most other ChE faculty members at Purdue are equally active in undergraduate research. In a particular academic year anywhere from 35 to 60 undergraduates may conduct undergraduate research in a formal or informal way, representing about one third of a typical graduating class in chemical engineering at Purdue. □

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UNIVERSITY OF COLORADO

UNDERGRADUATE RESEARCH IN CHEMICAL ENGINEERING

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INTRODUCING UNDERGRADUATES to the excitement of research may be our most effective means of addressing the problem of the widening gap between supply and demand for chemical engineers with M.S. and Ph.D. degrees. This article, which reviews our efforts at the University of Colorado to promote an interest in undergraduate research, is organized as follows. First, I will discuss briefly each course at the University of Colorado which involves undergraduate research. I then will inject my personal philosophy concerning undergraduate research. In this latter section I will indicate how I attempt to motivate students to undertake an undergraduate-research project, various forums for disseminating the results of these projects, and finally, possible sources of funding for undergraduate research.

OPPORTUNITIES FOR UNDERGRADUATE RESEARCH

Research is defined as "careful search," or "a studious inquiry." In this context there are three courses in our chemical engineering curriculum at CU which involve undergraduate research. These are ChE 940, Undergraduate Independent Study; ChE 403, Chemical Engineering Laboratory; and ChE 322, Chemical Engineering Principles II. The nature of each of these courses will be discussed briefly here.

Undergraduate Independent Study is an optional course which can be used toward the 12 to