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Age, Education and the Technical Ladder

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INTRODUCTION

The effectiveness of the so-called "dual ladder" system has for many years been a subject of debate in both academic and industrial circles (Moore and Davies, 1977; Smith and Szabo, 1977; Sacco and Knopka, 1983). Earlier research by the present authors (Allen and Katz 1986; 1988) shows that, given a choice, scientists and engineers more frequently choose management or simply a career of interesting project assignments in preference to technical ladder promotions. Nevertheless, even in that study there was a strong minority (21.5 percent) who opted for the technical ladder career. Furthermore, this proportion remained fairly stable with age, increasing slightly for those in the 30 to 40 year age group but returning to about 20 percent after that.

A question naturally arises concerning the characteristics of those scientists and engineers, who indicate a preference for the technical ladder. Were they to show a consistent set of characteristics, knowledge of that fact could provide management with important guidance regarding the appropriate use of the dual ladder system for those types of people or situations. Two obvious possibilities that might influence career preference are the nature of the work conducted (i.e. its position along a spectrum from basic research to development to technical support) and the level of education attained by the scientists or engineers. Two hypotheses suggest themselves:

H1: The degree of preference for a technical ladder career will vary

systematically with the nature of the work performed by an individual scientist or engineer, viz., those performing basic research will exhibit a stronger preference than those engaged in applied research, development and technical support. Those doing applied research will show a stronger preference than those engaged in development or technical support, and so on.

H2: The degree of preference for a technical ladder career will vary systemically with the level of education of the individual engineer or scientist, viz., those with a PhD degree will exhibit a stronger preference than those with an Master of Science degree. Those with an M.S. will show a stronger preference than those with a Bachelor of Science.

RESEARCH METHOD

The data were collected in a study of about 2,500 scientists, engineers and managers in nine U.S. and two European organizations. The selection of participating organizations could not be randomized, but they were chosen to represent several distinct sectors and industries. Two of the organizations are government laboratories, one in the U.S. Department of Defense the other in the National Aeronautics and Space Administration. Three are not-for-profit firms doing most of their business with government agencies. The six remaining organizations are in private industry: two in aerospace, one in electronics two in the manufacture of industrial equipment and one in the food industry.

In each organization, short meetings were scheduled with the respondents, to solicit their voluntary cooperation and to explain the purposes of the study. Each scientist or engineer received an individually addressed questionnaire at this time. The questionnaire included the usual demographic questions plus several questions about the ways in which the respondent viewed his future career and the ways in which the organization structured its reward system around career factors. There are also several questions addressing the way in which engineers view their jobs and the importance that they attach to various features in their jobs. The present paper is developed around the central questions shown in Table I. These questions ask engineers the degree to which they would each of three alternative careers. They were asked to choose between progression on either the managerial or technical ladders or in lieu of these, the opportunity to engage in challenging and exciting projects irrespective of promotion[1].

Individuals were asked to complete their questionnaires as soon as possible. They were provided with stamped return envelopes so they could mail completed forms to the investigators directly. These procedures not only enhance data quality since respondents must commit their own time and effort but they also increase the response rate. The response rate across organizations was extremely high ranging from 82 percent to 96 percent. A total of 2,199 usable questionnaires was returned. Of these, 546 were from

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[1]Using questions and definitions developed by Pelz and Andrews (1976) and the National Science Foundation, individuals indicated how well the categories of research, development and technical support represented the activities, in which they were engaged.

managers. Since a minority of them stated a technical ladder preference, they are included in the analysis and the effect of managerial position is controlled statistically.

Table I

Format of the Principal Questions

To what extent would you like your career to be:

	not at all		somewhat				to a great extent
a) a progression up the technical professional ladder to a higher-level position?	1	2	3	4	5	6	7
b) a progression up the managerial ladder to a higher-level position?	1	2	3	4	5	6	7
c) the opportunity to engage in those challenging and exciting research activities and projects with which you are most interested, irrespective of promotion	1	2	3	4	5	6	7

RESULTS

A three-way analysis of variance was performed on the data, with nature of the work (basic research; applied research; development; technical support), education level (B.S., M.S., PhD) and position (manager or not)[2] as independent variables and the degree of technical ladder preference as the dependent variable. Since, in our earlier study (Allen & Katz, 1986), age was a significant factor influencing career orientation, it is used as a covariate in the analysis. Surprisingly, among this set of respondents, type of work does not affect the degree of technical ladder preference **(F=0.93; N.S.).** The first hypothesis is not supported by the data (Figure 1)[3]. Education level, on the other

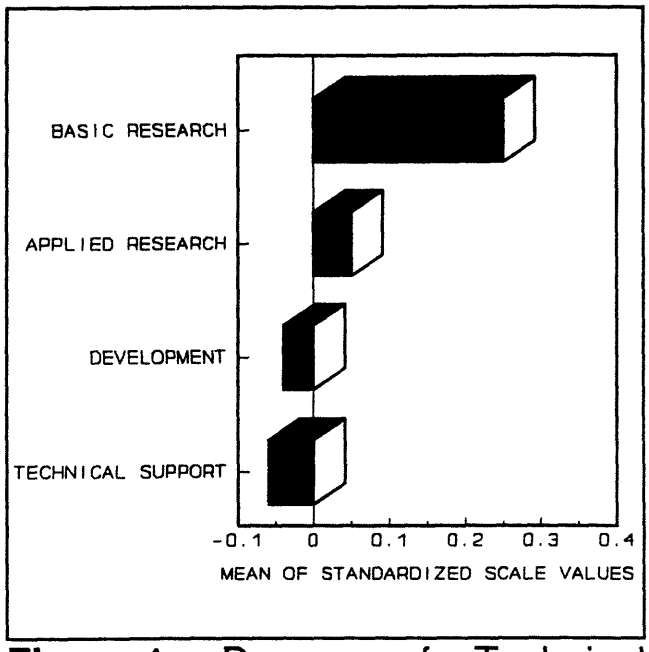

Figure 1. Degree of Technical Ladder Preference as a Function of the Nature of the Technical Work Performed.

[2] Managerial position was included as an independent variable to control for its effect, since it would be expected to influence attitudes toward the technical ladder.

[3]Although the means of the standardized preference scores of engineers in different types of technical work differ in the predicted direction, the differences do not reach statistical significance.

hand, has a significant effect ($F = 7.26$; $p < 0.001$), as does managerial position. As hypothesized, PhDs have a much stronger preference for the technical ladder than engineers without a doctorate. The effect of managerial position was expected (one would expect managers to be less interested in the technical ladder) and this variable is included as a control. It is also interesting that even among the managers education has an effect. While the average for all managers was below the population mean in desire for a technical ladder career, those managers with a PhD degree scored much higher (-0.03) than those without (-0.26) and were very close to the overall mean. There is no indication of significant interaction among any of three categorical variables. The effect of the covariate (Age) was not significant ($F = 3.37$; $p = 0.07$).

Other Differences Exhibited by Those with a Doctoral Degree

The analysis shows that the more education an individual has, the more likely that person is to choose or prefer a technical ladder career. This is particularly true of those with a PhD degree. This information should be very helpful to organizations, since it indicates what circumstances would justify the cost of a dual ladder system and

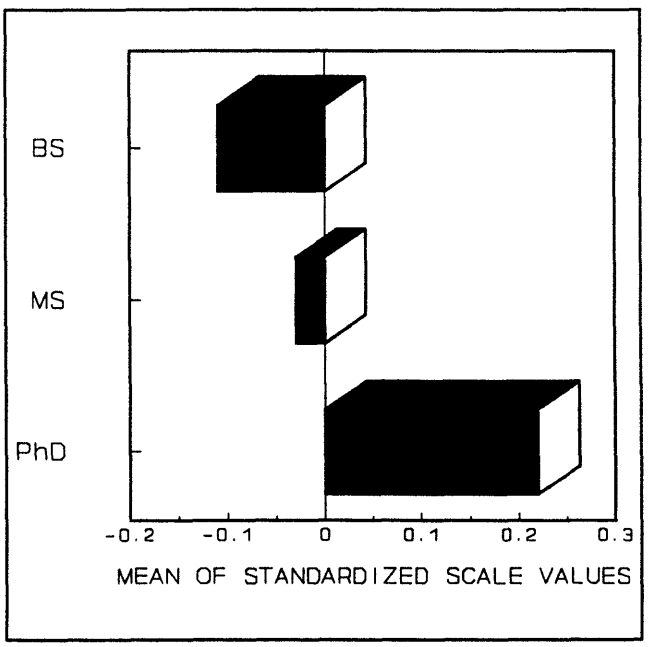

Figure 2. Degree of Preference for a Technical Ladder Career as a Function of Educational Level.

which people would feel more rewarded by promotion onto the technical ladder.

Since it is primarily those with a doctoral degree who fall into this class, it will be interesting to see in which other ways their motivations differ from those of their colleagues. If this were known, it could provide a deeper understanding of the reasons for choosing a technical ladder career and provide organizations with better guidance for its appropriate use.

One way of assessing an individual's work goals is to ask that individual for indicators of successful work outcomes. So the questionnaire includes a series of questions[4], which ask people to rate several possible outcomes on the degree to which, in their work, they would consider them measures of success (Table II). To simplify the analysis and reduce the number of variables, a factor analysis is performed on the responses to the questions, reducing them to two factors, one of which describes what one might consider academic/scientific measures of success, the other describing product-related commercial success (Table III).

[4]developed by Pelz and Andrews (1976).

Table II

Questions Relating to Success Measures

To what extent would each of the following experiences provide you with a sense of success or accomplishment?	Contributing to a product of high commercial success.
	Publishing a paper which adds significantly to the technical literature.
	Developing concrete answers or solutions to important technical problems.
	Developing new theoretical insights or solutions.
	Contributing to a product of distinctly superior technical quality.
	Coming up with a highly innovative idea or solution,

An ANOVA was then performed using educational attainment (i.e. PhD or non-PhD) as the independent variable and each of the two factor scores as dependent variables (Figure 3). Age was again controlled as a covariate. It is no surprise that those with a PhD degree attach importance to academic success criteria and are significantly less interested in commercial success. Adherence to success criteria, such as these, represent to some degree the way in which these individuals expect and want to be evaluated. Just who, the anticipated evaluators are is not

Table III

Factor Analysis of Questions Concerning Perceived Measures of Success

Question	Loading on Factor 1	Loading on Factor 2
Publishing a paper which adds significantly to the technical literature.	0.78	
Developing new theoretical insights or solutions.	0.83	
Developing concrete answers to important technical problems.	0.56	0.41
Contributing to a product of high commercial success.		0.79
Contributing to a product of distinctly superior technical quality.		0.79
Coming up with a highly innovative idea or solution.	0.60	

completely clear, nor does it matter. It is the internal self-evaluation that is important for our purposes. That these individuals evaluate themselves against particular external success criteria should provide insight into the nature of their career orientation and underlying value system. Those who are more inclined toward an academic career will measure their success according to appropriate criteria such as publication or theorizing (factor 1). Those inclined toward an industrial career will also choose appropriate criteria, in that case participating in the development of a successful product (factor 2).

It is clear from Figure 3, that educational level strongly influences the choice of success criterion. Those individuals with a PhD degree are much

more inclined toward the academic/scientific criteria and less toward the commercial/product-oriented criterion than are their colleagues who do not hold a doctoral degree. This is certainly understandable, although perhaps not desirable.

The long time which those with a PhD degree spend in graduate school allows a degree of socialization into academic values that apparently persists even after these individuals have worked in industry for quite some period. In a sense one might argue that occupational socialization for these people is much stronger than their organizational socialization.

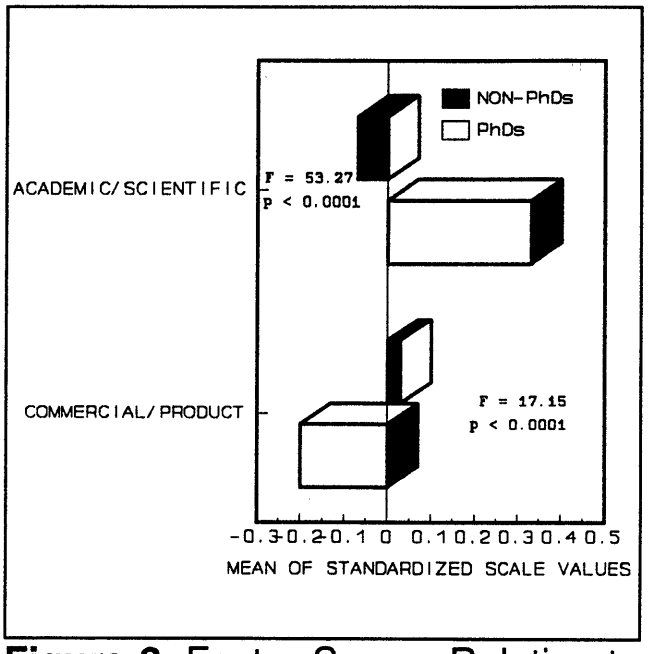

Figure 3. Factor Scores Relating to Success Criteria as a Function of Education.

Socialization and Re-Socialization

It should be interesting to see how long the effect of academic socialization persists. This can be examined by plotting the degree to which respondents cite, as a function of their age, the two types of success criteria. These plots are shown for those with a PhD degree in Figure 4 and for those without the PhD in Figure 5. It is startlingly clear from these figures that the effect of academic socialization is very persistent. It occurs for engineers and scientists, regardless of education level. They all enter industry with a much stronger orientation toward academic/scientific goals. For those without a

doctorate, however, the commercial/product goals gradually increase in importance becoming dominant at about the age of 30. This is a surprisingly long period of accommodation and would appear even more unusual, were it not for the situation among the PhDs, who appear never to reach a reasonable accommodation with industrial goals. Although the orientation toward commercial/product goals also increases in importance for those with a PhD, the magnitude of this success factor always falls below that for academic/scientific success. To be certain, once again, that it is educational level and its concomitant socialization process that causes the effects shown in Figure 5, the same data can be plotted after separating people on the type of work that they are doing. The four types of work, which were considered earlier in the paper will, for simplification, be aggregated into two. Basic and applied research are grouped together as research (Figures 6 and 7). Development and technical support form the second grouping (Figures 8 and 9). Separated in this manner, the plots are not very different

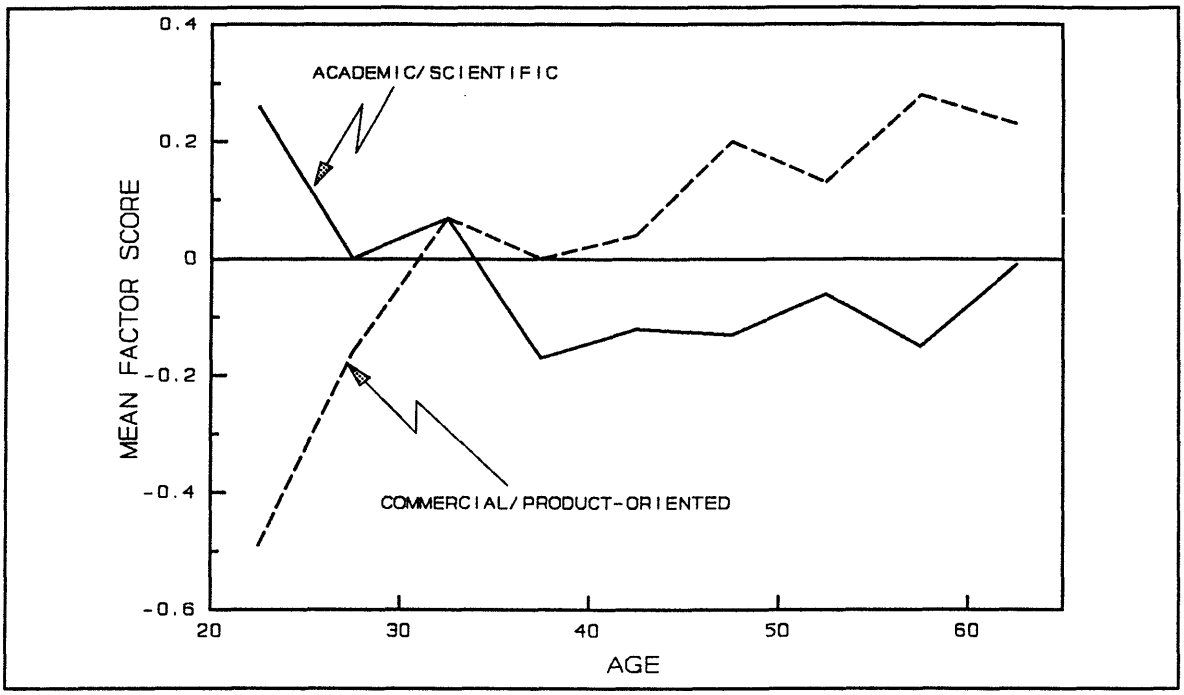

Figure 4. Success Criteria as a Function of Age for Non- PhD Engineers and Scientists.

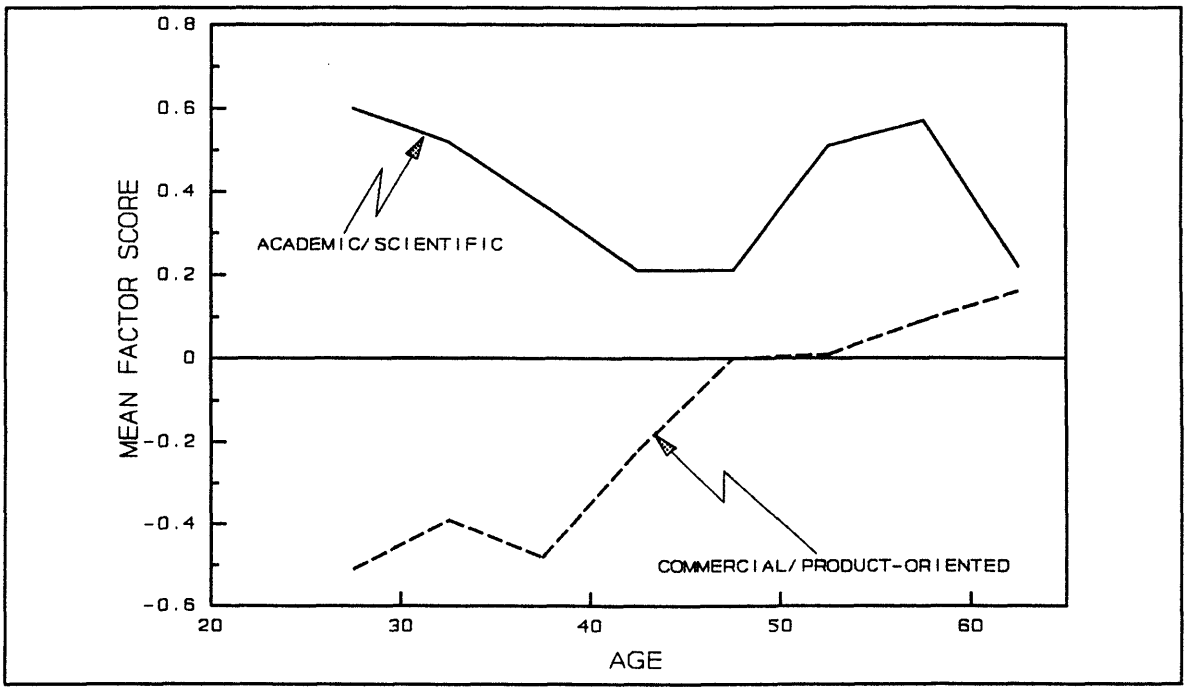

Figure 5. Success Criteria as a Function of Age for PhD Engineers and Scientists.

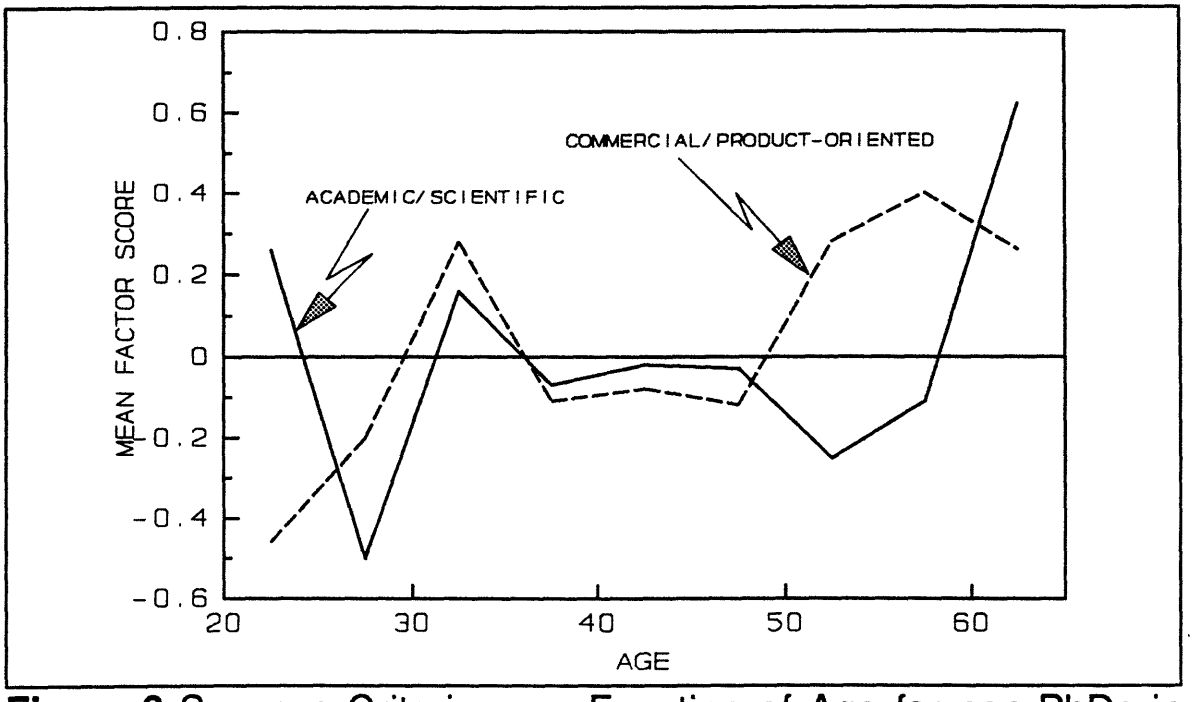

Figure 6 Success Criteria as a Function of Age for non-PhDs in Research.

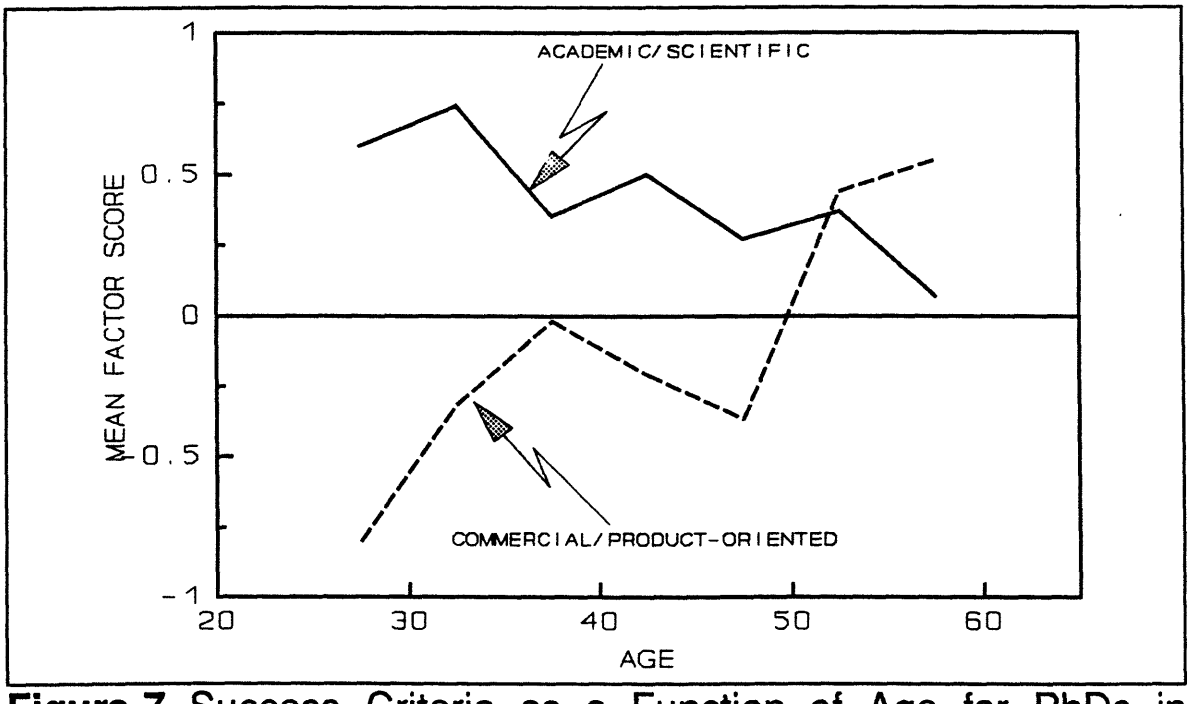

Figure 7 Success Criteria as a Function of Age for PhDs in Research.

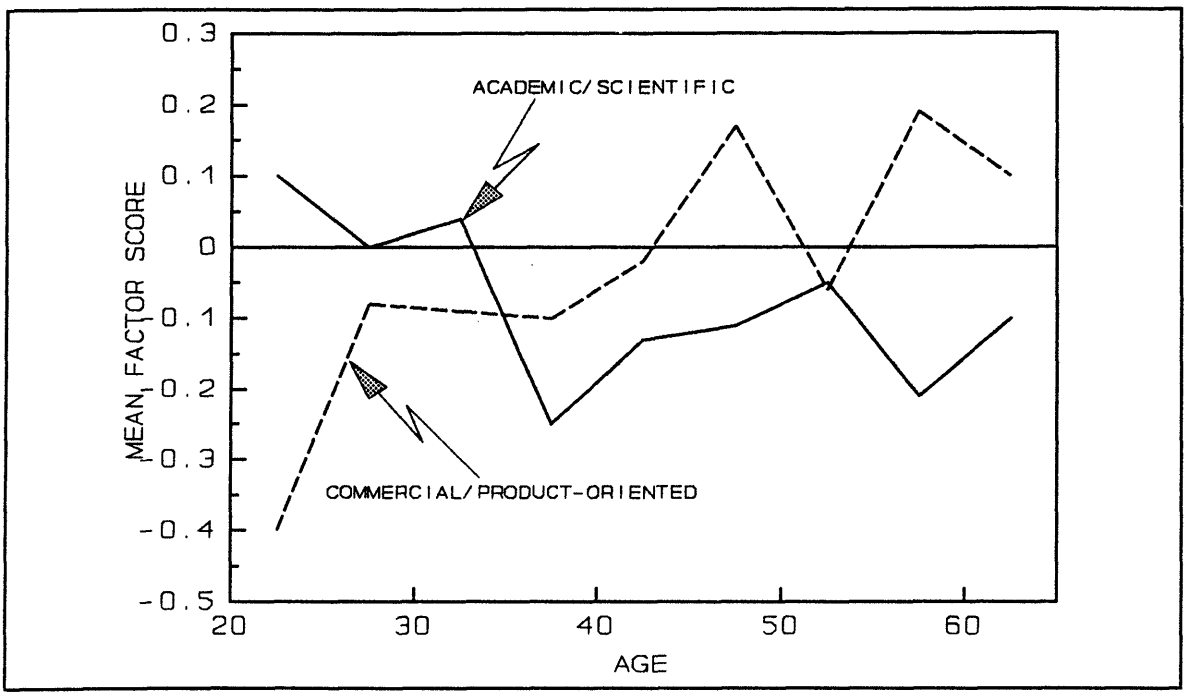

Figure 8 Success Criteria as a Function of Age for non-PhDs in Development and Technical Support.

from those seen in Figures 4 and 5. Those without a PhD degree begin their industrial careers with a stronger academic than commercial orientation. After a few years of experience, they shift and become more commercially oriented. The PhDs, begin similarly but never lose their academic orientation. Deep into their industrial careers, they are still concerned about academic success measures. This phenomenon appears for those with a PhD degree whether they are working in research or in development or technical support.

The only modest exception to the general pattern is that of the non-PhDs in research. Non-PhDs in research are generally treated as little more than technicians. The PhDs, for whom they work, usually receive all of the recognition for any successes that come out of their laboratory.

Consequently, the non-PhDs are less satisfied and probably have great difficulty deciding what the appropriate measure of their success is.

Relationship to Technical Ladder Preference.

To investigate further the interrelationships between educational attainment and perceptions of success, a two-way ANOVA was performed on preference for a technical ladder career, with education and success factors as independent variables. Although both effects are significant, the effect of education is greater (Figure 10). What is more important, the standardized means clearly indicate that it is the combination of a PhD degree and an academic/scientific orientation toward success that produces the strongest preference for the technical ladder. Non-PhDs with a commercial/product

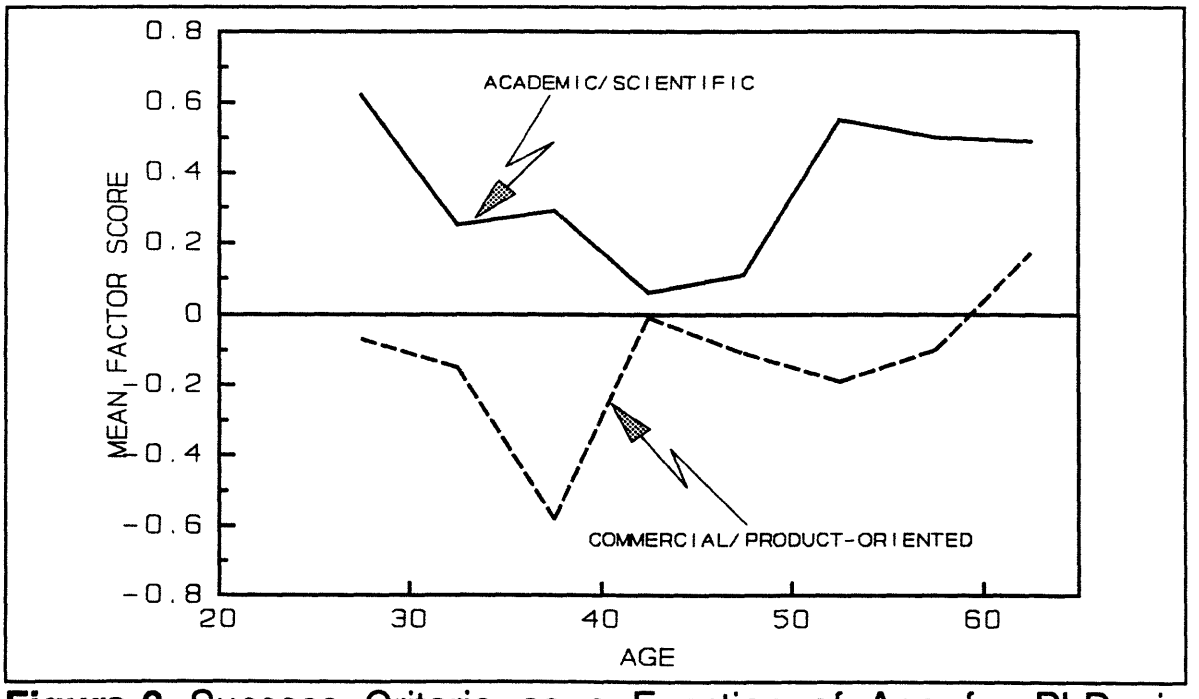

Figure 9 Success Criteria as a Function of Age for PhDs in Development and Technical Support.

orientation have the lowest preference. It is also important to note that PhDs with a commercial/product orientation and non-PhDs with an academic/scientific orientation respond in a similar fashion concerning their preference for the technical ladder. Both are very close to the overall mean (zero, since the data were standardized).

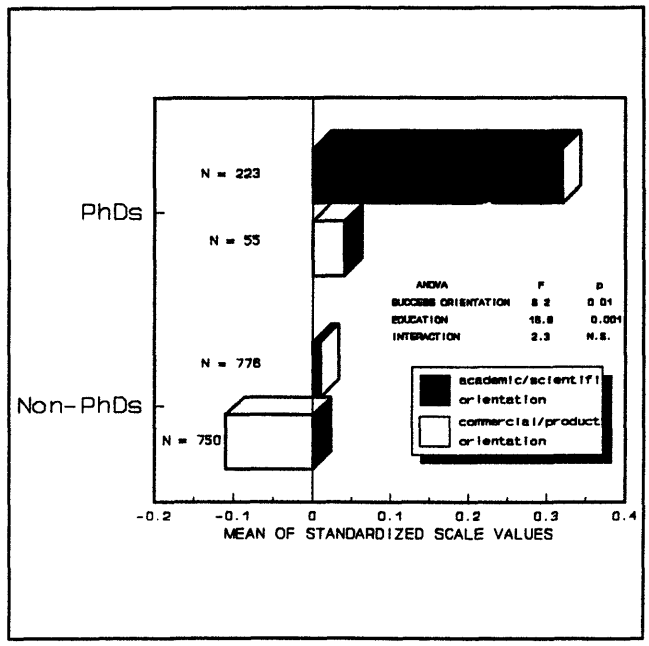

Figure 10 Preference for Technical Ladder as a Function of Education and Criteria for Success.

If, in fact, the population groupings differ sharply in how they view the technical ladder, then it is important to know if they differ greatly in other work-related ways. Toward this end, a series of questions, previously used and described by Pelz and Andrews (1976) were included in the study. These questions measure respondents' perceptions of important work-related opportunities and problem-solving approaches. The standardized mean responses to these items for the two extreme[5] subgroups are shown in Table IV. Not only do these subgroups differ sharply in their preference for the technical ladder, but they also differ significantly in the way in which they relate to their work

[5]PhDs with an academic/scientific vision of success and non-PhDs with a commercial/product vision of success.

environments[6]. Those who most prefer the technical ladder also prefer to work more conceptually and in greater depth on problems that are more important to their professional disciplines. In contrast, those who least prefer the technical ladder least, want to work on more immediate solutions to problems, that are more relevant to the organization. Similarly, those preferring the technical ladder also value freedom and independence and prefer to work less collaboratively[7]. The groups did not differ on their need to work on challenging tasks or with competent colleagues.

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[6]The items are listed in Table IV by the magnitude of the disparities between the two groupings, not in the order in which they appeared in the questionnaire.

[7]Interestingly enough, for each of the items, the mean standardized responses for the non-congruent (i.e. commercial/product PhDs and academic/scientific non-PhDs) groupings fell within the ranges reported in Table IV and were not significantly different from the overall population means.

Table IV

Contrasting Perceptions of Work-Related Issues

Work Opportunities and Problem Solving Approaches	Means of Standardized Scores for: PhDs with Academic/Scientific Orientation	Non-PhDs with Commercial/product Orientation	Difference
Preference for working toward immediate concrete solutions	-0.36	0.23	0.59*
Importance of working on organizationally significant tasks	-0.19	0.27	0.46*
Preference for working in collaboration with others	-0.24	0.16	0.40*
Importance of working on difficult and challenging assignments	0.04	0.08	0.04
Importance of working with technically competent colleagues	0.11	0.01	-0.10
Importance of pursuing one's own ideas	0.15	-0.06	-0.21*
Importance of having freedom to be creative	0.20	-0.18	-0.38*
Importance of working on professionally significant tasks	0.27	-0.12	-0.39*
Preference for deep probing of narrow areas	0.32	-0.17	-0.49*
Preference for working with general established principles	0.37	-0.14	-0.51

*$p < 0.001$

DISCUSSION

Companies recruit engineers and scientists with a PhD degree for their degree of education and for their demonstrated intelligence and perseverance, having survived a long and sometimes arduous educational career. They are also frequently recruited for their independence of thought. To the degree that this latter goal exists, industry may be getting more than they bargained for. Few firms can truly afford to support employees whose principal goals are publishing and theory development. Even in industry these may be fine as secondary goals. But the primary goal must be developing products that will allow the company to remain in business. Those without a doctoral degree are much quicker to see this. They begin their careers with a similar academic orientation, but after a few years they re-orient themselves appropriately and become more commercially oriented. A real danger exists in that the PhDs are much more likely to be promoted onto the technical ladder. They will have their academic values therefore reinforced and never become adequately socialized into the goals necessary to keep the firm in business. The PhDs, in our study, maintained a very strong academic and scientific orientation throughout their careers.

Education

If there were ever any doubt that the technical ladder reward system is better received by those educated to the level of the PhD the present research should certainly remove that doubt. Over the several years required to achieve a doctoral degree, students are very strongly socialized

into an academic system which has its own values and rewards. These are distinctly different from those of industry. The technical ladder reward system was originally designed to be more aligned with that view of the world. It attempts to emulate the academic reward system, based on a belief in the importance of peer recognition for technical professionals. Those with a PhD degree prefer it because they have been thoroughly steeped in the academic value system. Those without the PhD degree, in contrast are not as thoroughly socialized into the academic system. The technical ladder consequently does not have the same appeal or value in their eyes. The failure to recognize this fact has led to many problems in implementing the dual ladder system. It has also led to frustration on the part of personnel officers who cannot understand why so many engineers fail to see the wonderful benefits of their technical ladder.

About 80 percent of the 278 PhDs in our sample had a stronger academic/scientific focus than a commercial/product one. Based on the results of our study, it is these individuals who are especially likely to opt for technical ladder careers. It is important to recognize that this group of individuals differs from their organizational counterparts in many other important ways particularly with respect to work-related goals and problem-solving approaches. The establishment of two formal parallel career ladders creates added differentiation within the organization (Lawrence and Lorsch, 1967). If the two ladders are also staffed with individuals who are significantly different from each other not only in terms of educational background but also in terms of values, attitudes, and work-related preferences, then the organization runs the risk of differentiating itself even

more.

One of the more important forces affecting interaction patterns within organizations is the tendency for individuals to communicate more frequently with those who are most like themselves and whose ideas and viewpoints are most likely to agree with their own interest and perspectives (Katz and Allen, 1982). Based on this notion of selective exposure and the strong differences emerging from our dual ladder study, it is not surprising that communication between technical and managerial groups may be severely strained. Promotional dynamics may even be exacerbating this problem. Prior research by Katz and Tushman (1983) showed that individuals promoted on the technical ladder communicate less often and are significantly more isolated from organizational peers than those promoted to management. The results of our study indicate that organizations may be compounding this problem by promoting to the technical side individuals who not only have weaker communication ties to begin with but who also claim "they cannot do their best work in collaboration with others". They prefer, instead, the freedom to work independently and pursue their own ideas. Clearly, organizations need to build forces for integration that compensate for the structural and staffing differentiation that accompanies the dual ladder. Without establishing strong bridging mechanisms (Roberts, 1979) to overcome the problems of coordination and communication, those on the technical ladder are likely to become decoupled from the rest of the organization.

CONCLUSIONS

Although the PhDs, through their longer and more intense exposure, are more thoroughly indoctrinated in the academic values, all young people coming through the university system are to some degree affected. The views expressed by the younger people in the present sample show this. They feel that publication, theory building and specialization are important. This culminates, after a few years on the job in an attraction toward a technical ladder career. Shortly after that, however, reality begins to set in. They begin to understand that industry needs management as much as technology; that theories and publications don't put bread on the table and that commercially important projects are not necessarily those of the greatest scientific interest. This awakening occurs in the early to mid-thirties and results in a pronounced shift away from the technical ladder and increased interest in management. The initial state is found both among the research PhDs who are most interested in the technical ladder and among the other engineers and scientists not so predisposed. The degree to which the two groups adapt as time goes on differs considerably, however. Over time, the strength of the commercial focus among the non-PhDs greatly exceeds the strength of their academic interests. Although the commercial focus of PhDs also increases over time, it is always exceeded by their concern for academic and scientific success.

While many alternative personality and situational explanations could account for this strong difference, one possibility lies in the organizational experiences of the two groups. Perhaps through the nature of their work

assignments, their reporting relationships, or even the location of their offices, non-PhDs become more socialized into the value system of the organization and its management. The organizational socialization encounters and interactions of PhDs, on the other hand, may be very different. Perhaps they are given more independent activities, or research tasks that require little interaction, or they are co-located with each other, or they are assigned only to supervisors with similar academic values. Whatever the reasons, it may be that the organizational socialization experiences of these individuals are very different from their less highly educated colleagues.

Since whatever happens during organizational socialization dramatically affects one's performance, career, communication networks, and overall perspective, future research is clearly needed to understand and compare the organizational socialization process for engineers and scientists from differing backgrounds and educational environments. If the dual ladder is to work effectively, in organizations, we must learn how to better organize and structure the early experiences of engineers and scientists to create better working relationships between those promoted technically and managerially, rather than estranging them from each other.

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