Journal of Vocational Behavior **15**, 107–117 (1979)

Student Self-selection for Specializations in Engineering

DAFNA IZRAELI, MOSHE KRAUSZ,[1] AND RIVKA GARBER

Tel-Aviv University

The general hypothesis that students self-selecting themselves for different occupational fields differ in relevant values and interests was tested for specializations within engineering. Industrial engineers were found to be different in work values and in their image of their subfield from students of other engineering specializations. The study concludes that in terms of type of student selecting engineering, the profession cannot be treated as an undifferentiated entity. It is suggested that in future research engineering students may be regarded as relatively homogenous with respect to work values only if their area of specialization is duly considered.

That people tend to self-select themselves for occupations which are compatible with their interests and values is a well-established premise in occupational choice theory. (Blau, Gustad, Jessor, Parnes, & Wilcox, 1956; Maslow, 1968; Roe, 1957; Strong, 1943; Super, 1957; Holland, 1966; Hall, 1976).

Underlying this "matching theory" of occupational choice is the empirically supported proposition that individuals differ in terms of some more or less coherent set of interests, needs, and values, and that occupations or occupational environments are distinguishable in the opportunities they provide for meeting them.

The self-selection premise has been found applicable to college students as well and has been used to explain their choice of academic specialization (Davis, 1965; Rosenberg, 1957). Following Super (1957), undergraduate transfers are often interpreted as a search for a better fit between the student's interests and personal orientation and his field of study (Southworth and Morningstar, 1970).

Studies of occupational choice among college students tend to treat

[1] The ordering of the first two names is based on alphabetical sequence.

The authors thank Professor Arie Shirom for helpful comments on an earlier draft.
Requests for reprints should be mailed to either of the first two authors at the Department of Labor Studies, Tel Aviv University, Tel Aviv, Israel

0001-8791/79/040107-11$02.00/0

engineering as a single entity; (two notable exceptions are Neal and King (1969) and Molnar and Delauretis (1973)). They fail to distinguish among engineering specializations, but rather compare the interests of students attracted to engineering as a whole with those of students in other fields. The purpose of this study is to test whether, based on the matching hypothesis, students within engineering can be distinguished in their interests and values, according to the subfields they select within engineering.

In a study of 18 college fields, Davis (1965, p. 189) found that values made the greatest independent contribution to explaining the choice of engineering. The distinguishing value characteristics of engineers most frequently cited are their preference for working with things over working with people (Davis, 1965; Harrison, Tromblen, & Jackson, 1955; Moore & Levy, 1951) and their being object oriented (Steiner, 1953). Rosenberg (1957) found that engineers ranked 17th from the top among 18 college fields in being "people-oriented."

This value orientation is consonant with that of the profession. By formal definition, "engineering knowledge does not include people," but rather "is concerned with physical forces and physical underlying science" (Maynard, 1963, p. 7). A review of the curricula of various engineering subfields reveals that they indeed deal rather exclusively with the world of things, with one exception—industrial engineering, which includes courses designed to enhance the student's understanding of human behavior.

As different from the other subfields, industrial engineering operates at the interface of people and things. It designs systems to be used by people and, therefore, "It draws upon specialized knowledge and skill in the mathematical, physical and social sciences . . ." (American Institute of Industrial Engineers n.d.).

Industrial engineering is related to working with people also through its association with managerial roles. While all branches of engineering may serve as a channel into line management, the link between industrial engineering and management is more institutionalized and direct. In some colleges the field is taught outside the engineering faculty in a special school of industrial management. In Israeli universities the subfield is entitled "Industrial Engineering and Industrial Management."

In view of this distinguishing characteristic of the industrial engineering subfield, namely its association with "people-work," it is relevant to ask whether students attracted to it differ in their interests and values from those drawn to the other specializations. In other words, the purpose of this study is to discover whether this differentiating quality of industrial engineering is associated with differences among students who choose the field when compared to those who select other engineering specializations.

The main hypothesis was that students of industrial engineering will differ, in ways relevant to their future managerial role, from students in other subfields. Compared to students in other specializations:

1. Industrial engineers (IE) will indicate a greater interest in working with people.
2. IE will indicate a lesser interest in working with things.
3. IE will view their specialization as offering greater opportunity for influence and authority.
4. IE will place greater importance on the opportunity to exert influence and authority.
5. IE will attach more importance to people-related professions and occupations in the organization.

METHOD

Sample

The sample consisted of two successive cohorts representing 70% of first-year students in the faculty of engineering at Tel Aviv University. One hundred twenty were from one cohort and 170 from the second, making a total of 290 students (283 males, 7 females). Of the total number, 138 were in the electrical engineering subfield (henceforth EE), 100 from mechanical engineering (ME), and 52 industrial engineering students (IE). These are the only three subfields taught in the Faculty of Engineering.

The intake criteria are uniform for all engineering specializations. These are based on some combination of scores from the standard university psychometric tests and high school grades with greater weight placed on mathematical and scientific subjects. The university exams test for ability and not for attitudes, values, or other personality variables. Prior to registration a faculty catalog is available in which the specializations are described. The description of industrial engineering makes specific reference to the field's association with management. No other preview is given to students to assist them in their selection of engineering specialization.

To obtain a self-selected sample, only those who were registered in the subfield they had indicated as their first priority when applying to the faculty were included. The final sample for which data are reported consisted of 266 respondents.

Tools and Procedures

Questionnaires were completed in classes within 2 months after the students had started their academic studies when all students were still in a common engineering program. They were distributed by persons unknown to the students who explained that the research was being conducted by a department in the Faculty of Social Sciences for the purpose of enhancing knowledge on engineering students. The questionnaire consisted of the following four parts.

Preferences for work with things and with people. Separate questions requested the respondents to rate their preference for working with things and working with people. Respondents used a five-step scale ranging from "To a very great extent" (= 1) to "To a very small extent" (= 5). The rationale for treating the items as two independent variables, rather than as a forced choice between opposing alternatives (as in Rosenberg, 1957) was the assumption that students may rank high (or low) on both preference for work with things and preference for work with people.

Image of the subfield. Subjects reported the image they held of their own subfield using a semantic-differential scale with 20 variables. The variables included were extent of autonomy, authority, influence, salary, practicality, interest, richness of content, thought demanding, satisfying, importance, prestige, creativity, diversity, opportunities for advancement, challenging opportunities for self-expression, and social contribution. Although our hypotheses anticipated differences only with regard to authority and influence, the other variables were included.

Importance of work characteristics. The same 20 characteristics were used to determine the relative importance of each for the students. Students were asked to indicate on a five-step scale, from "very high importance" to "very low importance" how important it was for them that their specialization have each of the above mentioned characteristics.

The relative importance of various occupations. The relative importance IE attribute to people-related occupations in the organization compared to students of other subfields, was investigated by the relative salary a respondent was willing to offer the incumbent in each of them. Subjects were requested to view themselves as owners of a newly built factory for which they had to hire personnel in nine different occupations presented in the following order: economist, industrial psychologist, industrial engineer, mechanical engineer, personnel manager, system analyst, safety engineer, training specialist, and marketing manager. The possible salary he was free to offer to each of those persons ranged from IL 2000 to IL 12,000 per month. At the time of the study IL 8.70 = $1.00. We expected that IE would offer higher salaries to occupations directly involved in utilizations and development of human resources, namely industrial psychologist, personnel manager, and training specialist, than would students in other subfields. In addition, students were requested to provide data concerning biographical background.

RESULTS

Since we could not assume a priori that EE and ME were homogenous relative to the variables we wished to test, the data for each subfield were analyzed separately. The discussion, however, focuses on differences between IE and the other subfields and no attempt is made to interpret those between ME and EE.

Preference for Working with People and Things

Separate Analysis of Variance tests were conducted for the two questions concerning preferences for working with people and things (Table 1).

Hypotheses 1 and 2 were confirmed. The subfields differed significantly on both tests. IE showed the lowest preference for working with things, and the highest for working with people. *t* tests for repeated measures compared the within-subfield differences for the two questions. Only one value was significant; IE students indicated a higher preference for working with people than with things. The trend for the other two subfields was in the opposite direction but the values were not significant.

Image of Subfield

For each of the 20 items, group means were computed and then compared by means of a multivariate analysis of variance (MANOVA). Table 2 presents the overall *F* from the MANOVA as well as the univariate *F* values for items showing significant differences.

The multivariate *F* value was highly significant. To identify the source of the overall difference MANOVA was run between each pair of subfields. The results are presented in Table 3. As seen in Table 3, the multivariate F values between each pair were significant. As expected, the univariate tests for influence and authority were significant. The post hoc comparisons (LSD tests, see Nie, Hull, Jenkins, Steinbrenner, & Bent, 1975) indicated that IE, compared to students in other subfields, viewed their specialization as providing more influence and authority. An unexpected finding was the IE viewed their subfield as being less clear than did the other groups.

TABLE 1
Mean Preference for Working with Things and with People in Three Subfields

	Subfield			
	EE (n = 76)[a]	ME (n = 52)	IE (n = 36)	F
Working with things	1.89[b]	1.73	2 47	8.149**
Working with people	2.14	1.84	1 72	3.485*
T value for written group difference	n.s.	n.s.	3 17**	

[a] Data were available for one cohort only.
[b] The smaller the number, the higher is the rated preference.
* $p < .05$
** $p < .01$.

TABLE 2
Means and F Values of sıgnıficant Differences of Subfield Image

	Means			
Item	EE	ME	IE	F
Authorıty	2.671[a]	2 702	2 183	6.088**
Influence	2.866	2 797	2.458	3 381*
Clarıty	2 385	2 260	2 771	4 664**
Dıversıty	1 696	2 020	1 734	4.396**
Autonomy	2 144	2.483	2.062	4 366**
Content Rıchness	1 544	1 854	1 562	4 929**
Fast Changing	1 474	2 159	2.246	17.567**
	Multıvariate F = 2 440**			

[a] The lower the numbers, the closer they are to the pole denotes a hıgh extent of the qualıty concerned For example, the lower the mean for "Authorıty" the closer ıt ıs to the poles that denotes "Provıdes opportunıty for much (rather than lıttle) authorıty " A high mean for "Fast Changing" ındicates a perceptıon that the "subfield ıs fast rather than slow ın changing "

* $p <$ 05.

** $p <$ 01.

The comparisons indicated that with respect to three other significant differences (4–6 in Table 2), IE and ME students perceived their respective subfield similarly but differently from EE students. These two groups viewed their subfields more as providing opportunities for autonomy, as being versatile and rich in content. EE students perceived their subfield more as being fast changing than did IE or ME students. This difference in perception may be explained by the rapid technological developments in the field of electronics.

Importance of Work Characteristics

MANOVA compared the overall means of the three subfields with regard to the importance of work characteristics. The F value ($F = 1.223$) was not significant. Three items reached significant univariate F values:

TABLE 3
Multıvarıate F Values and Sıgnificance Levels of MANOVA Tests for Each Part of Subfields, Concerning Image of Subfield

	Subfields		
	EE	ME	IE
EE	—	F = 3 142 p = 000	F = 2.587 p = .000
ME		—	F = 1.663 p = 05

authority ($F = 3.227$, $p < .04$), influence ($F = 2.819$, $p < .06$), and autonomy ($F = 2.935$, $p < .05$). In all three cases, IE students rated those work characteristics much higher in importance than did students of the other subfields. Thus Hypothesis 4 was confirmed. It should be pointed out that the range of mean importance of work characteristics within each subfield was small; students attributed high importance to most characteristics which would indicate that engineering students as a whole have high expectations from their future profession.

The Relative "Value" of Occupations

The relative "value" attributed to people-related occupations was analyzed along two dimensions: first by comparing the average salaries offered between subfields within each occupation, second by comparing the rank order of salaries offered among the subfields.

Table 4 presents the multivariate *F* value, the univariate *F*s, and the ranks. The multivarate *F* was significant. Since only two univariate *F* values were significant, pairwise comparisons of subfields were not conducted. Contrary to our hypothesis, IE did not offer significantly higher salaries to any of the three people-related occupations. Students of industrial engineering and those of mechanical engineering each assigned their own respective specialization a higher salary than did students of the other specializations. An electrical engineer was not included in the list of occupations.

The nine occupations were aggregated into three occupational groups: Engineering (Table 3, Nos. 1, 4, and 7); Business Management (Nos. 3, 8, and 9), and Human Resources (Nos. 2, 5, and 6). The engineering group was assigned the highest average salary, business management second, and that pertaining to personnel functions the lowest salary. Table 3 also presents the rank order of salary levels within each engineering subfield. It is clear that there was considerable agreement among the groups concerning the relative market value of each occupation. IE did not remunerate people-related occupations higher than did the other subfields and Hypothesis 5, therefore, was not confirmed by the data.

DISCUSSION

To date, most studies of differences among engineers according to field of work specialization have related to practicing engineers (Dunnette, 1957; Dunnette, Wernimont, & Abrahams, 1964; Webster, Win, & Oliver 1951). Neal and King (1969) looked at students in advanced years of study. It is not surprising that differences were found among categories of practicing engineers, since the self-selection hypothesis views the process of occupational choice as developmental. Self-knowledge and occupational information increase with age and experience, leading over time to improved fit between a person's interests and his occupation. The choice

TABLE 4
Mean Salaries (Israeli Pounds) Offered by Students of each Subfield to Nine Occupations

	Subfield						
Occupations	EE (73)[b]	σ	ME (35)	σ	IE (23)	σ	F
1. Industrial engineer[a]	6609(2 5)[b]	25.04	7320(2)	28.55	8739(1)	25.97	5864*
2 Personnel manager	5924(4)	24.97	6471(4)	27.59	6174(4)	18.07	
3. Operations researcher	5623(6)	17.55	6170(7)	29.56	6130(5)	20 24	
4. Safety engineer	5482(7)	20.69	6229(6)	25.17	5978(7)	19.45	
5. Industrial psychologist	4812(8)	21.79	5579(8)	26.63	4691(8)	20.77	
6. Training manager	4653(9)	16.29	5300(9)	25.64	4613(9)	14.55	
7. Mechanical engineer	6836(1)	24 11	8000(1)	26.60	7500(3)	23.01	2 716*
8. Marketing manager	6609(2 5)	25 77	7111(3)	26.12	7545(2)	22.57	
9. Economist	5801(5)	22.40	6279(5)	25.74	6043(6)	16.92	
		Multivariate F = 2.038**					

[a] The order of occupations is random and corresponds to their order of appearance in the questionnaire
[b] Numbers in parentheses indicate within subfield ranks of salary means. Where 1 is highest mean and 9 is the lowest.
* $P < .05$.
** $P < .01$

of a sample within 2 months after entry into the university reduces the likely effect of accumulated experience and information as well as of dissonance reduction on the data.

Successful self-selection can be problematic for the first-year student of engineering since it requires knowledge not only of the field as a whole but also of the relevant differences between subfields.

Engineering students must commit themselves to the profession early in their academic careers, even prior to arriving on campus (Perucci, 1969, p. 147). Only those with required background in mathematics and science are accepted. Furthermore the Faculty of Engineering requires students to define themselves in terms of one of the three professional specializations offered, prior to entry. Because of late exposure to the field such self-definition is more problematic for the Industrial engineers than for the other groups.

Relative late exposure occurs at two levels. First at the level of everyday life, youth have contact with electrical and electronic equipment as well as with a variety of machines making possible a general familiarity with the basic subject matter of these engineering specializations. This is not the case with industrial engineering, whose specialized concern is with such noneveryday activities as production planning and work measurement. This may be one reason why they view their field as being less clear than do the other subgroups.

Second, at the level of formal training, there are many more opportunities for studying electronics and machine technology in high school and later during compulsory army service than there are to study elements unique to industrial engineering. In our sample, 54.4% of the electrical engineers and 37% of the mechanical engineers had completed technical high schools, compared with 30.6% of the I.E. We found furthermore that in answer to the question "When did you decide to study your specific specialization in engineering?" IE made the decision later than did the other groups and the difference was statistically significant.

Despite these constraints there is remarkable stability in the initial decision to enter a specialization. The vast majority of dropouts from the faculty of engineering occur during the first year and these average only 2.5% per cohort. Approximately 5% of the first-year students request transfer to another subfield, with most transfers occuring between EE and IE equally in both directions. In other words, the choice of industrial engineering is clearly not arbitrary, a generalization supported by our data.

First IE do display basic knowledge of the special characteristics of their fields. Second, they differ in ways relevant to these characteristics, from students in other subfields. Leading as it does to a managerial career, industrial engineering involves a greater component of working with people and a smaller component of working with things, relative to the other two subfields which more often lead to staff positions in organizations. The rationale for IE viewing their specialization as having more authority and influence, however, is less obvious. Authority may be based on either expertise or on position in the hierarchy (Gouldner, 1954; Weber, 1947). We reasoned that IE would view their specialization as providing them with authority based on both professional expertise and hierarchical position, while the authority of the other groups is based primarily on expertise. We expected, therefore, that while all groups would view their respective fields as providing authority, IE would perceive theirs as providing more authority than would the other groups, which in fact they do. Similarly, managers, more than staff specialists, are responsible for policy making and implementation as well as for the allocation of organizational resources. They, therefore, have more influence over people. IE perceive their field more as influential. They also value both authority and influence more than the other groups.

Contrary to our expectations, IE did not attribute greater importance to occupations geared toward utilization of human resources, as measured by the relative salaries offered to them.

Assuming that salaries are a valid measure of relative value of contribution of an occupation to the organization, which admittedly it may not be, a possible interpretation is that IE have a basically engineering approach to human resources. That is, they assume that people, especially the lower participants in the organizations are passive elements in the system, whose compliance and cooperation are nonproblematic. It reflects the naive belief characteristic of the technological approach to management, that the logically better (cheaper, or more rational) solutions will get adopted and that human emotional resistance, with which industrial psychologists and trainers are qualified to deal, is not a serious barrier to policy implementation.

In conclusion, the findings of this study support the proposition that "engineers should not be lumped together into a single category" (Dunnette et al., 1964, p. 492).

Engineers do not form a homogenous category because engineering, like other professions, is not homogenous. It is rather, as Bucher and Strauss (1961) have suggested, "an amalgamation of segments," characterized by different objectives, activities, values, and interests, "more or less delicately held together under a common name, at a particular period in history" (Bucher & Strauss, p. 326). Such a perspective on professions has implications for the matching hypothesis of occupational choice. Instead of examining the characteristics of persons gravitating toward engineering, we should inquire into what types of persons select which types of engineering.

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Received: August 28, 1978