DOCUMENT RESUME

ED 219 239 SE 038 291

AUTHOR	Harrell, Daniel E.; Gibbs, Rebecca F.
TITLE	Continuing Education for Scientists and Engineers: Delivery Systems in North Carolina.
INSTITUTION	North Carolina State Univ., Raleigh. School of Engineering.
SPONS AGENCY	National Science Foundation, Washington, D.C. Directorate for Science Education.
PUB DATE	Jun 81
GRANT	NSF/SED-81003; SEDR-78-21865
NOTE	189p.
EDRS PRICE	MF01/PC08 Plus Postage.
DESCRIPTORS	*College Science; *Delivery Systems; Employee Attitudes; Employer Attitudes; *Engineering Education; *Engineers; Higher Education; Industry; Interviews; *Professional Continuing Education; Professional Development; School Business Relationship; Science Education; *Scientists
IDENTIFIERS	National Science Foundation; *North Carolina; Science Education Research

ABSTRACT

Focusing on the continuing education (CE) of scientists/engineers in North Carolina working in small (1-500 employees), geographically dispersed companies, this study: 1) identified and described CE resources currently being used by scientists/engineers to maintain and extend their professional competence and capabilities; 2) determined the extent of use and the perceived effectiveness of these education resources in meeting CE needs of scientists/engineers; and 3) identified deficit CE needs of scientists/engineers and the preferred delivery systems. Scientists/engineers (N=480) and managers (N=61) were interviewed using instruments developed for the study (included in an appendix). Results are reported under the following headings for 1) scientist/engineer data: description of scientist/engineer participants, participation in structured and unstructured educational resources, personal evaluation of current knowledge in field, objectives for participating in CE, impact of CE on professional growth, preference rating on delivery systems, employee perceptions of employer attitudes, and requested courses and preferred delivery systems; and 2) management official data: description of participating companies, use/support/effectiveness of structured and unstructured educational resources, recognition/reward for participation and annual expenditures for scientist/engineer CE, employer perceptions of scientists'/engineers' objectives for CE, and requested courses and preferred delivery systems. Results, conclusions, recommendations, supporting documentation (statistical tables) and list of desired courses are included. (Author/SK)

NSF/SED-81003

DELIVERY SYSTEMS IN NORTH CAROLINA

NORTH CAROLINA STATE UNIVERSITY
SCHOOL OF ENGINEERING
INDUSTRIAL EXTENSION SERVICE

CONTINUING EDUCATION FOR ENGINEERS AND SCIENTISTS: DELIVERY SYSTEMS IN NORTH CAROLINA

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The material presented in this report is based upon research supported by the National Science Foundation under Contract No. SEDR78-21865. Any opinions, findings, conclusions, or recommendations expressed in this report are those of the authors and do not necessarily reflect the views of the National Science Foundation or individuals or company representatives who provided information and assistance for it.

June, 1981

ACKNOWLEDGMENTS

The preparation of this document would have been impossible without support and assistance throughout its conduct.

The Division of Science Education Development and Research, Directorate for Science Education, National Science Foundation, sponsored the study under contract No. SEDR78-21865. Dr. Lyle Phillips and Dr. Gene D'Amour of the National Science Foundation provided guidance during the course of the project.

Dr. Art Eckles, professor of Electrical Engineering, North Carolina State University, assisted in the preparation of the proposal.

The faculty and staff of the School of Engineering, North Carolina State University, were very helpful in the collection of data. Our interviewers included Professor Norman Bell, Electrical Engineering; Instructor Tom Culbreth, Industrial Engineering; Stu Coward, Dick McCormack, and Bill Simpson, Extension Specialists.

We owe much to two graduate students who provided expertise from their specific fields. Steve Kuekes wrote the computer programs needed to analyze the raw data collected. Statistical verification of the analyses was supplied by Nick Fountis.

Many thanks to Lynn Kaufman, Mara Frost, and Maggie Clark for their unending patience in typing draft after draft, chart after chart.

Finally, we appreciate and are thankful for the willingness of engineers, scientists, and managers in small industries throughout North Carolina to take the time to talk with us personally.

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INTRODUCTION

"Half of everything a well-educated engineer knows today will be obsolete in a few years," says Donald E. Scott, director of the videotape instruction program in electrical and computer engineering at the University of Massachusetts at Amherst.[1] Both statistics and industry operation attest to the validity of this statement, making participation in continuing education (CE) a necessity for engineers and scientists wanting to avoid the scrap heap of technical obsolescence.

The role of continuing education in the engineer's/scientist's career development is extremely significant. According to David L. Leaman, Education Director for the American Society for Quality Control, CE provides more than up-to-date technology. He contends that, "aside from actual knowledge gained from meaningful learning experiences, such efforts show to peers and superiors an initiative, a self start, that speaks well for promotion and salary improvement."[2] In industry, where job performance is the key to promotion, there are correlations between continuing education and career success. National Longitudinal Surveys of Ohio State University Center for Human Resource Research (Paines, 1976) did an impact study of occupationally related continuing education on career development. The survey data provided abundant evidence that adults who participated in continuing education experienced greater career success (i.e., more responsibility, greater compensation) than adults with similar levels of education and age who did not.[3]

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[1] D. E. Scott, "Get a Master's Degree on the Job," Audiovisual Instructor 24 (November 1979):16.

[2] David L. Leaman, "Continuing Professional Development: The Ultimate Engineering Investment," Professional Engineer 49 (October 1979):35.

[3] Alan B. Knox, Assessing the Impact of Continuing Education (San Francisco: Jossey-Bass, Inc., Publishers, 1979), p. 16.

With such benefits of continuing education established, it is easily understood why participation in continuing education would be on the uprise.[4] Another secondary incentive for participation is that it tends to mix theory with practice, giving it an edge on full-time programs tending only to teach theory.[5] It's pragmatic. Instruction can be honed to meet the specific needs of any particular industry.

One might well ask, "If personal gain is to be had by those involving themselves in continuing education, why do so many engineers and scientists abstain?" A survey conducted by the College Industry Education Conference in Tampa on New York State showed that 85 percent of the registered professional engineers up for relicensure had participated in no formal continuing education during that previous three year span.[6] This hesitancy of engineers to involve themselves in continuing education is confirmed by authorities in the field. "You have to force engineers to take courses," says Dr. Joseph Biedenbach, chairman of IEEE's continuing education committee. "They won't if you don't use some kind of stick."[7]

The paradox between personal gain and participation is yet unanswered. Little is known about the engineer/scientist and his/her attitudes toward continuing education. Still less is known about the rural based engineer, working and living outside SMSA counties. What are the needs of those engineers/scientists who do not have the resources normally found in metropolitan areas available to them? This stud will focus in on the special situation of engineers and

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4 A Special Report to the President and to the Congress of the United States, National Advisory Council on Extension and Continuing Education (September 30, 1979), p. 37.

5 John P. Klus and Judy A. Jones, "Continuing Education Around the World," IEEE (1978):957.

6 David L. Leaman, "Continuing Professional Development: The Ultimate Engineering Investment," Professional Engineer 49 (Oct. 1979):34 (Reprint UMI).

7 C. Paton, "Challenge of Keeping Current," IEEE Spectrum 16 (August 1979): 53.

scientists working in geographically dispersed companies and provide data on:

- the profile of the engineer/scientist who participates in continuing education;
- motivations for participation; and
- the preferred delivery systems for participation.

This data should be of value to educators and industry alike as they plan development programs for engineers and scientists and endeavor to motivate them toward participation.

PROJECT OBJECTIVES

The principal objectives of this study of continuing education (CE) delivery systems were:

- To identify and describe continuing education resources currently being utilized by engineers and scientists to maintain and extend their professional competence and capabilities.

- To determine the extent of use and the perceived effectiveness of these educational resources in meeting CE needs of engineers and scientists.

- To identify deficit CE needs of engineers and scientists and the preferred delivery systems.

In particular, this study focused upon the continuing education of engineers and scientists in North Carolina working in relatively small, geographically dispersed companies.

SCOPE

This study, as originally proposed, would have concentrated solely on engineers and scientists; however, two important meetings of project directors having similar projects yielded valuable additions and a set of unified definitions designed to permit some correlation of data and results between the different studies. The North Carolina study was expanded to include the concurrent collection and evaluation of information from management officials relating to their companies' participation, encouragement, and support of continuing education activities for their engineers and scientists.

For the study, engineers and scientists were defined as employees who hold at least a bachelor's degree in an engineering or scientific field, or who are equally qualified as engineers or scientists in some other way, such as by experience or competent performance of engineering or scientific duties. They must also spend more than half their time in any of the following job functions:

- Research
- Development
- Testing and Evaluation
- Design
- Construction
- Inspection
- Production
- Installation
- Operation
- Maintenance
- Planning
- Contract and Grant Administration
- Data Collection
- Providing or Researching of Scientific or Technical Information
- Enforcement of Standards or Regulations
- Other Engineering or Scientific Activities

Specifically excluded were engineers and scientists who spend more than half their time in management, sales, advertising, personnel work, teaching and training, or providing medical, psychological, or social services.

To focus on engineers and scientists working for small, geographically dispersed companies, the study was limited to firms employing 500 persons or fewer at a single physical location in non-SMSA (Standard Metropolitan Statistical Area) counties in North Carolina. In addition, the study excluded those non-SMSA counties having a college or university granting four year or higher engineering and/or scientific degrees.

Engineers/scientists were asked to include all continuing education (CE) activities in which they participated during the last year or last three years. Management officials were asked to report all activities conducted or supported during that same time frame, but fiscal periods could be used if more convenient. Managers were also asked to count each distinct activity only once. If the same activity was conducted at three different times, or for three different groups of participants, it was counted as only one activity.

The types of continuing education to be reported fell into two basic categories, structured and unstructured. Structured activities include:

- college credit courses, graduate or undergraduate, held in college or university facilities
- college credit courses, graduate or undergraduate, using videobased instruction, usually held in off-campus facilities
- worksho , short courses, seminars, etc., usually non-credit and sponsored and conducted by universities, professional societies, and/or private organizations, usually not held in-company
- in-company courses taught by non-employees
- in-company courses taught by employees
- broadcast educational television courses
- packaged media courses with instruction on film or videotape accompanied by student study and exercise manuals
- programmed instruction courses
- correspondence courses

Unstructured activities include:

- self-study of textbooks, technical journals, etc.
- technical consultation with colleagues within your company
- technical consultation with colleagues outside of company
- technical society meetings
- special supervised technical projects

METHODOLOGY

To collect the data needed from working engineers/scientists and management officials, it was necessary to develop, test, and refine a survey instrument; select the sample to be surveyed; and collect the data.

SURVEY INSTRUMENT

The project directors and other representatives of the five organizations doing parallel research met with the NSF project monitor on two occasions to discuss project objectives, definition of terms, strategies, and methodology. The intent was for each project director to proceed, where possible, in a way that would permit some comparison and correlation of the results of the five individual studies.

As a result of those meetings, general agreement was reached regarding the common types of information to be collected from engineers and scientists, although the composition of the actual questions was left to each organization. It was agreed that information and data collected would include:

- educational and professional profile of the engineer/scientist
- the amount and type of participation in continuing education, as well as the type of organizational support received
- objectives for participation in continuing education and the degree to which those objectives have been met
- preferred delivery systems for participation
- perception of employer attitudes toward continuing education

While the North Carolina State University (NCSU) proposed study had not included the collection and evaluation of information from management officials relating to their companies' support of continuing education for engineer/scientist employees, this dimension was added by the project director. It was generally agreed that information collected from management officials would include:

- organizational profile
- the amounts and types of continuing education supported by the industry
- the incentives given for participation
- expenditures on continuing education
- perception of employees' objectives for participation in continuing education

The instruments went through several field tests, and areas of ambiguity were noted by the researcher conducting the interviews. Several questions were reworded and data collection tables clarified in the endeavor to get the right information, and at the same time ask questions that the organizations and individuals would be inclined to answer. Participants were assured of anonymity and that the collected information would be consolidated and published in aggregate form only.

SAMPLE SELECTION

The original plan was to do a random sampling in order to obtain an unbiased sample with the greatest possible design efficiency. Lists were compiled from the 1979-1980 Directory of North Carolina Manufacturing Firms and cross-referenced with computerized listings of engineers and companies employing engineers and scientists across the state. Following this process, the number of engineers and scientists that would need to participate in each county to yield a broad spectrum of the continuing education (CE) needs in the state and to reach the goal of 450 participating engineers was established.

It was found very early in conduction of the study, however, that it was necessary to contact the entire listing of manufacturers in order to obtain the desired number of participants. This was not altogether surprising, recognizing the project limitations on size of company and restriction from interviewing engineers and scientists in SMSA counties, where continuing education opportunities are generally plentiful. In addition, we interviewed a maximum of five engineers/scientists at a particular plant location to avoid biasing the sample. The difficulty in locating qualified survey participants suggests that the sample was actually a large percentage of the total population.

SURVEY CONDUCTION

The "interview" method of survey conduction was chosen because it offered several distinct advantages, both direct and indirect, over other approaches such as a mailed questionnaire or a conference of continuing education consumers. Its use allowed the collection of both very accurate unbiased data as well as anecdotal information about continuing education. Also, while the return of less than 20 percent could be expected from a mailed questionnaire, virtually every interview scheduled was completed. This gave a very unbiased sample, whereas a low return rate from a questionnaire may have constituted a bias toward continuing education, assuming that participants already in CE programs would be more motivated to complete and return the questionnaires.

One other advantage of the interview besides the collection of more and better information is that it enabled the academic faculty (interviewers) to interface with their industrial counterparts. These face-to-face meetings provided numerous opportunities for faculty interviewers to gain a better understanding of the industrial environment and its CE needs.

Managers of qualified firms were called and asked if they had any engineering or scientific personnel in their employment. If the answer was affirmative, the telephone interviewer then stated the objectives of the study and asked for an appointment to interview them and a management official. As already noted, no more than five engineers or scientists from one plant site were interviewed, to avoid biasing the results. If a company employed more than five qualified engineers/scientists, then five were randomly selected. It was found that, by using this method of setting up interviews, the companies and organizations contacted were most cooperative, and very few who employed engineers and/or scientists declined formal interviews.

Interviewers were alert to the definition of the titles "engineer" and "scientist" as used by industry. Often, upon arriving for the interview, it was discovered that the person titled "engineer" was really a technologist or technician, i.e., a person operating in some capacity other than that defined by this study as an "engineer" or "scientist." At the same time, every interviewer was alert to special situations where an individual, by his own initiative, may have acquired knowledge through self-education and work experience, enabling him/her to function as an engineer or scientist. People who did not meet the stated definition of engineer or scientist and, in the opinion of the interviewer, had not attained the inherent technical skills necessary to perform accordingly were dropped into a sub-category of technologist/technician and will be addressed in Appendix D of this report.

In total, 480 engineers/scientists and 61 managers were interviewed. A management official was not necessarily interviewed at every company where engineers were interviewed.

PROJECT RESULTS

ANALYSIS OF ENGINEER/SCIENTIST DATA

Analysis of the individual sets of data for the engineer/scientist and management official groups will be followed by a comparison or cross-analysis of data, where possible, between the two.

Description of Engineer/Scientist Participants. Information was collected from a total of 480 engineers and scientists during face-to-face interviews. The survey forms used in collecting the data are presented in Appendix A. All participants were from small industrial and consulting engineering organizations located in non-SMSA counties in North Carolina. Table 1 presents a breakdown of the standard industrial classifications represented and the percentage of participants from each industry. Survey participants were from eighteen (18) different industry classifications with 56 percent coming from four -- textile, chemical, machinery (except electrical), and electrical machinery.

In limiting the study to organizations employing 500 or fewer persons, organizations employing 1 to 166 persons were designated as S1, 167 to 333 persons as S2, and 334 to 500 persons as S3. The participants were evenly distributed throughout all three categories, with 31.7 percent responding from S1 companies, 33.7 percent from S2 companies, and 34.6 percent from S3 companies.

Most of the participants were employed for more than four years by the same company, with the more experienced ones concentrated in the smallest companies (designated S1). Refer to Appendix Table B-1. (Note: For future reference, designations such as B-1, C-1, etc., refer to tables in those respective appendices.) Table 2 shows the breakdown of participants by size of company and number of years employed.

TABLE 1. Distribution of Participants by Standard Industrial Classification

SIC code	Industry	Percentage of participants (N=480)
20	Food and kindred products	.6
22	Textile mill products	17.3
23	Apparel and finished products	3.8
24	Lumber and wood products	.8
25	Furniture and fixtures	7.5
26	Paper and allied products	2.7
28	Chemicals and allied products	12.9
29	Petroleum refining	.2
30	Rubber and miscellaneous plastic products	8.8
32	Stone, clay, glass and concrete products	1.0
33	Primary metal industries	3.1
34	Fabricated metal products	5.0
35	Machinery, except electrical	14.0
36	Electrical and electronic machinery	12.5
37	Transportation equipment	3.5
38	Measuring, analyzing and controlling instruments	3.3
39	Miscellaneous manufacturing industries	.6
73	Consulting engineering agencies	2.3

TABLE 2. Years Employed as an Engineer/Scientist by Company Size

Company size designation	Years employed as an engineer/scientist (%)		
	3 or under	4 to 9	10 or over
S1 (N=156)	18.18	24.24	57.58
S2 (N=162)	24.69	33.33	41.96
S3 (N=151)	25.83	33.11	41.06

Key: S1 = 1 to 166; S2 = 167 to 333; S3 = 334 to 500

Table 3 compares the number of years participants were employed as engineers with the number of years employed with their current organization. While a majority of participants (56.6 percent) had been with their present company for four years or more, comparatively more participants (77.2 percent) had been practicing engineers for more than four years. Correspondingly, while 47.1 percent of the participants had been employed as engineers for 10 years or more, 25.1 percent had been employed by the same company for 10 years or more. These figures may suggest a fair degree of job mobility within the scientific/engineering field.

TABLE 3. Comparison of Years Employed with Present Organization and as an Engineer

Number of years employed	Percentage of participants	
	As an engineer (N-480)	With current organization (N-479)
3 or under	22.8	43.4
4 to 9	30.1	31.5
10 or over	47.1	25.1

The largest grouping of participants by age was in the 26 to 35 age bracket, with 41.2 percent of the participants. The 25 and under grouping had 12.3 percent, the 36 to 45 grouping had 24.6 percent, and the 46 and over grouping had 21.9 percent of the participants, as represented in Figure 1.

Figure 1. Grouping of Participants by Age

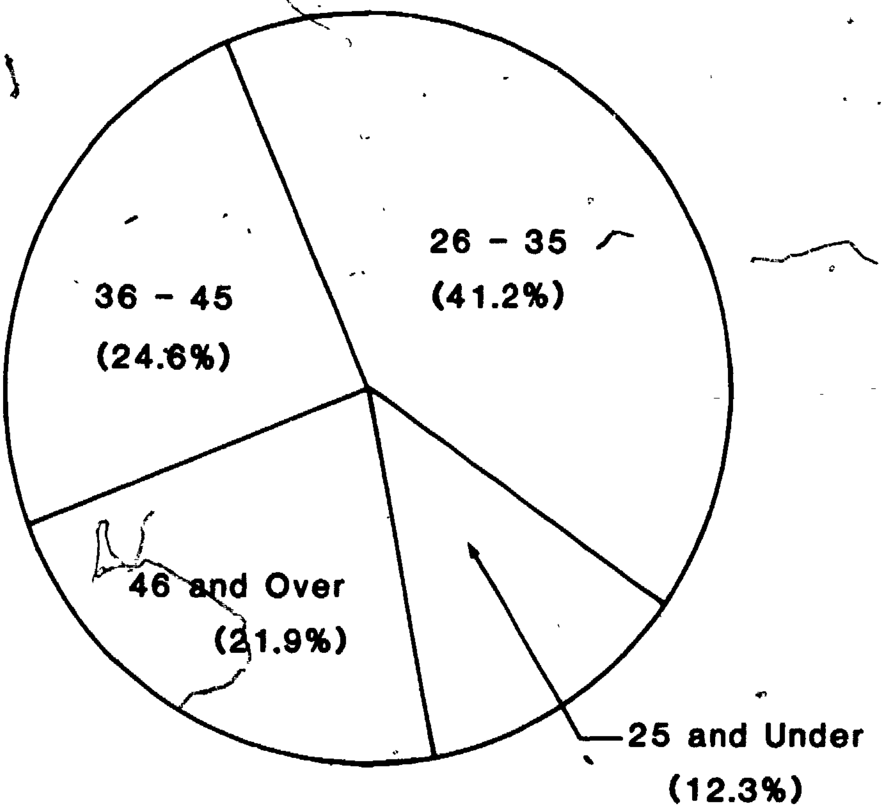


Table 4 presents the highest degree held by participants. For the purposes of this study, the Associate/Technical degree is a two-year degree, and the Bachelor of Engineering Technology is a four-year degree. The percentage of graduate degrees (9.4 percent) was lower than the national average on 27 percent, but this may be accounted for by the industrial emphasis of the study (as opposed to education and research), as well as the rural nature of the study (as opposed to metropolitan areas where advanced educational opportunities are more abundant).

[1]"National Patterns of Science & Technology Resources 1980," NSF 80-308 (Washington, D.C.: U.S. Government Printing Office), pp. 70-72.

TABLE 4. Distribution of Participants by Highest Degree Held

Degree	Percent of participants (N=480)
High school	3.7
Associate/Technical	9.2
Bachelor of Engineering Technology	5.4
Bachelor of Science	67.5
Masters degree	7.9
Ph.D./Ed.D./M.D.	1.5
Other	4.8

The industry breakdown of the highest degree held by participants is shown in Table 5. Bachelor of Science degrees had the highest and substantially larger representation than other degrees and were concentrated more in the electrical/electronic machinery and chemicals and allied products than in textile mill products and machinery except electrical industries (see B-2). Almost all Associate/Technical degrees were concentrated in machinery except electrical and textile mill products industries, and Bachelors of Engineering Technology degrees were evenly distributed in the four industry classifications. The graduate degrees were found to be concentrated more in 35 and 36 than in 22 and 28 industry codes (see B-2).

It was also found (B-3) that there were more graduate degrees in larger companies than in smaller ones as shown in Table 6.

The majority of the participants (57.7 percent) had degrees in engineering. Another 18.1 percent of the participants had degrees in the physical sciences. Figure 2 illustrates the distribution of the other degrees.

A small number of participants, 9.3 percent, reported that they held professional certification in engineering. Another 6.9 percent of the participants held professional certification in some other field, while 83.8 percent held no certification at all. By age groups, there were proportionally

TABLE 5. Distribution of Participants by Principal Industries by Highest Degree Held

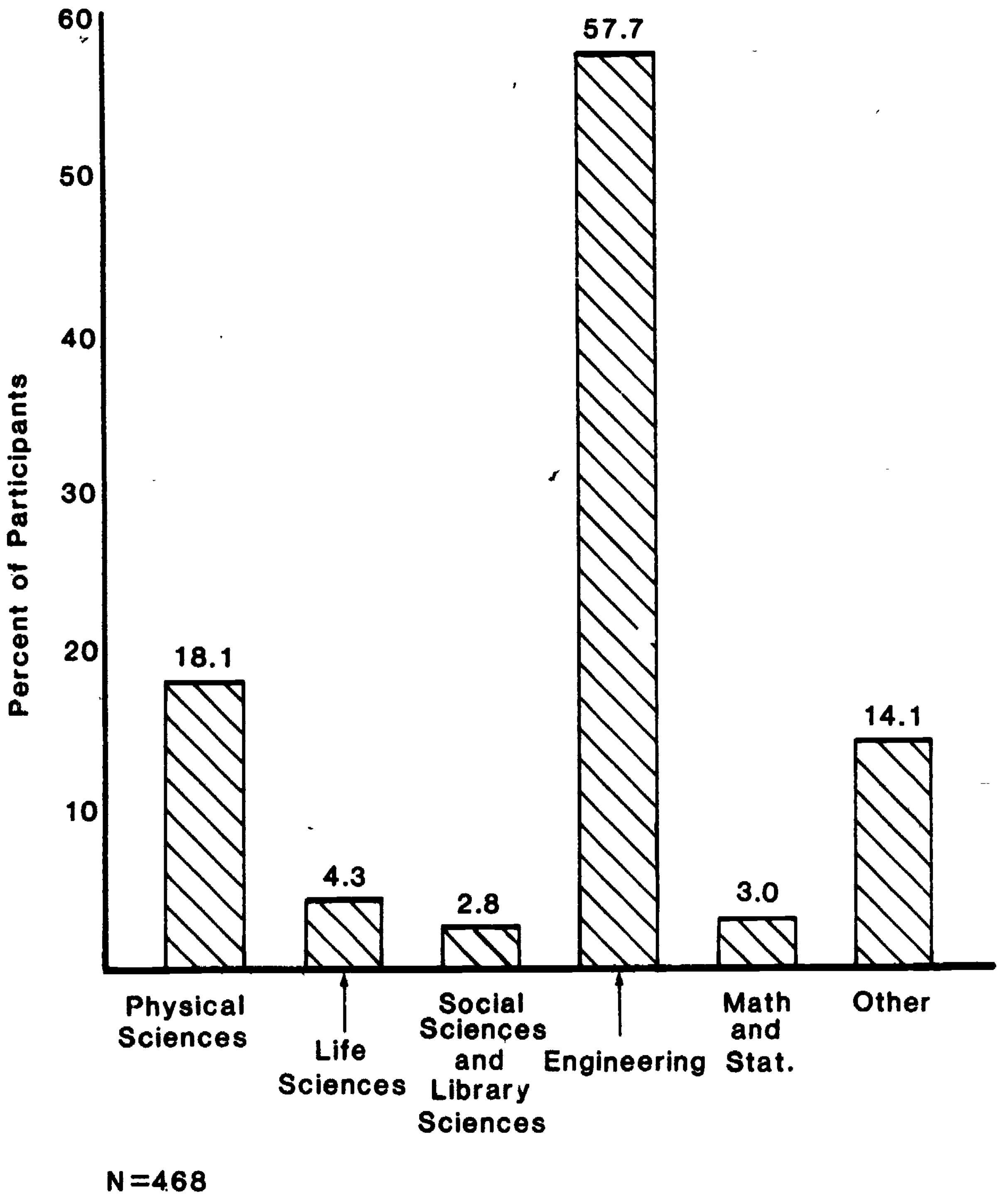
		Highest degree held by percent			
SIC	Industry	Assoc/ Tech	Bach of Engr Tech	Bach of Science	Graduate
22	Textile mill products (N=83)	13.25	4.82	59.04	4.82
28	Chemicals and allied products (N=62)	1.61	4.84	82.26	8.06
35	Machinery, except electrical (N=67)	13.43	4.48	64.18	10.45
36	Electrical and electronic machinery (N=60)	0	6.67	78.33	13.33

TABLE 6. Graduate Degrees by Company Size

Company size designation	Percent of engineer/scientist employees holding graduate degrees
S1 (N=166)	6.63
S2 (N=162)	9.26
S3 (N=152)	12.49

Key: S1 = 1 to 166; S2 = 167 to 333; S3 = 334 to 500

Figure 2. Type Degree Held by Participants



more participants holding professional certification in the 36 and over group than the 35 and under group. (See Table 7, Table 8, and B-4.)

TABLE 7. Professional Certification of Participants by Age Groups

Age	Percent who have professional certification
25 and under (N=59)	11.87
26 to 35 (N=198)	14.15
36 to 45 (N=118)	17.77
46 and over (N=105)	20.00

There were proportionally more participants with masters degrees that were certified than all other participants combined. (See Table 8 and B-5.)

TABLE 8. Professional Certification of Participants by Highest Degree Held

Highest degree held	Professional certification percent		
	Engineering	Other	None
Assoc/Tech degree (N=43)	9.30	6.98	83.72
Bach of Engr Tech (N=26)	3.85	3.85	92.30
Bach of Science (N=324)	9.04	6.54	84.42
Master's degree (N=38)	23.68	10.53	65.79
Ph.D./Ed.D./M.D. (N-7)	0	0	100.00

Of those participating, 74.8 percent were involved in some level of supervisory responsibility; the breakdown of this figure is given in Table 9.

TABLE 9. Participants by Current Level of Supervisory Responsibility

Level of responsibility	Percent of participants (N=480)
No supervisory responsibility	25.2
Supervision of technicians/non-technical personnel	27.1 *
Supervision of engineering/scientific personnel	38.5 *
Management of supervisory personnel	9.2 *

* 74.8 percent have some supervisory responsibility.

The breakdown of the highest level of supervisory responsibility by industry SIC code is shown in Table 10 (see B-6).

TABLE 10. Participants' Highest Level of Supervisory Responsibility by Principal Industry

		Highest level supervised by participant			
SIC	Industry	None	Technicians/ non-techs	Engineers/ scientists	Super-visors
22	Textile mill products (N=83)	13.25	34.94	43.47	8.44
28	Chemicals and allied products (N=60)	11.29	38.71	41.94	8.06
35	Machinery, except electrical (N=67)	34.33	16.42	38.80	10.45
36	Electrical & electronic machinery (N=60)	50.00	16.66	31.66	1.67

Eighty-five percent of the participants perform their technical work independently, with the various degrees of technical responsibility listed in Table 11.

TABLE 11. Current Level of Technical Responsibility

Level of responsibility	Percent of participants (N=479)
Perform limited assignments with specific direction	2.1
Perform assignments with limited direction	12.9
Perform most work independently	39.9 *
Work independently extending known techniques	15.7 *
Technical direction and review of others' work	29.4 *

* 85 percent work independently.

Participation in Structured Educational Resources. Participants were asked to give some historical data on their involvement in continuing education over the past three years, the employer support they received, and their assessment of the effectiveness of the activity. The summary of this data, for the structured educational resources, appears in Tables 12 through 24.

Table 12 presents the participation in structured educational resources by length of activity. The shorter activities (less than 30 hours) drew more participation across the board with substantial differences noted for workshops and short courses, not in-company; in-company courses taught by non-employees; and in-company courses taught by employees. For the combined results, the most participation was drawn by workshops/short courses, not in-company (48.75 percent); in-company courses taught by employees (26.25 percent); college courses, on-campus (25.42 percent); and in-company courses taught by non-employees (23.96 percent).

TABLE 12. Participation in Structured Educational Resources During the Last Three Years by Course Length

Type of resource	Percent participating in activity of less than 30 hours (N=480)	Percent participating in activity of more than 30 hours (N=480)	Percent participating at either level
College courses, on campus	15.63	12.08	25.42
College courses, videobased	2.50	1.46	3,96
Workshops, short courses not in-company	40.21	13.75	48.75
In-company courses taught by non-employees	18.54	6.46	23.96
In-company courses taught by employees	20.21	9.38	26.25
Educational TV courses	3.13	0.63	3.75
Packaged media courses	2.71	1.25	3.96
Programmed instruction	4.38	3.13	7.50
Correspondence courses	1.46	1.46	2.92

The average number of courses participated in within the past three years is presented in Table 13. College courses, on-campus, was the most likely resource to be used repeatedly by a participant over a three-year period, followed by college courses, videobased; in-company courses taught by employees and non-employees; and workshops/short courses, not in-company. Of those participating in continuing education, the average number of structured educational activities participated in over a three-year period was 4.69. Participants with degrees in engineering had taken on the average 4.88 courses (Table 14), which was found to be significantly different from the average number of courses (3.78) taken by participants with degrees in the other areas (see B-7).

In addition, participants with higher levels of supervisory responsibilities (e.g. engineers/scientists or supervisory personnel) were found to have taken more courses on the average than participants with lower level or no supervisory responsibilities (see Table 15 and B-8).

Table 16 is the principal industry breakdown of the participants using structured educational resources (delivery systems) during the past three years. The percentage of participants employed in the 35 and 36 industry classifications (taken as a group) who had taken college courses on campus was found to be higher than those employed in the 22 and 28 industry classifications. For workshops/short courses, not in-company, the opposite results were found (see B-9).

There was not enough evidence to support the apparent differences in participation in in-company courses taught by employees between 22 and 28 industry classifications and both 35 and 36 classifications, but it was found that relatively more engineers/scientists participate in in-company courses, employee taught, in classification 36 than in classification 35 (see B-9). Lastly, there were relatively more participants in in-company courses, non-employee taught, in classification 22 than in 28, 35, and 36 taken as a group (see B-9).

Tables 17 and 18 present a further breakdown of the participation in structured educational resources by age group and highest degree held. The first two age groups -- 25 and under and 26 through 35 -- had similar participation in college

TABLE 13. Average Number of Courses Participated in During the Last Three Years by Course Length

Type of Resource	< 30 hours			> 30 hours			Total		
	N*	Mean	SD**	N*	Mean	SD**	N*	Mean	SD**
College courses, on campus	75	2.37	2.05	58	4.57	5.45	122	3.63	4.44
College courses, videobased	12	1.92	1.08	7	3.86	7.13	19	2.63	4.31
Workshops, short courses, not in-company	193	2.12	1.53	66	1.92	2.48	234	2.30	2.01
In-company courses taught by non-employees	89	2.66	5.44	31	1.52	0.85	115	2.47	4.82
In-company courses taught by employees	97	2.52	4.05	45	1.78	1.09	126	2.57	3.80
Educational TV courses	15	1.07	0.26	3	1.00	0	18	1.06	0.24
Packaged media courses	13	1.92	2.06	6	1.17	0.41	19	1.68	1.73
Programmed instruction	21	1.86	2.03	15	1.73	1.83	36	1.81	1.93
Correspondence courses	7	1.57	1.13	7	1.00	0	14	1.29	0.83
Total number of all courses							378	4.69	5.71

* Number of respondents

** Standard deviation

TABLE 14. Average Number of Courses Participated in During the Last Three Years by Field

Area of highest degree	Of those participating in CE, average number of courses taken in the last three years	Standard deviation
Physical sciences (N=66)	3.86	3.09
Life sciences (N=19)	3.47	2.78
Engineering (N=215)	4.88	6.20

TABLE 15. Average Number of Courses Participated in During the Last Three Years by Level of Supervisory Responsibility

Highest level supervised by participants	Average number of courses participated in during the last three years	Standard deviation
None (N-100)	4.25	5.96
Technicians/non-technical (N=93)	3.96	2.98
Engineers/scientists (N=156)	5.06	4.94
Supervisors (N=29)	6.52	11.89

TABLE 16. Participation in Structured Educational Resources During the Last Three Years by Principal Industry

Type of resource	Percent participating in activity			
	22 Textiles (N=83)	28 Chemicals (N=62)	35 Machinery (N=66)	36 Electrical (N=60)
College courses, on campus	21.69	19.36	34.33	33.33
College courses, videobased	6.02	4.84	4.48	5.00
Workshops, short courses, non in-company	50.60	59.68	46.27	40.00
In-company workshops taught by non-employees	30.12	17.74	20.90	20.00
In-company workshops taught by employees	28.92	27.42	20.90	35.00
Broadcast educational TV	3.61	4.84	2.99	3.33
Media	6.02	3.23	2.99	5.00
Programmed instruction	8.43	6.45	5.97	13.33
Correspondence	2.41	6.45	2.99	1.67

TABLE 17. Participation in Structured Educational Resources During Last Three Years by Participant Age Group

Resources / Age group	College courses on-campus	College courses video-based	Workshops not in-company	In-company courses non-emp. taught	In-company courses employee taught	Broadcast Educational TV	Packaged media courses	Programmed instr.	Corresp. courses
25 and under (N=59)	35.59	3.39	35.59	25.42	28.81	1.69	5.09	8.48	0
26-35 (N=198)	30.30	6.06	50.00	24.80	30.80	5.05	4.55	9.08	3.03
36-45 (N=118)	21.19	2.54	54.24	22.88	[illegible].03	2.54	2.54	6.78	3.39
46 and over (N=105)	15.24	1.91	47.62	22.86	20.95	3.81	3.81	4.76	3.81

TABLE 18. Participation in Structured Educational Resources During Last Three Years by Highest Degree Held

Resources	College courses on-campus	College courses video-based	Workshops not in-company	In-company courses non-emp. taught	In-company courses employee taught	Broadcast educational TV	Packaged media courses	Programmed instr.	Corresp. courses
High Sch (N=18)	11.11	0	27.78	27.78	22.22	0	0	5.65	0
Assoc Tech (N=44)	27.27	9.09	40.91	29.55	15.91	4.55	0	2.27	4.55
Bach Engr Tech (N=26)	11.54	0	46.15	34.62	19.23	0	3.85	15.39	0
B.S. (N=324)	26.34	4.32	51.24	23.15	29.94	4.32	4.63	5.86	2.78
M.A. (N=38)	28.94	0	52.63	10.53	26.32	5.26	5.26	23.68	2.63
Ph.D./Ed.D./M.D. (N=7)	57.14	14.29	14.29	14.29	14.29	0	0	0	14.29

courses, on-campus, and in-company courses, employee and non-employee taught. Participation in the same educational resources by the next two age groups -- 36 through 45 and 46 and over -- were also similar. These data show that relatively more engineers/scientists in the age group 35 and under participated in college courses, on campus, and in-company courses, employee taught, than in the age group 36 and over. Both groups were equally represented in participation in in-company courses, non-employee taught (see B-10). In addition, relatively fewer young engineers/scientists (25 and under) than older (26 and over) participated in workshops/short courses, not in-company (see B-10).

Finally, it appears that participation in most of the structured resources studied increases with the level of education as shown in Table 18 (also see B-11). Note the minor exceptions for in-company courses, employee and non-employee taught.

The participation in college courses, on-campus, and in-company workshops, employee taught, by highest level of supervisory responsibility is shown in Table 19. Those supervising supervisors were found to participate proportionally more in college courses, on-campus, and less in in-company workshops, employee taught (see B-12).

TABLE 19. Participation in Structured Educational Resources During the Last Three Years by Level of Supervisory Responsibility

Hignest level supervised by participants	Percent participating in this activity	
	College courses, on-campus	In-company workshops, employee taught
None (N=121)	27.27	28.93
Technicians/non-techs (N=130)	20.77	26.92
Engineers/scientists (N=185)	24.32	28.65
Supervisors (N=44)	38.64	6.82

Table 20 lists data for type of support provided by employers for structured resources. The strongest employer support (full tuition) went to workshops/ short courses, not in-company. Note from Table 12 that this resource also had the heaviest participation. Employers also provided good support for college courses, on-campus; packaged media courses; in-company courses, non-employee and employee taught; and college courses, videobased.

In particular, note (1) that release time from work at full pay was substantially greater for workshop/short courses and in-company courses than for other educational resources, (2) that payment for books and supplies by employers was good for all educational resources, with approximately 30 to 45 percent of the participants reporting support, and (3) that reimbursement for travel and subsistence by employers was also good, with more fluctuations noted among the type resources used than with payment for books and supplies.

Tables 21 and 22 highlight differences in support for two educational resources -- college courses, on-campus, and workshops/short courses, not in-company -- by size of company. While the overall support by S1 sized companies for CE was generally higher than for S2 sized companies, the only significant difference was in the area of partial tuition (see B-13). With S1 and S2 taken as a group, it was found that they were more supportive than S3 sized companies for all types of support except full and partial tuition, where they were equally supportive (see B-13).

For workshops/short courses, not in-company, it was found that the group S2 and S3 were more supportive than S1 across the board, except in partial tuition, where they were found to be equally supportive (B-14).

The level and extent of employer support for CE for engineers/scientists are strong as evidenced by these data. Comparison of these data with earlier employer support data, if they are available, would likely confirm a continuous trend toward greater and greater employer support.

Table 23 suggests that as the supervisory responsibility of engineers/scientists increases, there is generally more support for participating in CE. One notable

TABLE 20. Employer Support for Structured Educational Resources

Type of Resource	Payment for books/supplies	Partial reimbursement for travel, subsistence	Full reimbursement for travel, subsistence	Release time from work to be made up by employee	Release time from work at full pay	Release time from work at partial pay	No support provided	Partial tuition or fee reimbursement	Full tuition or fee reimbursement
	Of those participating, percent receiving this support								
College courses, on-campus	36.07	1.64	27.05	1.64	20.49	0	21.31	13.12	49.18
College courses, videobased	36.84	0	21.05	0	21.05	0	15.79	15.79	31.58
Workshops, short courses not in-company	44.44	1.28	65.39	0.86	52.99	0	5.13	3.42	61.11
In-company courses taught by non-employees	40.00	0	26.96	3.48	51.30	0	2.61	0	41.73
In-company courses taught by employees	39.68	2.38	38.10	2.38	51.58	0	2.38	0.79	29.37
Broadcast educational TV	44.44	0	11.11	0	33.33	0	22.22	0	33.33
Packaged media courses	36.84	0	15.79	0	42.11	0	15.79	0	42.11
Correspondence courses	28.57	0	7.14	0	7.14	0	35.71	21.43	21.43
Programmed instruction	33.33	0	22.22	0	22.22	0	13.89	0	41.67

TABLE 21. Employer Support for College Courses, On-Campus

Company size designation	Percent of participants receiving support				
	Payment for books	Full travel	Free release time	Partial tuition	Full tuition
S1 (N=36)	44.44	36.11	27.78	22.22	44.44
S2 (N=45)	37.78	33.33	22.22	4.44	46.66
S3 (N=41)	26.83	12.20	12.20	14.63	56.10

Key: S1 = 1 to 166; S2 = 167 to 333; S3 = 334 to 500 employees

TABLE 22. Employer Support for Workshops/Short Courses, Not In-Company

Company size designation	Percent of participants receiving support				
	Payment for books	Full travel	Free release time	Partial tuition	Full tuition
S1 (N=88)	38.64	59.09	42.05	3.41	53.41
S2 (N=83)	46.99	68.68	60.24	1.21	65.06
S3 (N=63)	49.21	69.84	58.73	6.34	66.67

Key: S1 = 1 to 166; S2 = 167 to 333; S3 = 334 to 500 employees

TABLE 23. Employer Support for College Courses, On-Campus, by Level of Supervisory Responsibility

Highest level supervised by participants	Percent of participants receiving support			
	Payment for books	Travel	Free release time	Full tuition
None (N=33)	30.30	12.12	15.15	33.33
Tecnnicians/non-tech (N=27)	44.44	18.52	11.11	48.15
Engineers/scientists (N=45)	35.56	28.89	24.44	53.33
Supervisors (N=17)	35.29	64.71	35.29	70.59

exception is that those supervising technicians and non-technical personnel reported relatively stronger support for reimbursement for books and supplies than other levels (see B-15).

When participants were asked to rate, on a scale of 0 to 4, the effectiveness of the delivery systems used during the past three years, every delivery system except one received an average to very effective rating (Table 24). As anticipated, workshops/short courses, not in-company; credit courses, on-campus; and in-company courses were rated effective, while packaged media courses, surprisingly, were rated highest -- between very effective and most effective (3.16). Note the small sample, however. Educational television courses rated lowest with a 2.11 rating.

TABLE 24. Evaluation of Effectiveness of Structured Educational Resources

Type of resource	Number of participants	Mean rating*	Standard deviation
College courses, on campus	120	2.91	0.83
College courses, videobased	17	2.53	0.87
Workshops, short courses, not in-company	215	2.86	0.82
In-company courses taught by non-employees	109	2.73	0.83
In-company courses taught by employees	113	2.74	0.79
Educational TV courses	18	2.11	0.90
Packaged media courses	19	3.16	0.77
Programmed instruction	33	2.64	0.74
Correspondence courses	15	2.60	0.99
Other	2	2.50	0.71

* Rating values: 4-most effective; 3-very effective; 2-satisfactory or neutral; 1-slightly effective; 0-not effective at all

Participation in Unstructured Educational Resources. Participants were asked to provide data and information regarding their personal use of unstructured educational resources (delivery systems) during the past three years. They were asked the approximate number of hours devoted to unstructured educational resources each month, the approximate number of resources used each month by type, the type and extent of employer support provided, and their evaluation of the effectiveness of each type resource in furthering engineering and scientific knowledge. The summary of this data appears in Tables 25 through 32.

Table 25 presents the participation in unstructured educational resources by the average number of hours spent each month and by the average number of each type resource used each month. Survey participants relied most on the self-study of textbooks and technical journals, with 74.58 percent devoting an average of 12.4 hours per month to this resource. Participants also reported using an average of 4.66 different textbooks or journals each month.

Tables 26 and 27 list the number of participants using unstructured educational resources during the last three years by highest degree held and by age group. The more educated participants were relatively more involved with unstructured educational resources than the less educated ones (B-16) and similar behavior was observed for older engineers/scientists (B-17).

Table 28 lists the average number of hours spent each month by highest degree held. Note that the amount of time devoted to self-study generally increases as the level of education increases, with one exception at the Bachelor of Techonology level (note the relatively small number of technology degree participants). Their committing more time to self-study suggests that participants with higher level degrees (Master's and Doctoral -- see B-18) are either more aware of the need to keep themselves current in their fields or more motivated than those with other degrees.

While reading engineering or scientific journals and periodicals is not the same as self-study, it is another way that engineers/scientists keep in touch with the outside and changes that are occurring. Most of the participants of the study, 86.4 percent, regularly read engineering or scientific journals (see Figure 3).

TABLE 25. Participation in Unstructured Educational Resources During Last Three Years

Type of Resource	Percent participating by resource (N=480)	Average hours per month	Standard deviation	Average number of this type resource utilized per month	Standard deviation
Self-study of textbooks/journals	74.58	12.44	12.21	4.66	5.34
Technical consultation with colleagues in own company	62.92	17.15	16.91	5.17	5.06
Technical consultation with colleagues outside company	46.67	8.04	9.30	4.75	6.52
Technical society meetings	30.21	2.98	2.46	1.29	0.77
Special supervised technical projects	13.13	13.75	13.18	4.04	4.54
Other	0.63	7.33	10.97	1.00	0.00

TABLE 26. Participation in Unstructured Educational Resources During Last Three Years by Highest Degree Held

Degree \ Resources	Self study of textbooks/journals	Technical consultation in-company	Technical consultation outside company	Technical society meetings	Special supervised technical projects	Other
High school (N=18)	61.11	55.56	55.56	16.67	11.11	0
Assoc/Tech Degree (N=44)	77.27	70.46	40.91	22.73	13.64	0
Bach Engr Tech (N=26)	76.92	50.00	42.31	23.08	3.85	0
B.S. (N=324)	74.69	63.89	46.61	29.94	12.96	0
Master's (N=38)	81.58	68.42	50.00	39.47	23.68	2.63
Ph.D./Ed.D./M.D. (N=7)	100.00	71.43	42.86	57.14	100.00	28.57

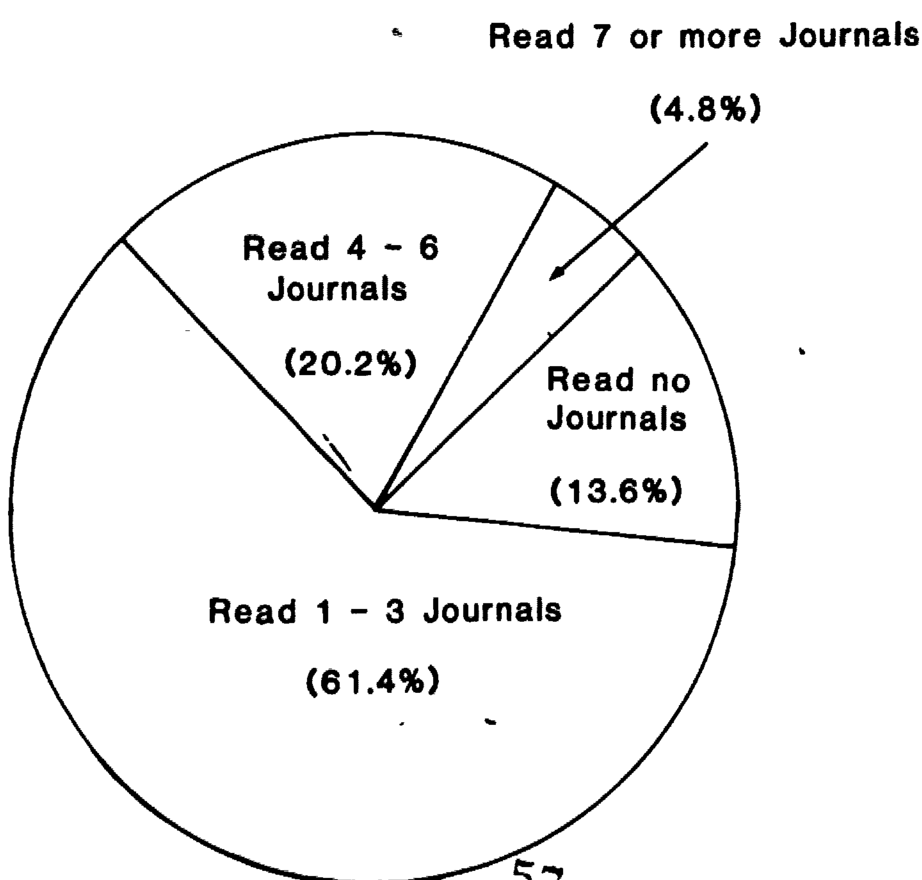
TABLE 27. Participation in Unstructured Educational Resources During Last Three Years by Participant Age Group

Age group \ Resources	Self study of textbooks/journals	Technical consultation in-company	Technical consultation outside company	Technical society meetings	Special supervised technical projects	Other
25 and under (N=59)	72.88	62.71	42.37	22.03	15.25	0
26-35 (N=198)	70.78	60.60	38.38	24.24	11.61	0
36-45 (N=118)	78.81	67.80	55.93	39.83	11.86	.85
46 and over (N=105)	78.10	61.90	54.29	35.23	16.19	1.90

TABLE 28. Self-Study of Textbooks and Technical Journals by Highest Degree Held

Highest degree held	For participants, average hours per month	Standard deviation	Standard error of mean
Assoc/Tech (N=34)	10.15	9.02	1.546
Bach of Engr Tech (N=20)	18.70	12.46	2.786
Bach of Science (N=242)	11.40	10.76	.692
Master's (N-31)	16.55	18.63	3.346
Ph.D./Ed.D./M.D. (N-7)	34.43	21.85	

Figure 3. Breakdown of Participants by Number of Journals Read



The majority (61.4 percent) read one to three on a regular basis, while 20.2 percent read four to six and 4.8 percent read seven or more.

Distributions of participants who regularly read engineering or scientific journals or periodicals by age group and principal industry classifications are listed in Tables 29 and 30. Relatively more young engineers/scientists (25 and under) did no reading at all (B-19), and proportionally more in the age group of 46 and over read seven or more journals (B-19).

TABLE 29. Distribution of Participants Who Regularly Read Engineering or Scientific Journals or Periodicals by Age Group

Age group	Percent of participants read:			
	None	1 - 3	4 - 6	7 or more
25 and under (N=59)	20.34	59.32	18.64	1.70
26 - 35 (N=198)	14.14	66.16	16.67	3.03
36 - 45 (N=118)	11.11	58.12	26.50	4.27
46 and over (N=105)	11.43	57.14	20.95	10.48

It is interesting that, for all age groups, about the same percentage (57 to 66) read one to three journals or periodicals and about the same percentage (18 to 26) read four to six, with the variances occurring in the none read and seven or more columns.

More engineers and scientists in the machinery (35 and 36) classifications tended to read more journals and periodicals than those in the chemicals and textile (28 and 22) classifications. There was not sufficient evidence to support the apparent differences between 35/36 and 22/28 classifications for heavy readers (4 to 6 journals); however, there were proportionally more engineers/scientists in the 35/36 classification reading 1 to 3 journals (B-20).

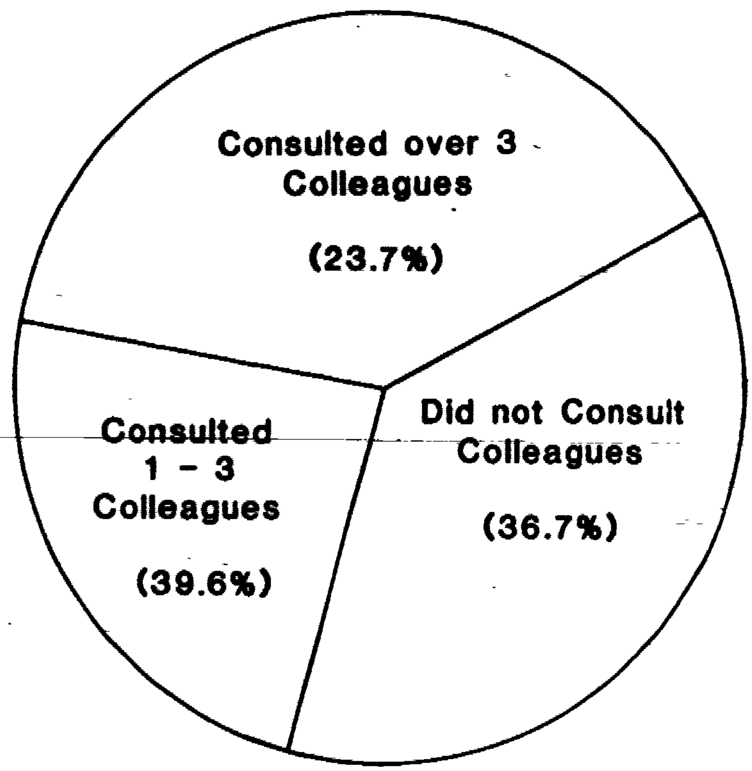
TABLE 30. Distribution of Participants Who Regularly Read Engineering or Scientific Journals or Periodicals by Principal Industry Classification

SIC	Industry	Percent of participants read:			
		None	1 - 3	4 - 6	7 or more
22	Textile mill products (N=83)	25.30	61.45	10.84	2.41
28	Chemicals & allied products (N-62)	16.13	53.23	30.64	0
35	Machinery, except electrical (N-66)	10.61	66.67	18.18	4.54
36	Electrical & electronic machinery (N=60)	6.67	78.33	10.00	5.00

Other important unstructured resources used included technical consultation with colleagues both in their own companies (with 62.92 percent participating) and other companies (with 46.67 percent participating). Technical consultation with colleagues within their own company was the most frequently used unstructured resource -- 5.17 times per month -- and more time was spent on this resource than any other -- an average of 17.15 hours per month (See Table 25).

In a separate question which was similar to one part of the unstructured educational resources question, a somewhat different overall result emerged regarding consultation with colleagues outside their organization. A breakdown of the participants by the number of colleagues consulted on a regular basis is shown in Figure 4. A total of 39.6 percent of the participants exchanged information with one to three colleagues outside the company, and 23.7 percent consulted with more than three colleagues on a regular basis. According to the data in Figure 4, more than a third (36.7 percent) of the participants did not exchange information with colleagues outside their organization, whereas, according to Table 25, it appears that slightly over half did not consult colleagues outside their own company. During the interviews the engineers/scientists often commented that there was a company policy prohibiting any contact with outside colleagues. The reason given for this policy was protection of technical secrets.

Figure 4. Breakdown of Participants by Number of Colleagues Consulted Outside Their Organizations on a Regular Basis



Referring to Table 25, less than a third (30.21 percent) of the participants attended technical society meetings. While participants utilizing special supervised technical projects engaged in them an average of 4.04 times per month and devoted almost fourteen (14) hours per month to them, only a small percent (13.13) of those surveyed actually reported using them.

Because of the nature of unstructured educational resources, it is difficult to assess employer support. Table 31 lists employer support for unstructured educational resources used by participants during the last three years. The strongest support components included payment for books and supplies, reimbursement for travel and sibsistence, and release time from work at full

TABLE 31. Employer Support for Unstructured Educational Resources Used During the Last Three Years

Type of Resource (Delivery System)	Of those participating, percent receiving this support						
	Payment for books/supplies	Partial reimbursement for travel, subsistence	Full reimbursement for travel, subsistence	Release time from work to be made up by employee	Release time from work at full pay	Release time from work at partial pay	No support provided
Self study books/journals	49.17	--	--	0.83	13.54	0.28	29.01
Technical consultations with colleagues in own company	13.31	1.30	19.48	0.65	30.84	0	11.69
Technical consultations with colleagues outside company	12.50	1.34	26.34	1.79	26.79	0	14.29
Technical society meetings	21.38	7.59	48.97	2.07	25.52	0	14.48
Special supervised projects	18.18	1.52	22.73	0	21.21	1.5	12.12
Other	33.33	0	0	66.67	0	0	0

pay. Although there appear to be support patterns emerging for unstructured education, many participants commented that there was no company policy, or only a vague policy governing support for these areas.

When asked to rate on a scale of 0 to 4 the effectiveness of their unstructured educational activities, those participants involved in special supervised technical projects were the most enthusiastic about the outcome of the activity, giving it a mean effectiveness rating of 3.22. Table 32 presents the detailed results, indicating that consultation with colleagues, both inside and outside the company, was also considered to be a very effective resource.

TABLE 32. Evaluation of Effectiveness of Unstructured Educational Resources

Type of resource	Number of participants	Mean rating*	Standard deviation
Self study of textbooks/journals	337	2.67	0.79
Technical consultation with colleagues in own company	275	3.05	0.72
Technical consultation with colleagues outside of company	197	2.95	0.74
Technical society meetings	138	2.56	0.96
Special supervised technical projects	58	3.22	0.77
Other	4	3.50	0.58

* Rating values: 4-most effective; 3-very effective; 2-satisfactory or neutral; 1-slightly effective; 0-not effective at all

Personal Evaluation of Current Knowledge in Field. Less than half of the participants (42.24 percent) perceived themselves as right up-to-date or almost up-to-date in their fields as presented in Table 33. The largest segment (48.76 percent) judged themselves as average or moderately up-to-date. On a scale of 0 to 4, the average rating was 2.44 with a standard deviation of 0.89.

TABLE 33. Personal Evaluation of Current Knowledge in Field

Degree of currency	Percent of participants (N=445)
Right up-to-date (4)	13.48
Almost up-to-date (3)	28.76
Moderately up-to-date (2)	48.76
Slightly up-to-date (1)	6.52
Not up-to-date at all (0)	2.47

When engineers/scientists were asked, "How up-to-date do you consider yourself in your technical field?" it is interesting that their mean ratings increased with each succeeding higher level degree held (see Table 34). At the lower end, holders of associate or technician degrees rated themselves a mean of 2.32 on a scale of 0 to 4, while doctoral degree holders rated themselves right up-to-date with a mean of 4.00. These ratings suggest the engineers'/scientists' perceptions of whether or not they are up-to-date are linked to the level of their formal education. Graduate degree holders rated themselves higher than other degree holders (B-21).

TABLE 34. Personal Evaluation of Current Knowledge in Field by Highest Degree Held

Highest degree held	Mean rating*	Standard deviation
Assoc/Tech (N=41)	2.32	0.93
Bach of Engr Tech (N=25)	2.36	0.70
Bach of Science (N=300)	2.45	0.89
Master's (N=36)	2.72	0.85
Ph.D./Ed.D./M.D. (N=5)	4.00	0.00

* Rating values: 4-right up-to-date; 3-almost up-to-date; 2-moderately up-to-date; 1-slightly up-to-date; 0-not up-to-date at all

Objectives for Participating in Continuing Education. Participants were asked to rate their objectives for participating in continuing education on a scale of 0 to 4. Table 35 details the results of this question, with the highest motivations for participation attributed to gaining new insights and performing present job assignment better. These results were correlated with data in Table 36 which presents participants' responses as to how CE has already impacted or affected their careers. Again, gaining new insights and performing present job assignment better were the most likely career gains as a result of continuing education, with the other motivations and career gains following similar patterns. It should be noted that participants ranked the objectives of attaining a salary increase or fulfilling requirements for a promotion or meeting the expectations of management near the bottom in both cases. These findings appear to indicate that expectations from continuing education bear a strong correlation with actual results.

Impact of CE on Professional Growth. Continuing education was recognized by the study participants as an important factor in their job performance and career growth up to now. For specific ways their performances have been affected, refer to Table 36, page 50. They rated technical continuing education more important than non-technical (Table 37).

TABLE 35. Engineers'/Scientists' Objectives for Participating in Continuing Education

Objectives	Number of participants	Mean rating*	Standard deviation
Gain new insights, explore alternate solutions	476	3.30	0.78
Perform your present job assignment better	475	3.17	0.89
Prepare for increased responsibility	471	3.10	1.00
Attain enhanced position in your field	474	2.78	1.01
Intellectual stimulation	474	2.70	1.06
Remedy deficiencies in initial education	473	2.42	1.24
Maintain your present position in company	471	2.26	1.19
Attain salary increase	473	2.25	1.22
Prepare for a new job in current field	470	2.16	1.24
Fulfill requirements for a promotion	472	2.13	1.35
Meet expectations of management	470	1.78	1.28
Prepare for a new job in another field	470	1.74	1.32

* Rating values: 4-of highest importance; 3-very important; 2-moderately important; 1-slightly important; 0-not at all important

TABLE 36. Areas Where Continuing Education Has Already Been a Major Factor for Participants

Results aided by continuing education	Percent of participants (N=480)
Performing present job assignment better	62.50
Gaining new insights, exploring alternative solutions	60.63
Stimulating intellectually	49.79
Preparing for increased responsibility	48.75
Remedying deficiencies in initial education	35.42
Attaining enhanced position in field	27.71
Maintaining present position in company	21.25
Attaining a salary increase	21.25
Fulfilling requirements for promotion	20.21
Preparing for new job in current field	18.96
Preparing for new job in different field	14.38
Meeting expectations of management	13.75

TABLE 37. Importance of Continuing Education to Professional Growth Up to Now

Continuing education	Number of participants	Mean rating*	Standard deviation
Technical	454	2.12	1.16
Non-technical	437	1.90	1.22

* Rating values: 4-of highest importance; 3-very important; 2-moderately important; 1-slightly important; 0-not at all important

Engineers/scientists having managerial responsibilities for other engineers/ scientists and/or supervisory personnel rated the importance of CE, up to now, higher than those with less supervisory responsibility (Table 38 and B-22).

TABLE 38. Importance of Continuing Education in Professional Growth Up to Now by Level of Supervisory Responsibility

Highest level supervised by participant	Importance of continuing education in professional growth up to now					
	Technical CE			Non-technical CE		
	N	Mean*	SD	N	Mean*	SD
None	111	1.94	1.25	104	1.57	1.18
Technicians or non-techs	119	2.00	1.15	114	1.67	1.21
Engineers/scientists	181	2.20	1.07	177	2.12	1.15
Supervisors	43	2.51	1.22	42	2.43	1.25

* Rating values: 4-of highest importance; 3-very important; 2-moderately important; 1-slightly important; 0-not at all important

More importantly, participants projected that CE would have a greater impact on their professional growth in the future than in the past, as presented in Table 39. The mean ratings increased from 2.12 to 2.56 for technical CE and from 1.90 to 2.32 for non-technical CE.

TABLE 39. Importance of CE to Future Professional Growth

Continuing education	Number of participants	Mean rating*	Standard deviation
Technical	472	2.56	0.99
Non-technical	447	2.32	1.11

* Rating values: 4-of highest importance; 3-very important; 2-moderately important; 1-slightly important; 0-not at all important

Preference Rating of Delivery Systems. Table 40 presents structured educational resources (delivery systems) rated according to personal preference. As supported by previous data, workshops and short courses, not in-company, were the most preferred of the resources with a mean rating of 3.07 on a scale of 0 to 4, followed closely by on-campus college courses, with a mean rating of 2.92.

TABLE 40. Structured Educational Resources Rated According to Personal Preference

Type of resource	Number of participants	Mean rating*	Standard deviation
College courses, on campus	468	2.92	1.01
College courses, videobased	464	2.09	0.99
Workshops, short courses non in-company	476	3.07	0.84
In-company courses taught by non-employees	474	2.66	0.90
In-company courses taught by employees	471	2.09	1.00
Broadcast educational TV	467	1.97	0.97
Packaged media courses	474	1.89	0.91
Programmed instruction	468	2.05	0.94
Correspondence courses	471	1.75	1.04
Other	3	1.81	1.22

* Rating values: 4-like very much; 3-like; 2-neutral toward; 1-dislike; 0-strongly dislike

In-company courses taught by non-employees was the third most popular delivery system with a mean rating of 2.66. The least preferred resource was correspondence courses with a rating of 1.75. Since less than half of the participants had utilized any of the different delivery systems during the last three years, ranging from 48.75 percent for workshops/short courses to 2.92 percent for correspondence courses (see Table 12), we can assume that many did not have personal experience with the different types of structured resources. Experience or inexperience with various delivery systems probably influenced their personal preference ratings. Engineers/scientists have more experience with college courses, workshops and seminars held away from the company, and in-company courses where outside "experts" are brought into the company (see Table 24) and, therefore, may have given them a higher personal preference rating. The lower rating of other delivery systems could be a result of their lack of exposure to them. Unstructured educational resources are rated according to personal preference in Table 41. Technical consultation with colleagues in the engineers'/scientists' own company was the most preferred resource, with a mean rating of 3.06 on a scale of 0 to 4. Self-study and technical consultation with colleagues from outside the company followed closely.

TABLE 41. Unstructured Educational Resources Rated According to Personal Preference

Type of resource	Number of participants	Mean rating*	Standard deviation
Self-study textbooks/journals	480	3.04	0.82
Technical consultation with colleagues in own company	478	3.06	0.77
Technical consultation with colleagues outside company	477	3.00	0.83
Technical society meetings	476	2.37	0.95
Special supervised technical projects	467	2.49	0.88
Other	20	1.80	1.11

* Rating values: 4-like very much; 3-like; 2-neutral toward; 1-dislike; 0-strongly dislike

Employee Perceptions of Employer Attitudes. When participants were asked to give their perceptions of what their employers' attitudes were toward continuing education, 44.8 percent said that their managers expected them to participate in continuing education, while 30.53 percent said they did not, and 24.63 percent stated that they didn't know what their managers' expectations were (see Figure 5). In conjunction with this question, participants were asked whether their managers encouraged participation in continuing education. The majority, 57.96 percent, said that participation was encouraged, while 42.04 percent said it was not. Relatively fewer managers employed by chemical and allied products companies were found to expect and encourage engineer/scientist participation in CE companies than managers in other major types of companies (Table 42 and B-23).

Statistically, there are no perceived differences among engineers/scientists at different supervisory levels regarding expectations of their managers for participating in CE (Table 43). It was found, however, that managers do encourage engineers/scientists having management responsibility for supervisors to participate in CE more than others (Table 43 and B-24).

Participants with degrees in engineering were found to be relatively more encouraged than participants with degrees in other fields (Table 44 and B-25).

Requested Courses and Preferred Delivery Systems. Participants were asked to list courses that they would like to take in the future, why they had not done so already, and to identify the delivery system they would prefer for each course. The results are compiled in Tables 45 and 46 and Appendix C.

Most participants (34.55 percent) cited that desired courses either were not available or were not available at a convenient location as reasons for not taking them previously. That courses were not available at a convenient time was the only other major factor listed. Neither the type of delivery system nor the cost of programs seemed to be important to participants (Table 45).

When participants were asked which delivery system they would prefer for requested courses, college courses, on campus, and workshops/short courses, not in-company, were the most popular, commanding a combined 73.04 percent (38.26 + 34.78) of the first choices. Another 13.91 percent (6.96 + 6.95)

Figure 5. Engineers'/Scientists' Perceptions of Employer Attitudes Toward Participation in Continuing Education

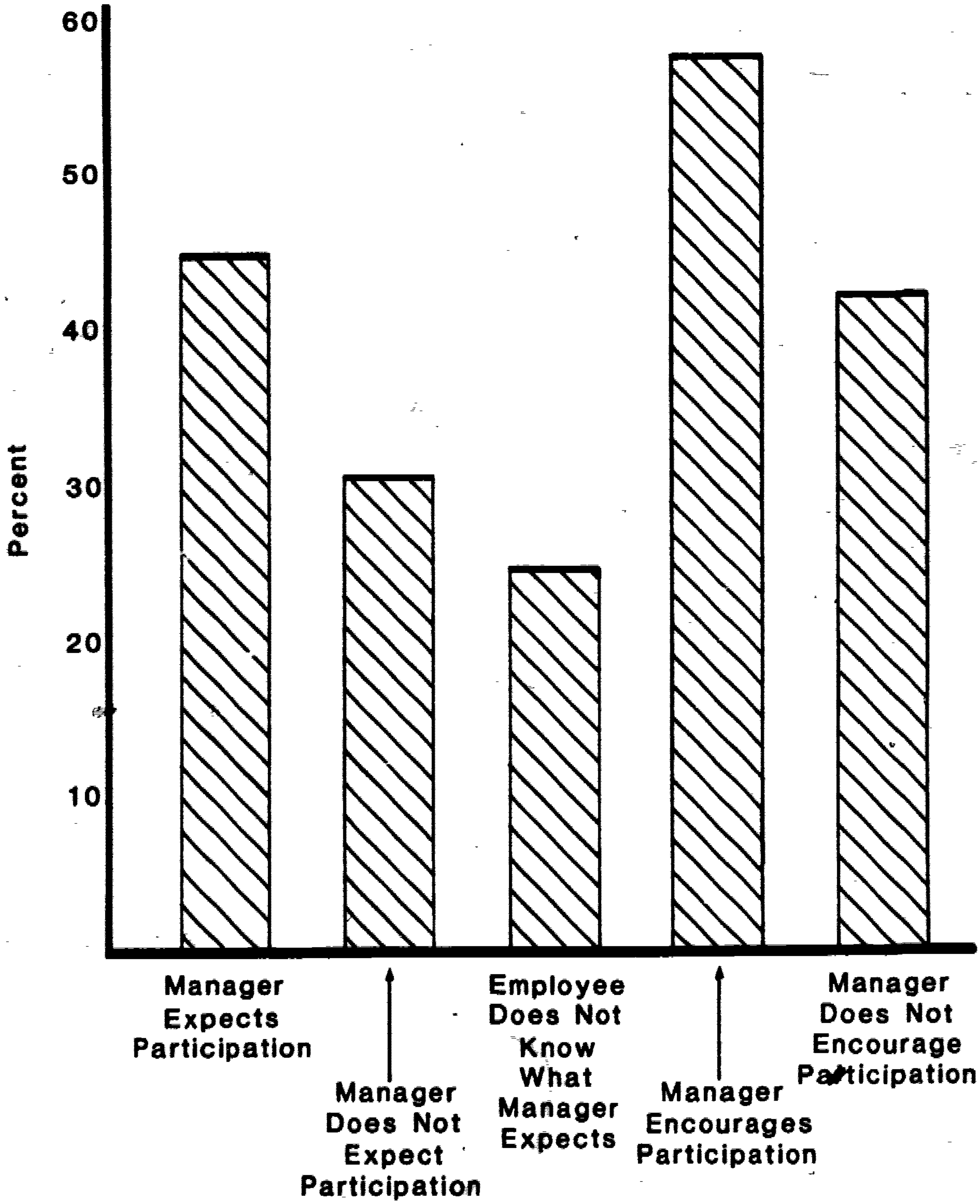


TABLE 42. Participants' Evaluation of Whether Managers Expect or Encourage Engineers/Scientists to Participate in CE by Principal Industry

SIC	Industry	Manager expects partic. (percent) Yes	No	Don't know	Manager encourages partic. (percent) Yes	No
22	Textile mill products (N=83)	49.40	30.12	20.48	61.45	38.55
28	Chemicals & allied products (N=62)	30.64	38.71	30.65	40.32	59.68
35	Machinery, except electrical (N=67)	56.92	21.54	21.54	66.67	33.33
36	Electrical & electronic machinery (N=60)	46.67	31.67	21.66	59.32	40.68

TABLE 43. Participants' Evaluation of Whether Managers Expect or Encourage Engineers/Scientists to Participate in CE by Highest Level of Supervisory Responsibility

Highest level supervised by participants	Manager expects participation (percent)				Manager encourages partic. (percent)		
	Yes	No	Don't know	N	Yes	No	N
None	41.32	27.27	31.41	121	56.67	43.33	121
Technician/non-tech	41.86	35.66	22.48	129	55.04	44.96	129
Engineers/scientists	47.80	26.92	25.28	182	56.91	43.09	181
Supervisors	51.16	39.54	9.30	43	75.61	24.39	41

TABLE 44. Participants' Evaluation of Whether Managers Encourage Engineers/Scientists to Participate in CE by Major Field

Field	Manager encourages participation (percent) Yes	No
Physical sciences (N=85)	44.71	50.59
Life sciences (N=20)	50.00	45.00
Engineering (N=270)	62.22	36.67

TABLE 45. Reasons for Not Taking Desired Courses Previously

Reasons	Percent of participants (N=356)
It is not available	34.55
Not available at a convenient time	26.40
Not available at a convenient location	34.55
Delivery system not appropriate	5.62
Too costly as presently offered	7.02
Level of available course too low	4.21
Level of available course too high	0.56
Other	12.36

TABLE 46. Preferred Delivery Systems for Requested Courses Within the Next Three Years

Delivery systems	Percent of participants (N=345)
College courses, on campus	38.26
College courses, videobased	6.96
Workshops, short courses, not in-company	34.78
In-company courses taught by non-employees	6.95
In-company courses taught by employees	0.87
Educational TV courses	3.19
Packaged media courses	1.45
Programmed instruction	4.06
Correspondence courses	2.61
Other	0.87

preferred the college courses, videobased, and in-company courses taught by non-employees. In comparing the delivery systems of courses taken during the last three years with courses that participants would like to take (Tables 12 and 46), it is interesting that 26.25 percent participated in in-company courses taught by employees during the last three years while less than one percent (0.87) indicated a preference for that system as their first choice for courses they would like to take.

During interviews, participants often commented that their desire to take a college course on campus was idealistic. The actualization would be complicated by not having a college or university within driving distance or not being able to get the required release time from work. The desire to get away from the work-place so that they could give the course their undivided attention was often cited as a high motivational factor.

Engineers/scientists were given the opportunity to list specific subjects they would like to take in the next three years. Appendix C lists the courses requested. Management courses were requested most frequently (151) followed by computer courses (114). This appears to be at variance with previous data in which engineers and scientists stated that non-technical courses would not be as important to their professional growth as technical courses.

Technicians and Technologists. While conducting the survey, it was discovered that many individuals who were called "engineers" did not actuall meet the educatioal or experiential requirements as defined by this study. The compilation of their responses to the survey appears in Appendix D.

ANALYSIS OF MANAGEMENT OFFICIAL DATA

Description of Participating Companies. Management interviews were set up at 61 different companies and conducted with company officials who had knowledge of or access to information and data concerning the continuing education of scientists and engineers at their particular plant locations. A distribution of the industrial response to the managerial survey is presented in Table 47. Electrical machinery, machinery (except electrical), and textile industries

TABLE 47. Distribution of the Management Officials by Standard Industrial Classification

SIC code	Industry	Percent of management officials (N=61)
22	Textile mill products	16.39
23	Apparel and finished products	9.84
24	Lumber and wood products	3.28
25	Furniture and fixtures	6.56
26	Paper and allied products	3.28
28	Chemicals and allied products	3.28
30	Rubber and miscellaneous plastic products	4.92
32	Stone, clay, glass and concrete products	1.64
33	Primary metal industries	1.64
34	Fabricated metal products	1.64
35	Machinery, except electrical	16.39
36	Electrical and electronic machinery	19.67
37	Transportation equipment	11.47

had the strongest representation. The management officials were fairly evenly distributed among the three employment size designations (Table 48).

TABLE 48. Distribution of the Management Officials by Size of Company

Size designation	Total employment	Percent of participants (N=61)
S1	1 - 166	27.87
S2	167 - 333	37.70
S3	334 - 500	34.43

primarily engaged in manufacturing. Consulting and other operations had c ly slight representation (Table 49).

TABLE 49. Type Plant Operation

Primarily engaged in:	Percent of officials (N=58)
Manufacturing	91.38
Engineering activities, such as consulting	1.72
Scientific research and development	0
Other	6.90

The average number of employees (full and part-time) was 272.64 with a standard deviation of 193.88. The average number of engineers and scientists employed per location was 7.98, with a standard deviation of 13.76. The large standards of deviation in both cases reflect great differentials in the responses. The relatively low number of engineers and scientists employed was predictable and resulted from sampling restrictions related to size and location of industrial firms surveyed. It should be noted here that while the interviewers defined the terms "engineer" and "scientist" to management officials, they did not necessarily meet with any or all to certify that they met the requirements defined in the study.

Use/Support/Effectiveness of Structured Educational Resources. The management officials interviewed were asked to provide information and data regarding the use of structured educational resources by their engineer/scientist employees during the last three years. Table 50 presents the percentage of organizations using/sponsoring structured educational resources by length of course. It shows a decided preference for educational courses that are less than thirty (30 hours in length and for the workshop/short course, college course, and in-compar course delivery systems.

TABLE 50. Structured Educational Resources Sponsored During the Last Three Years

Type of resource	Percent companies using/sponsoring courses		
	< 30 hours in length	> 30 hours in length	at either level
College courses, on-campus	24.59	19.67	40.98
College courses, videobased	1.64	3.28	4.92
Workshops/short courses, not in-company	57.38	14.75	62.30
In-company courses taught by non-employees	19.67	13.12	29.51
In-company courses taught by employees	26.23	16.39	37.71
Broadcast educational TV courses	9.84	3.28	13.12
Packaged media courses	6.56	0	6.56
Programmed instruction courses	4.92	8.20	13.12
Correspondence courses	8.20	4.92	13.12
Other	1.64	--	1.64

Data on the average number of courses (by type) utilized or sponsored by any single plant during the last three years are presented in Table 51. While a higher percentage of the management officials reported using workshops/short courses, not in-company (62.3 percent), the highest average usage/sponsorship occurred with college courses, on-campus, with a mean of 9.56. This was followed by in-company courses taught by employees (8.52); college courses, videobased (7.33); and workshops/short courses (6.97). Note the small number reporting college courses, videobased, however.

The structured resources with the greatest employer financial support include workshops/short courses, not in-company; college courses, on-campus; and in-company courses taught by non-employees and employees (Table 52). Overall,

TABLE 51. Average Number of Structured Educational Resources Sponsored During the Last Three Years

	< 30 hours			> 30 hours			Total		
Type of resource	N*	Mean	SD**	N*	Mean	SD**	N*	Mean	SD**
On campus college courses	15	9.00	12.73	12	8.67	9.57	25	9.56	13.24
College courses -- videobased	1	1.00	--	2	10.50	13.44	3	7.33	10.97
Workshops/short courses, not in-company	35	6.09	8.22	9	5.78	6.94	38	6.97	9.16
In-company courses taught by non-employee	12	1.83	0.94	8	4.88	6.81	18	3.39	4.67
In-company courses tuaght by employee	16	6.63	8.62	10	9.00	11.51	23	8.52	10.44
Broadcast educational TV	6	2.17	1.17	2	1.00	0	8	1.88	1.13
Packaged media courses	4	6.50	5.75	0			4	6.50	5.75
Programmed instruction	3	7.67	10.69	5	3.40	3.78	8	5.00	6.76
Correspondence courses	5	1.20	0.45	3	3.00	2.00	8	1.88	1.46
Other	1	1.00	0	0			1	1.00	--
Total number of all courses							52	16.92	21.04

* Number of participants
** Standard deviation

TABLE 52. Employer Support for Structured Educational Resources During Last Three Years as Reported by Management Officials

Type of resource	Of those participating, percent offering this support: Payment for books/supplies	Partial reimbursement for travel, subsistence	Full reimbursement for travel, subsistence	Release time from work to be made up by employee	Release time from work at full pay	Release time from work at partial pay	No support provided	Partial tuition or fee reimbursement	Full tuition or fee reimbursement
College courses, on-campus	48.00	16.00	32.00	12.00	20.00	4.00	8.00	16.00	64.00
College courses, videobased	33.33	--	33.33	--	33.33	--	--	--	33.33
Workshops, short courses not in company	63.16	2.63	73.68	--	52.63	2.63	--	--	65.79
In-company courses taught by non-employees	55.56	11.11	33.33	11.11	55.56	--	--	--	55.56
In-company courses taught by employees	39.13	4.35	52.17	--	56.52	--	--	--	47.83
Broadcast educational TV	37.50	--	37.50	--	37.50	--	12.50	12.50	25.00
Packaged media courses	75.00	--	--	--	--	--	--	--	--
Programmed instruction	37.50	12.50	37.50	--	37.50	--	12.50	--	62.50
Correspondence courses	50.00	12.50	--	--	--	--	12.50	25.00	12.50
Other	100.00	--	--	100.00	--	--	--	--	--

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the kinds of support most frequently given include payment for books and supplies (∿ 38 to 63 percent), full reimbursement for travel and subsistence (∿ 33 to 73 percent), release time from work at full pay (∿ 20 to 56 percent), and full payment for tuition (∿ 12 to 65 percent). Note that while 80 percent of the participating companies provide full or partial tuition reimbursement for employees taking college courses on-campus, and 48 percent pay for books and supplies, only 20 percent provide release time from work at full pay. Another 12 percent allow employees to make up used time. For employees of geographically dispersed companies, this must be somewhat paradoxical. On the one hand, companies provide excellent financial support for tuition and books, and on the other, their policies regarding release time make it very difficult for employees to find the time to travel to a college campus, especially during normal working hours.

When management officials were asked to rate the effectiveness of structured educational resources used/sponsored by their companies, they were most enthusiastic about college courses, on-campus, which had one of the highest mean ratings (3.41). They also rated in-company courses taught by non-employees; workshops/short courses, not in-company; college courses, videobased; and packaged media courses as very effective (Table 53). Note the low number of responses for videobased college courses and packaged media courses, however.

Use/Support/Effectiveness of Unstructured Educational Resources. Management officials reported that their engineer/scientist employees made substantial use of unstructured educational resources in doing their jobs during the last three years (Table 54). Almost two-thirds (65.57 percent) reported that each of their engineers/scientists consulted with colleagues in their own company an average of 15.23 hours per month regarding technical and job related matters. Slightly over 50 percent said their engineers/scientists utilized the self-study of text materials and technical journals for an average of 8.68 hours per month per engineer/scientist, and 44.26 percent indicated that almost a day a month (7.93 hours) was spent in technical consultation with colleagues outside their companies. Technical society meetings and special supervised technical projects were also popular unstructured educational resources utilized.

TABLE 53. Employer Ev- -ion of Effectiveness of Structured Educatio- -urces Used/Sponsored During Last Three Y

Type of resource	Number of management officials	Mean*	Standard deviation
College courses, cn-campus	22	3.41	0.73
College courses, videobased	3	3.00	1.00
Workshops/short courses, not in-company	32	2.91	0.59
In-company courses taught by non-employee	15	3.07	0.70
In-company courses taught by employee	21	2.57	0.68
Broadcast educational TV	7	2.29	0.49
Packaged media courses	2	3.50	0.71
Programmed instruction	5	2.60	0.55
Correspondence courses	7	2.00	0.58
Other	1	3.00	--

While there was general support by management for this use of unstructured educational resources by their engineers/scientists, the lack of well defined company policies complicated the collection and interpretation of data. Table 55 indicates that release time from work, reimbursement for travel, and payment for books and supplies were the types of support most frequently provided, although less than half of those reporting their participation actually provided support for most of the resources.

In evaluating the effectiveness of unstructured educational resources, management officials rated special supervised technical projects and technical consultation with colleagues in their own company highest (Table 56). Technical consultation with colleagues outside their company and the self-study of textbooks and

TABLE 54. Unstructured Educational Resources Used/Sponsored During the Last Three Years

Type of resource	Percent participating by resource (N=61)	Average hours per engineer per month	Standard deviation	Average number of this type resource utilized per month	Standard deviation
Self-study of textbooks/journals	60.66	8.68	10.60	7.47	13.67
Technical consultation with colleagues in own company	65.57	15.23	16.10	5.69	8.04
Technical consultation with colleagues outside company	44.26	7.93	11.53	5.00	4.63
Technical society meetings	36.07	2.18	1.74	1.81	1.83
Special supervised technical projects	22.95	14.79	22.32	1.70	1.16
Other	3.28	3.50	3.54	5.00	--

TABLE 55. Employer Support for Unstructured Educational Resources During the Last Three Years as Reported by Management Officials

	Of those participating, percent offering this support						
	Payment for books/supplies	Partial reimbursement for travel, subsistence	Full reimbursement for travel, subsistence	Release time from work to be made up by employee	Release time from work at full pay	Release time from work at partial pay	No support provided
Self-study books/journals	81.08	--		5.41	27.03	--	8.11
Technical consultation with colleagues in own company	22.50	--	27.50	--	35.00	--	2.50
Technical consultation with colleagues outside company	11.11	--	33.33	--	22.22	--	7.41
Technical society meetings	50.00	9.09	59.09	4.55	31.82	--	4.55
Special supervised projects	14.29	--	21.43	--	43.86	--	--
Other	--	--	--	--	100.00	--	--

technical journals were next. In fact, the effectiveness of all listed unstructured resources was rated higher than average by management officials.

TABLE 56. Management Officials' Evaluation of Effectiveness of Unstructured Educational Resources Used/Sponsored During the Last Three Years

Type of resource	Number of management officials	Mean*	Standard deviation
Self-study textbooks/journals	33	2.49	0.71
Technical consultation with colleagues in own company	35	3.20	0.68
Technical consultation with colleagues outside company	28	2.89	0.69
Technical society meetings	23	2.30	0.64
Special supervised technical projects	12	3.25	0.75
Other	2	3.00	0

*Rating values: 4-most effective; 3-very effective; 2-satisfactory or neutral; 1-slightly effective; 0-not effective at all

Recognition or Reward for Participation in CE. The recognition given to employees by management for participation in CE is detailed in Table 57. Placing a record of CE participation in the employee's personnel file was the most frequently used (72.13 percent) recognition. A certificate of completion was given by 54.10 percent of the companies and pay raises and promotions were reported appropriate for 29.51 and 21.31 percent, respectively. However, on several occasions during the interviews, those managers who listed pay raises and promotions as rewards verbally qualified their responses. They emphasized that such rewards were not automatically given, nor was CE the sole basis of such recognition, but that it was a contributing factor.

TABLE 57. Recognition Given to Employees Within a Reasonable Time Following Their Participation in CE

Type of recognition	Percent of companies (N=61)
Certificate of completion	54.10
Record of CE participation put in personnel file	72.13
Pay raise	29.51
Promotion	21.31
Other	4.92

Annual Expenditures for Engineer/Scientist CE. When companies were asked to estimate the annual expenditures for continuing education for engineers and scientists during the most recent 12 months (to include tuition, materials, and related travel only), the variance in response was enormous. For tuition reimbursement programs, the average annual expenditure was $16,466, with a standard deviation of $43,494.39. For all other activities the average annual expenditure was $8,458, with a standard deviation of $29,139.12.

Employer Perceptions of Engineer/Scientist Objectives for Continuing Education. Management officials rated the preparation for increased responsibility, gaining new insights and exploring alternative solutions, and performing present job assignment better as the most important reasons for engineer/scientist participation in CE (Table 58). The objectives of attaining a salary increase or meeting the expectations of management received below average ratings. Other objectives were rated average to important.

Requested Courses and Preferred Delivery Systems. Management officials were asked to identify technical course subjects (specific or general) that they would like to have made available to their employees during the next three

TABLE 58. Employer Perceptions of Engineer/Scientist Objectives for Continuing Education

Objectives	Number of management officials	Mean*	Standard deviation
Prepare for increased responsibility	58	3.28	0.70
Gain new insights, explore alternative solutions	57	3.16	0.77
Perform present job assignment better	58	3.10	0.81
Attain enhanced position in your field	57	2.68	0.93
Prepare for new job in current field	55	2.44	0.92
Remedy deficiencies in initial education	56	2.18	0.97
Fulfill requirements for a promotion	56	2.14	1.18
Intellectual stimulation	56	2.13	1.03
Maintain your present position in company	57	2.05	1.09
Prepare for a new job in another field	57	2.02	1.06
Attain salary increase	56	1.93	1.06
Meet expectations of management	56	1.89	1.23

* Rating values: 4-of highest importance; 3-very important; 2-moderately important; 1-slightly important; 0-not at all important

years. They were also asked why their employees had not already taken such courses and what delivery systems they preferred for their employees.

A total of 117 different technical course subjects and 9 management course subjects were listed by management officials as needed during the next three years. The listing in Appendix C shows that the largest number of requested courses fell within the industrial, mechanical, and chemical engineering fields.

According to management officials, there were two major reasons why engineers/ scientists had not already taken the desired courses (Table 59). First, 52.08 percent said the courses they wanted were unavailable, and second, 33.33 percent indicated that desired courses were not available at a convenient location. Further study of these two reasons reveals a tie that is not readily apparent. From the listing of desired courses, it is obvious to CE professionals that most are already available. This suggests that small geographically

TABLE 59. Reasons Employees Had Not Taken Desired Courses Previously As Reported by Management Officials

Reasons	Percent of management officials (N=61)
It is not available	52.08
Not available at a convenient time	6.25
Not available at a convenient location	33.33
Delivery system not appropriate	4 17
Too costly as presently offered	8.33
Level of available course too low	6.25
Level of available course too high	2.08
Other	6.25

dispersed companies may not be receiving announcements and promotional materials about course availability from the sponsoring organizations. And, the fact that a large percent of the management officials indicated that courses were not offered at a convenient location is probably a direct consequence of their plant's being located away from metropolitan areas, coupled with their unwillingness to have employees travel very far.

Three other factors that one would expect to be important to the overall CE population (course cost, course delivery system, and course timing) were relatively unimportant to the officials surveyed.

Management officials indicated a strong preference for the workshop/short course, not in-company, delivery system for CE courses to be taken during the next three years (Table 60). There was moderate support for college courses, on-campus, and in-company courses taught by non-employees.

TABLE 60. Preferred Delivery Systems for Taking CE Courses During the Next Three Years as Reported by Managers

Delivery systems	Percent of management officials (N=47)
College courses, on-campus	23.40
College courses, videobased	6.38
Workshops/short courses, not in-company	42.55
In-company courses taught by non-employees	21.28
In-company courses taught by employees	2.13
Broadcast educational TV	--
Packaged media courses	--
Programmed instruction	--
Correspondence courses	2.13
Other	2.13

CROSS ANALYSIS OF DATA FROM ENGINEERS/SCIENTISTS AND MANAGEMENT OFFICIALS

A review of the questionnaires used (Appendix A) reveals that questions 11, 12, 14, and 22 in the engineer/scientist form are identical to 4, 5, 8, and 9 respectively in the management form. The responses to these common questions are analyzed here.

Structured/Unstructured Educational Resources -- Use/Sponsorship, Support, Effectiveness. Of all the delivery systems listed in Tables 12 and 50, engineers/scientists and management officials showed a greater use of workshops/short courses, not in-company. There was also general agreement on the next three most used delivery systems as shown below. Note that the use of a particular delivery system does not necessarily mean that it is preferred. Preferences will be covered later in this section.

Engineers/ scientists ranked by usage	Four most used/sponsored delivery systems for structured education	Management officials ranked by sponsorship
1	Workshop/short courses, not in-company	1
2	In-company courses, employee taught	3
3	College courses, on-campus	2
4	In-company courses, non-employee taught	4

The level of usage for all other delivery systems is low and is expected to remain low, with the possible exception of college courses, videobased, and packaged media courses. These similar delivery systems are relatively new. Their development is continuing, and usage is expected to increase.

Both engineers/scientists and management officials agreed that the use/sponsorship of the shorter length courses (< 30 hours) was greater than for the longer courses (> 30 hours).

Data from engineer/scientist and management official groups showed that college courses, on-campus, had the most repeated utilization of all the resources (Tables 13 and 51). This is not surprising since college courses, on-campus, represents the commitment of individuals or the sponsorship of individuals as compared with commitments for groups of people when utilizing some of the other resources.

For both the use/sponsorship and repeatability of the resources, the data provided by management officials was higher than that provided by the engineers/scientists. This may suggest that employees do not participate in continuing education activities as often as they are given opportunities. There may have been situations, however, where every course offered at a particular location was not applicable or beneficial to any one individual scientist/engineer. Management officials were providing data on all courses offered, across the board, to their engineer/scientist employees, while engineers/scientists, on the other hand, were providing data on the resources they used individually.

Figure 6 illustrates the differences between the support offered by companies for structured continuing education during the last three years and the support actually used by engineers/scientists during the same period. While there are only a few cases (e.g. payment for books and supplies for workshops/short courses) where there is statistical evidence to indicate stronger employer support than employee usage (Tables 20, 52, and B-26), the higher employer response may have implications. Engineers/scientists may not be aware of the full range of educational benefits offered by their employers; company policy may not be well defined for educational support programs; and preference may be given to certain employees for years of service to the company or job performance.

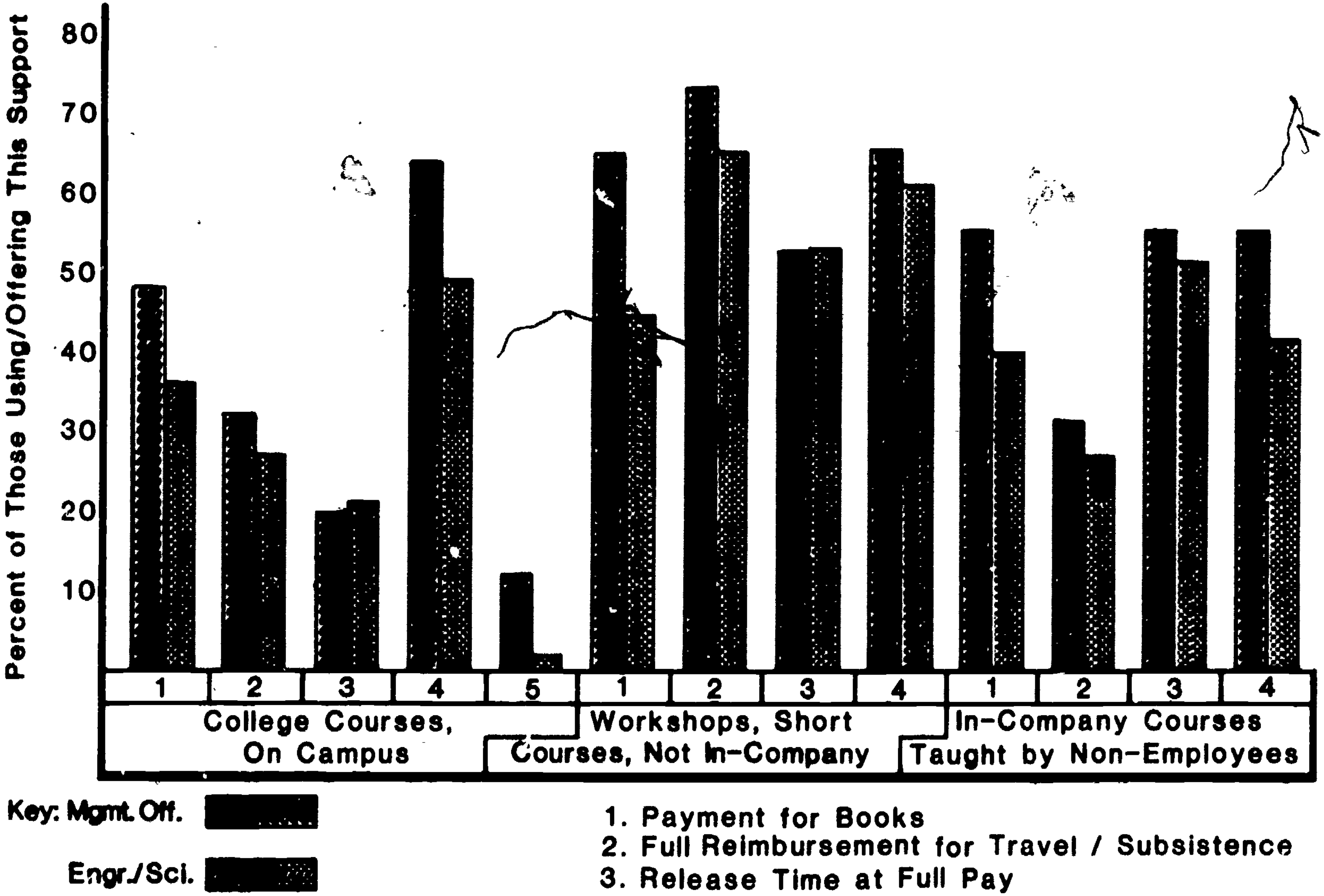
Similar patterns were observed in analyzing the support for unstructured educational resources (Tables 31 and 55). Again, although there are only a few cases with sufficient statistical evidence (B-27), support seemed to exceed usage (Figure 7).

Comparisons of the evaluation of effectiveness for structured and unstructured educational resources between engineers/scientists and management officials are illustrated in Figures 8 and 9. For all resource types for both structured and unstructured CE, management officials and engineers/scientists were found to be in general agreement. Of the delivery systems for structured resources, packaged media courses; college courses, on-campus; in-company courses, non-employee taught; and workshops/short courses, not in-company, were rated highest. Management officials rated one delivery system, college courses, on-campus, significantly higher than engineers/scientists did (B-28).

Of the delivery systems for unstructured resources, special supervised technical projects, technical consultation with colleagues in their companies, and technical consultation with colleagues outside their companies were rated most effective (B-29).

Comparison of Objectives for Participating in Continuing Education. In rating the objectives for participating in CE, engineers/scientists and management officials selected the same top four (Figure 10), although their rankings were interchanged. They agreed that gaining new insights and exploring alternative solutions, performing present job better, preparing for increased

FIGURE 6. Comparisons of Support for Structured Educational Resources During the Last Three Years as Reported by Engineers/Scientists and Management Officials

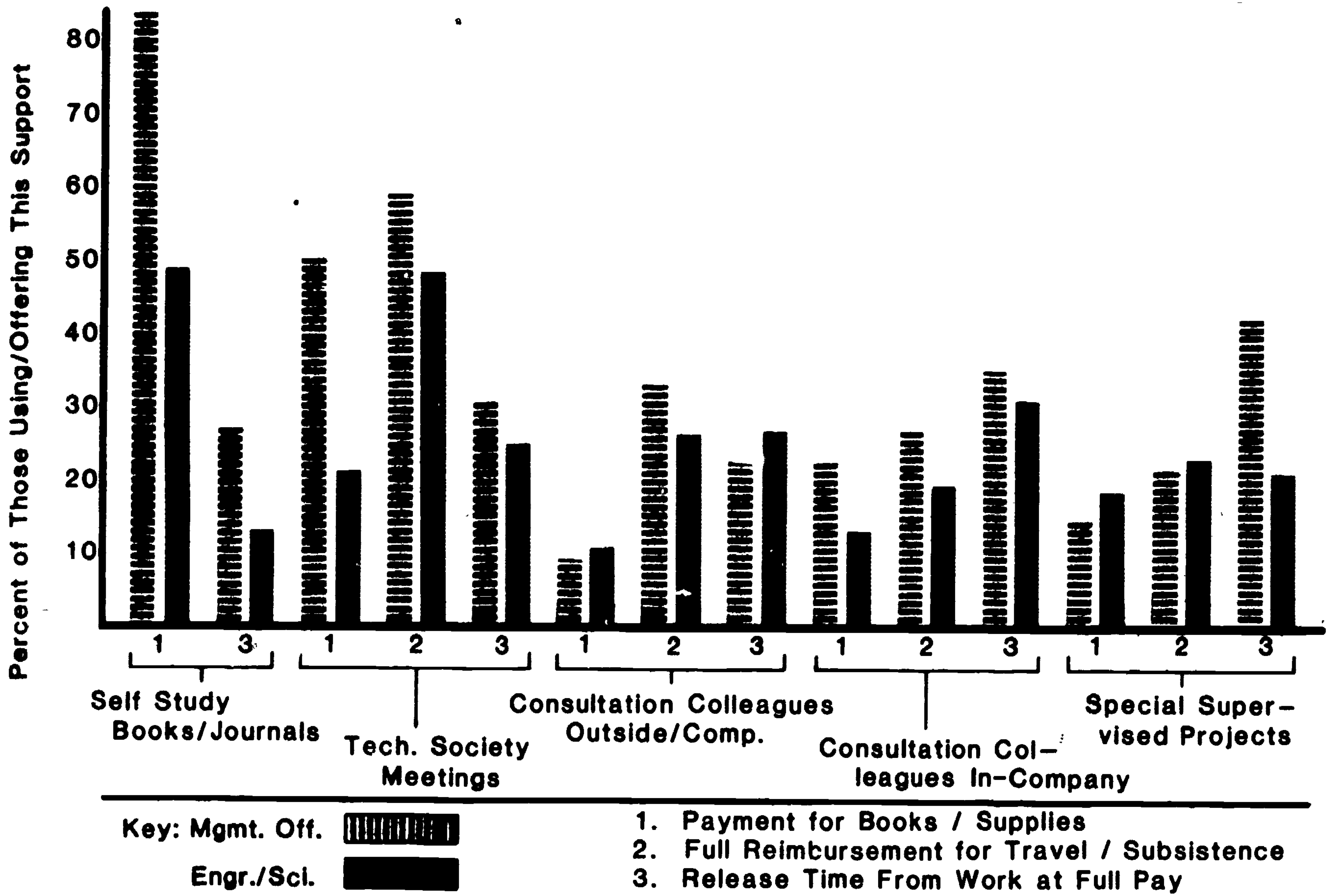


Reference: Tables 20, 52, B-26

96

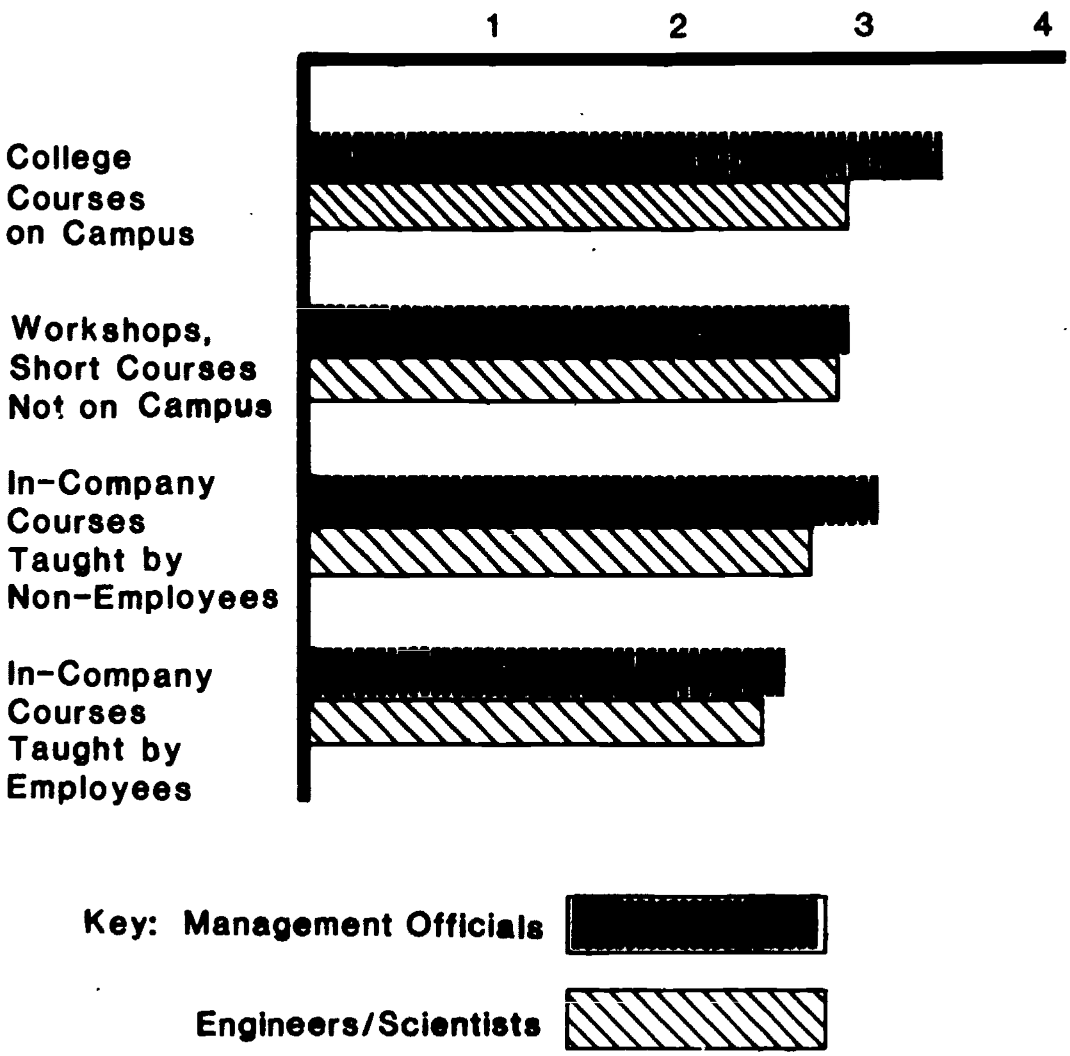
75

Figure 7. Comparisons of Support for Unstructured Educational Resources During the Last Three Years as Reported by Engineers/Scientists and Management Officials



Reference: Tables 31, 55, B-27

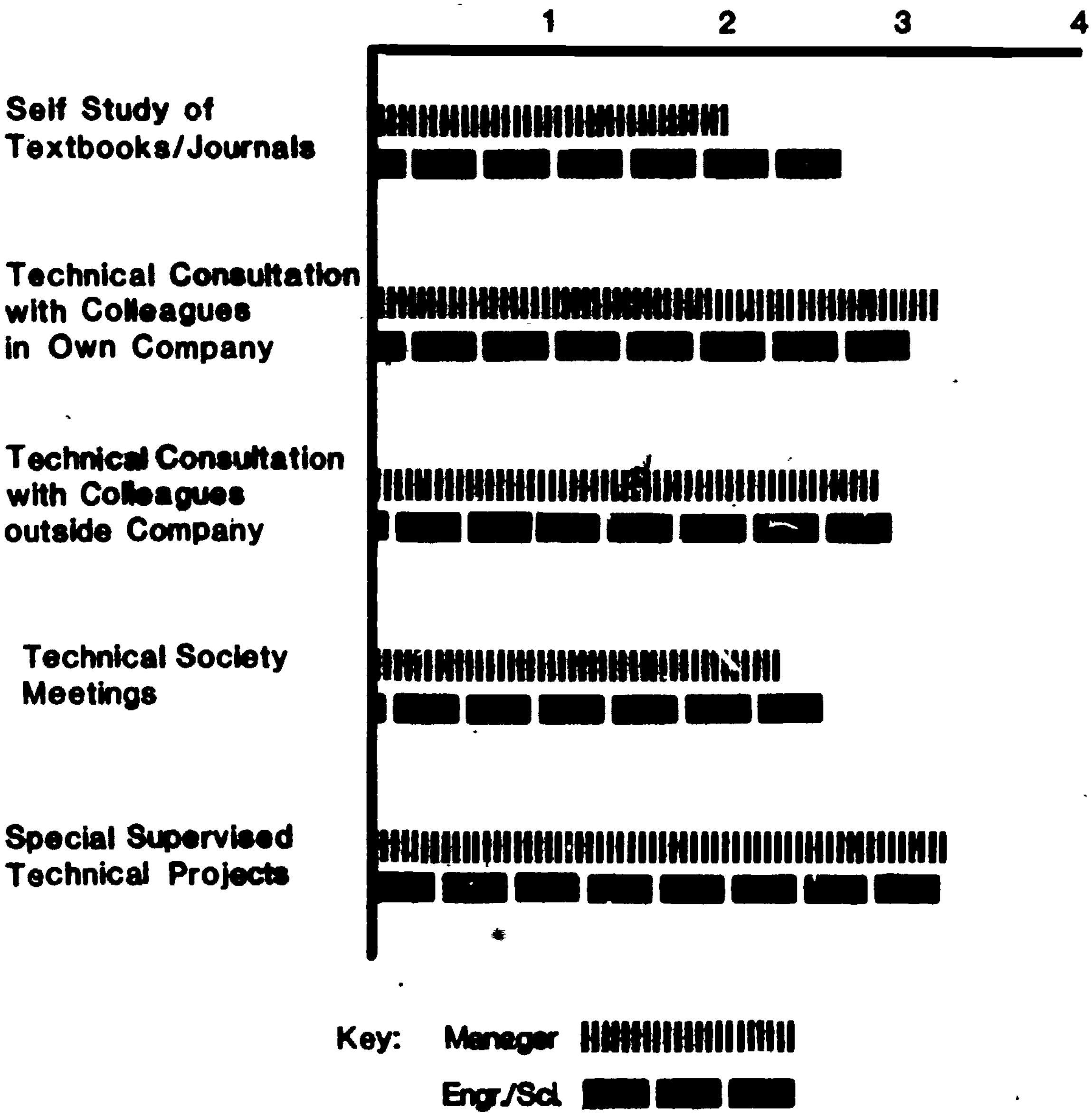
Figure 8. Comparison of Effectiveness Ratings of Structured Educational Resources by Engineers/Scientists and Management Officials



Rating Values: 4 - most effective
3 - very effective
2 - satisfactory or neutral
1 - slightly neutral
0 - not effective at all

Reference: Tables 24, 53, B-28

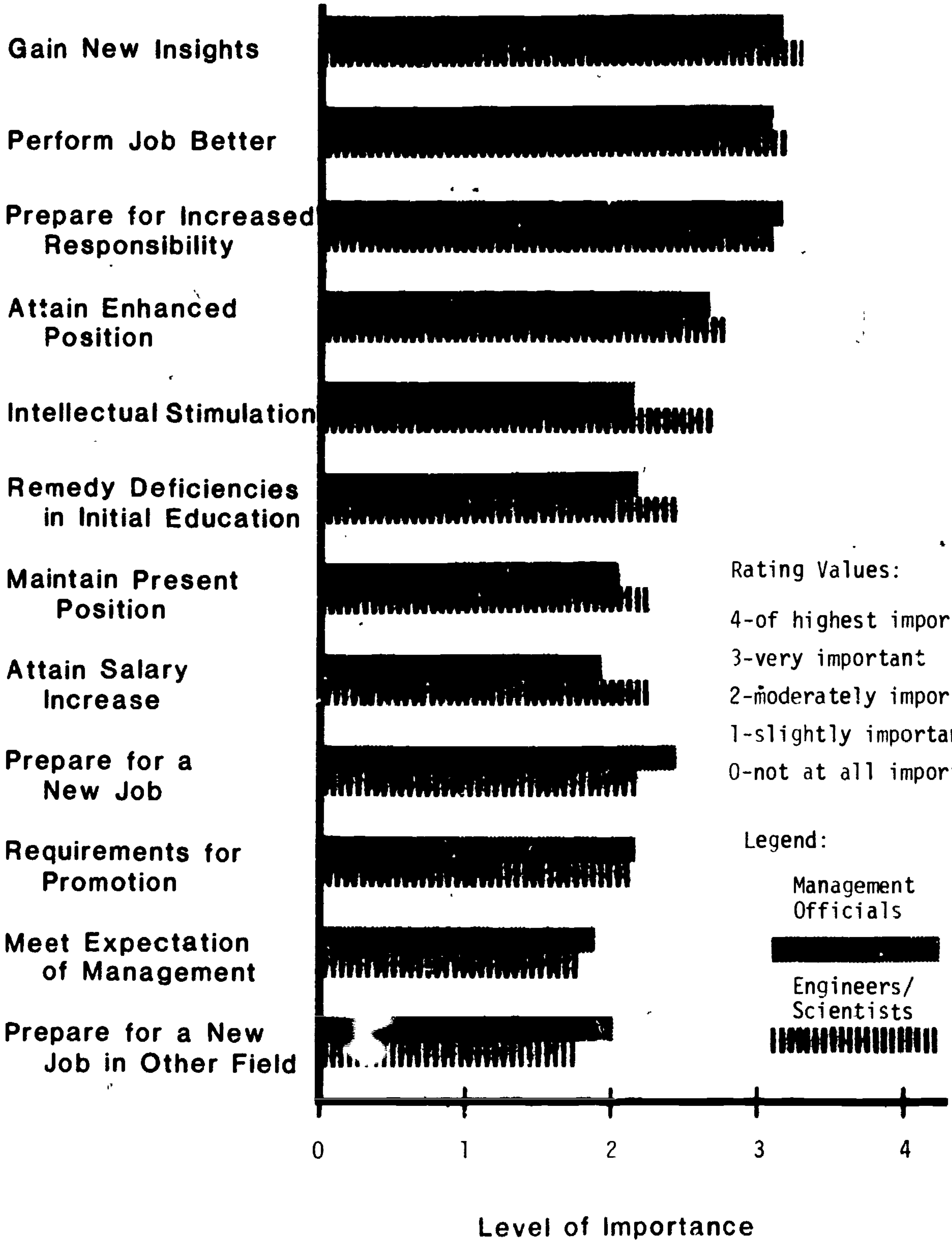
Figure 9. Comparison of Effectiveness Ratings of Unstructured Educational Resources by Engineers/Scientists and Management Officials



Rating Values:
4 - most effective
3 - very effective
2 - satisfactory or neutral
1 - slightly neutral
0 - not effective at all

Reference: Tables 32, 56, B-29

Figure 10. Objectives for Participating in Continuing Education as Reported by Engineers/Scientists and Management Officials



Reference: Tables 35, 58, B-30

responsibility, and attaining an enhanced position in their fields were the most important objectives for participating in CE. They disagreed on the ranking of intellectual stimulation, as management officials did not perceive it as important as engineers/scientists did, and on preparation for a new job, where the opposite was observed (B-30).

Comparison of Requested Courses and Preferred Delivery Systems. Both engineers/scientists and management officials were asked to identify CE courses that they needed or would like to see offered during the next three years. In response, 926 listings were received from the engineer/scientist group and 125 from the management official group. These inputs were taken from individuals, so it is not surprising that there were many duplications within each list as well as between them (Appendix C). In fact, duplications are very important in showing the depth of interest to CE professionals who plan and offer courses.

Because of the number of inputs, the engineer/scientist listing was both broader in topics covered and more specific in the identification of particular subjects or courses. The fields that received the largest number of course listings from the engineer/scientist group are management with 144 listings (48 of which are directly related to engineering management), computer science with 116, industrial engineering with 114, mechanical engineering with 99, and chemical engineering/chemistry with 77.

The management official listing was more general, but it focused more on engineering and science than the engineer/scientist listing. The heaviest emphasis was in the industrial engineering (32), mechanical engineering (21), and chemical engineering (20) fields.

From the following comparison it can be seen that engineers/scientists focused on three major reasons why they had not previously attended needed or desired CE courses. Management officials narrowed their major reasons to two for employee failure to take desired courses earlier.

Both groups agreed on the top two reasons -- courses not available or not available at a convenient location. However, on the third major reason listed by engineers/scientists -- not available at a convenient time -- there was wide disagreement. This likely stems more from the engineers'/scientists' crowded schedules than from management's unwillingness to let them take courses at a particular time. Note that the delivery system and cost factors were relatively unimportant.

Reported by engineers/ scientists (percent)	Reasons for not taking desired courses earlier	Reported by management officials (percent)
34.55	Course not available	52.08
26.40	Not available at convenient time	6.25
34.55	Not available at convenient location	33.33
5.62	Delivery system not appropriate	4.17
7.02	Too costly as presently offered	8.33
4.21	Level of available course too low	6.25
0.56	Level of available course too high	2.08
12.36	Other	6.25

In listing their preferred (first choice) delivery system for taking needed or desired courses, engineers/scientists selected two major ones and management officials selected three as seen in the following comparison.

Engineers/ scientists (percent)	Preferred (first choice) delivery system for taking needed or desired courses	Management officials (percent)
38.26	College courses, on-campus	23.40
6.96	College courses, videobased	6.38
34.78	Workshops/short courses, not in-company	42.55
6.95	In-company courses taught by non-employees	21.28
0.87	In-company courses taught by employees	2.13
3.19	Broadcast educational TV courses	--
1.45	Packaged media courses	--
4.06	Programmed instruction courses	--
2.61	Correspondence courses	2.13
0.87	Other	2.13
100.00		100.00

Engineers/scientists showed a slight preference for college courses, on-campus (38.26 percent) over workshops/short courses, not in-company (34.78 percent). This probably reflects both their comfort with traditional college courses and their satisfaction with workshops/short courses, not in-company. Management officials indicated a strong preference for workshops/short courses, not in-company (42.55 percent) followed by college courses, on-campus (23.40 percent) and in-company courses taught by non-employees (21.28 percent).

Substantial differences between engineers/scientists and management officials were noted for college courses (38.26 vs 23.40 percent, respectively) and for in-company courses taught by non-employees (6.95 vs 21.28 percent, respectively). These preferences by management officials probably reflect their reluctance to commit to the longer (semester length) courses which are viewed by many as more formal and less applicable to work situations.

Of the remaining systems, college courses, videobased, was ranked highest by both groups. This is considered excellent response considering that this delivery system has only been available in North Carolina on a limited basis during the last three years. Also worth noting is that in-company courses taught by employees was ranked lowest by engineers/scientists (0.87 percent) and near the bottom by management officials (2.13 percent).

In summary, a study of the listings of requested courses is very revealing. In comparing those courses with files of past course announcements, it is obvious that roughly 75 to 80 percent of the courses on the engineer/scientist listing and 90+ percent of those on the management official listing are currently being offered or have been offered during the last three to five years. This suggests that small geographically dispersed companies may not be receiving announcements or promotional materials about course availability from organizations offering such courses.

To organizations developing and presenting CE programs, several opportunities have emerged. First, it would be productive to better identify the target market for programs and make sure that the geographically dispersed companies are included. They are likely to have a greater unserved need than the same size company located in a metropolitan area and management officials have indicated that timing and cost are relatively unimportant. Second, if a convenient location is as important as indicated, then there is opportunity for the aggressive organization to plan and deliver some CE programs with live instruction at company sites. And, third, since geographically dispersed companies are less choosey about delivery systems, there is opportunity for the delivery of good packaged media courses.

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The following summary and conclusions are based upon information and data collected from 480 engineers/scientists and 61 management officials who work in small (1 to 500 employees), geographically dispersed industrial and consulting engineering organizations located in North Carolina. Further details can be obtained by referring to the proper section in the report.

SUMMARY/CONCLUSIONS

- Only a small percent of North Carolina's engineers and scientists (estimated to be less than ten percent) work in small, geographically dispersed companies. In several instances interviewers found that engineers and/or scientists serving small, geographically dispersed plants often provided service from their base of operations in sister plants located near larger cities. Of course, these did not qualify for the study. It also was not uncommon for interviewers to find that engineers/scientists working in small, geographically dispersed companies would commute 50 to 75 miles or more daily in order to establish their households ne a larger city.

- While a majority of the engineers/scientists reporting (56.6 percent) had been with their present organization four or more years, comparatively more (77.2 percent) had been practicing engineers or scientists for more than four years. This reflects some mobility or turnover, but it also confirms the relative stability of employment among engineers and scientists working in small, geographically dispersed plants.

- Of the participants accepted as performing as engineers or scientists, 81.7 percent had a Bachelor of Science or higher level degree. Of the total number interviewed (569) who had been described as performing engineering or scientific work, 89 (or 15.64 percent) were judged by the interviewers as not meeting the basic educational or experience criteria used in the study and, consequently, were placed into a classification denoted as technician or technologist. Data concerning this group is presented in Appendix D. This latter group would have been much larger (perhaps 30 to 40 percent of the total) had the person arranging the face-to-face interviews not recognized the situation and made adjustments by obtaining further information concerning the engineers'/scientists' qualifications from the management officials contacted.

- Proportionately more engineers/scientists with graduate degrees were employed by the larger companies (334 to 500 employees) than by the smaller ones (1 to 166 employees).

- Only 9.3 percent reported that they held professional certification in engineering. Another 6.9 percent reported professional certification in some other field, while 83.8 percent held no certification at all. There were proportionally more participants with Master's degrees that were certified than all other participants combined.

- Engineers/scientists who participated in structured CE during the last three years showed a definite bias for the shorter length courses (< 30 hours) over the longer courses (> 30 hours). Management officials were in agreement and reported sponsoring more of the shorter length courses than the longer ones during the last three years.

- Of all the delivery systems studied, engineers/scientists and management officials showed a greater use of workshops/short courses, not in-company, during the last three years. By actual use, the next three most popular delivery systems for both groups were in-company courses taught by employees; college courses, on-campus; and in-company courses taught by non-employees.

- Of those participating in CE, the average number of structured educational activities used over a three year period was 4.69. Participants with degrees in engineering had taken an average of 4.88 courses, which was found to be significantly higher than the average number of courses (3.78) taken by participants with degrees in other fields.

- Engineers/scientists with higher levels of supervisory responsibilities, i.e., those who supervised other engineers/scientists or supervisors, were found to have taken more courses on the average than participants with lower level or no supervisory responsibilities.

- Relatively more engineers/scientists in the age group 35 and under participated in college courses, on-campus, and in-company courses taught by employees than in the age group 36 and over. Both groups were equally represented in the use of in-company courses taught by non-employees. Also, relatively fewer young engineers/scientists (25 and under) than older (26 and over) participated in workshops/short courses, not in-company.

- Participation in most of the structured CE resources studied increased with the level of education of the participants.

- Engineers/scientists who also supervised other supervisors as a part of their jobs were found to participate proportionally more in college courses, on-campus, and less in in-company courses taught by employees.

- Data regarding the actual use by engineers/scientists or actual sponsorship by employers and the repeated uses of the resources during the last three years was higher from the management officials group than from the engineers/scientists group. This suggests that employees did not participate in CE activities as often as they were given the opportunity.

- The strongest employer support (as reported by engineers/scientists and management officials) went to workshops/short courses, not in-company. This was also the most heavily used delivery system. Employers also provided good support for college courses, on-campus; packaged media courses; in-company courses taught by non-employees and employees; and college courses, videobased. This support included either full or partial payment for tuition, books/supplies, travel, and release time from work.

- By size, the group of smallest firms with 1 to 166 employees were generally found to be more supportive of CE activities than the next larger size having 167 to 333 employees. When these two groups were combined, they were found to be more supportive of CE activities than the next larger size group with 334 to 500 employees for all types of support except full and partial tuition, where they were equally supportive.

- There was generally more support for participating in CE as the supervisory responsibilities of engineers/scientists increased.

- In rating the effectiveness of delivery systems used during the last three years for structured courses, engineers/scientists and management officials were in general agreement. Packaged media courses; college courses, on-campus; in-company courses taught by non-employees; and workshops, not in-company, were rated highest.

- Both engineers/scientists and management officials reported that a substantial usage of unstructured educational resources occurred during the last three years. Engineers/scientists relied most on the self-study of textbooks and technical journals with 74.58 percent devoting an average of 12.4 hours per month to this resource. They reported using an average of 4.66 different textbooks or journals each month. Other widely used unstructured educational resources included technical consultation with colleagues in their own company and technical consultation with colleagues outside their company.

- A majority (86.4 percent) of the participants regularly read one or more engineering or scientific journals or periodicals. By age group, relatively more young engineers/scientists (25 and under) did no reading at all and proportionally more of the age group of 46 and over read seven or more journals regularly.

- The more educated participants were relatively more involved with unstructured CE activities than the less educated ones. This suggests that participants with higher level degrees are either more aware of the need to keep themselves current in their fields or more motivated than those with other degrees.

- Because of the nature of unstructured educational resources, it was difficult to assess employer support. The lack of well defined company policies complicated the collection and interpretation of data. The strongest support components included payment for books and supplies, reimbursement for travel and subsistence, and release time from work at full pay.

- In rating the effectiveness of unstructured educational delivery systems, engineers/scientists and management officials were in agreement. They ranked special supervised technical projects most effective followed by technical consultation with colleagues in own company and technical consultation with colleagues outside their company. The resource most relied on by engineers/scientists to meet their unstructured CE needs -- self-study of textbooks/journals -- was rated next.

- Ratings of engineers'/scientists' perceptions on whether or not they were up to date in their fields increased as their level of education increased.

- Engineers/scientists and management officials agreed on the top four objectives or motivations for participating in CE. They agreed that gaining new insights and exploring alternative solutions, performing present job better, preparing for increased responsibility, and attaining an enhanced position in their fields were the most important. They disagreed on the ranking of intellectual stimulation, as management officials did not perceive it as important as engineers/scientists did, and on preparation for a new job where the opposite was observed. Both groups also agreed that attaining a salary increase or meeting the expectations of management ranked near the bottom.

- Engineer/scientist participants acknowledged that CE had been an important factor in their job performance and career growth up to now. They rated technical CE more important than non-technical, and they projected that CE would have an even greater impact on their professional growth in the future.

- In ranking their preferred delivery systems for structured CE, engineers/ scientists ranked workshops/short courses, not in-company, first; college courses, on-campus, second; and in-company courses taught by non-employees third. Correspondence courses were the least popular.

- In ranking their preferred delivery systems for unstructured CE, engineers/scientists ranked technical consultation with colleagues in their own company as a slight favorite over the next two -- self-study of textbooks/journals and technical consultation with colleagues outside their company.

- To recognize participants in CE, most employers placed a record of CE participation in the employee's file and/or presented him/her with a certificate of completion. In some cases pay raises or promotions followed; however, management officials pointed out that CE was only a contributing factor.

- For small, geographically dispersed companies, the average annual expenditure for tuition reimbursement programs was $16,466. This includes tuition, materials, and related travel only and does not include salaries or expenses of an in-house CE staff. For all other activities, the average annual expenditure was $8,458.

RECOMMENDATIONS

The following recommendations are directed to the principal benefactors of this study. Hopefully, the findings will enable them to develop and implement strategies and tactical plans that will lead to a better allocation of resources and improved results.

To all organizations that plan and offer continuing education programs for engineers and scientists, such as colleges, universities, professional societies, private companies, etc., this study contains a wealth of information and data that can and should be used to better direct and focus their efforts. Useful information and data provided include such things as a profile of the target population; types of courses and extent of participation during the last three years; preferences for courses, lengths of courses, and delivery systems; as well as a listing of unmet CE needs.

To all organizations that employ engineers and scientists, this report will be beneficial in helping them understand the needs and expectations of engineers and scientists regarding CE and the need to help keep them up to date and productive in their fields. Gaining a better understanding of their preferences for courses and delivery systems, etc., will enable employers to better organize and direct the allocation of CE resources used for engineers and scientists. It will help them understand the kinds of support needed for structured and unstructured CE and the need for developing and stating company policies on continuing education.

Engineers and scientists may find the information presented in these pages beneficial on several counts. First of all, it provides information concerning their peers, thus giving a yardstick with which to measure their own involvement in CE. Secondly, current trends are uncovered which may directly or indirectly effect the engineer or scientist. For instance, the level of supervisory responsibility is shown to be positively correlated with involvement in CE. Substantial career mobility is contingent upon keeping up with fresh technology. Certain delivery systems were clearly preferred for their effectiveness. These and other implications will help the engineer or scientist in assessing his past CE activities and planning his future CE endeavors.

To all organizations that not only see the need but also provide resources for studies that are in the nation's interest, more can and should be done. This and other parallel studies conducted in different geographic sections of the United States during the last two to three years have yielded important information and data; however, ways must be found to carry these efforts forward. For example, there are many, many almost forgotten engineers/scientists in geographically dispersed areas working for city, county, state, or federal agencies and for non-profit service organizations such as health care facilities. What about them? Or what about that very large engineer/scientist population living and working in urban areas?

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APPENDIX A

SURVEY INSTRUMENTS

Engineer/Scientist Form
Management Form

NORTH CAROLINA STATE UNIVERSITY
School of Engineering

SURVEY OF CONTINUING EDUCATION FOR ENGINEERS AND SCIENTISTS

Engineer/Scientist Form

Survey Objectives

The Industrial Extension Service (IES), School of Engineering, North Carolina State University, is conducting a study of continuing education (CE) delivery systems in North Carolina. The principal objectives of the study are:

- To identify and describe continuing education resources currently being utilized by engineers and scientists to maintain and extend their professional competence and capabilities.
- To determine the extent of use and the perceived effectiveness of these educational resources in meeting the CE needs of scientists and engineers.
- To identify deficit CE needs of scientists and engineers and the preferred delivery systems.

All information and data obtained from engineers and/or scientists will be consolidated and published in aggregate form only. Therefore, no individual data will be identifiable in the study results. Your participation and assistance with this study will be greatly appreciated.

SURVEY OF CONTINUING EDUCATION FOR ENGINEERS AND SCIENTISTS

Engineer/Scientist Form

Survey Number. . . . . E ___ ___ ___ ___ (1-5)

Standard Industrial Classification . . . . ___ ___ (6-7)

Sample Category. . . . . ___ (8)

Survey Questions 1 (9)

1. HOW OLD ARE YOU? (Circle one) (10)
   a. 25 and under
   b. 26 to 35
   c. 36 to 45
   d. 46 and over

2. WHAT IS THE HIGHEST ENGINEERING OR SCIENTIFIC DEGREE YOU HOLD? (Circle one) (11)
   a. High school diploma
   b. Associate or technical degree
   c. Bachelor of Engineering Technology
   d. Bachelor of Science degree
   e. Master's degree
   f. Ph.D./Ed.D./M.D.
   g. Other (specify:________________)

3. IN WHAT SUBJECT AREA DID YOU RECEIVE YOUR HIGHEST ENGINEERING OR SCIENTIFIC DEGREE? (Circle one) (12)
   a. Physical Sciences (Physics, Chemistry, Geology, etc.)
   b. Life Sciences (Zoology, Botany, Entomology, etc.)
   c. Social Sciences (Sociology, Economics, etc.)
   d. Engineering (all fields)
   e. Mathematics and/or statistics
   f. Information/Library Science
   g. Computer Science
   h. Other (specify:________________)

4 DO YOU HOLD PROFESSIONAL CERTIFICATION? (Circle one) (13)
   a. Yes, in engineering
   b. Yes, in other field (specify:________________)
   c. No

5. FOR HOW MANY YEARS HAVE YOU BEEN EMPLOYED WITH YOUR PRESENT ORGANIZATION? (Circle one) (14)
   a. 3 or under
   b. 4 to 9
   c. 10 or over

6. FOR HOW MANY YEARS HAVE YOU BEEN EMPLOYED AS AN ENGINEER OR A SCIENTIST? (Circle one) (15)
   a. 3 or under
   b. 4 to 9
   c. 10 or over

7. WHICH ONE CATEGORY BEST DESCRIBES YOUR HIGHEST CURRENT LEVEL OF SUPERVISORY RESPONSIBILITY?(Circle one) (16)
   a. No supervisory responsibility
   b. Supervision of technicians and/or non-technical personnel
   c. Supervision of engineering and/or scientific personnel (may also supervise technicians)
   c. Management of supervisory personnel
   d. Executive (upper management)

8. WHICH ONE CATEGORY BEST DESCRIBES YOUR HIGHEST CURRENT LEVEL OF TECHNICAL RESPONSIBILITY?(Circle one) (17)
   a. Perform limited assignments with specific direction under an experienced engineer or scientist
   b. Perform assignments with limited direction, with a general review of work done
   c. Perform most work independently with directions only to general results expected
   d. Work independently in extending known techniques, data, etc.
   e. Technical direction and review of work performed by others

9. HOW MANY ENGINEERING OR SCIENTIFIC JOURNALS OR PERIODICALS IN YOUR FIELD DO YOU REGULARLY READ? (Circle one) (18)
   a. Don't regularly read any
   b. Read 1 to 3 regularly
   c. Read 4 to 6 regularly
   d. Read seven or more regularly

10. WITH HOW MANY COLLEAGUES IN OTHER ORGANIZATIONS DO YOU EXCHANGE SCIENTIFIC OR ENGINEERING INFORMATION ON A REGULAR BASIS? (Circle one) (19)
   a. None
   b 1 to 3
   c. Over 3

3

II. IDENTIFY THE STRUCTURED EDUCATIONAL RESOURCES (DELIVERY SYSTEMS) YOU HAVE USED DURING THE LAST THREE YEARS.

Type of educational resource (delivery system)	Enter number of courses utilized according to length		Enter number of courses utilized according to college credit		Type of employer support.* Circle all applicable numbers for each resource (28-31)	Your evaluation of the effectiveness of each resource.** Circle one for each resource (32)	
	Less than 30 hours	30 hours or more	Credit	Non-credit			
a) College courses On-Campus	(20-21)	(22-23)	(24-25)	(26-27)	1 2 3 4 5 6 7 8 9	4 3 2 1 0	(20-32)
b) College courses Videobased					1 2 3 4 5 6 7 8 9	4 3 2 1 0	(33-45)
c) Workshops, Short Courses, etc. not In-Company					1 2 3 4 5 6 7 8 9	4 3 2 1 0	(46-58)
d) In-Company Courses taught by non-employees					1 2 3 4 5 6 7 8 9	4 3 2 1 0	(59-71)
e) In-Company Courses taught by employees					1 2 3 4 5 6 7 8 9	4 3 2 1 0	(Dupl 1-8, 2-9) (10-22)
f) Broadcast Educational TV					1 2 3 4 5 6 7 8 9	4 3 2 1 0	(23-35)
g) Packaged Media Courses					1 2 3 4 5 6 7 8 9	4 3 2 1 0	(36-48)
h) Programmed Instruction					1 2 3 4 5 6 7 8 9	4 3 2 1 0	(49-61)
i) Correspondence Courses					1 2 3 4 5 6 7 8 9	4 3 2 1 0	(62-74)
j) Other ______ Specify					1 2 3 4 5 6 7 8 9	4 3 2 1 0	(Dupl 1-8, 3-9) (10-22)

*Type of Employer Support

1. Payment for book, supplies, etc.
2. Partial reimbursement for travel, subsistence
3. Full reimbursement for travel, subsistence
4. Release time from work (to be made up by employee)
5. Release time from work (including sabbatical, fellowship, grant, etc.) at full pay
6. Release time from work at partial pay
7. No support provided
8. Partial tuition or fee reimbursement
9. Full tuition or fee reimbursement

**Effectiveness of Resource

4 - Most effective
3 - Very effective
2 - Satisfactory or neutral
1 - Slightly effective
0 - Not effective at all

12. IDENTIFY THE UNSTRUCTURED EDUCATIONAL RESOURCES (DELIVERY SYSTEMS) YOU HAVE USED DURING THE LAST THREE YEARS.

Type of educational resource (delivery system)	Approximate number of hours per month	Approximate number of this type educational resource utilized per month.	Type of employer support.* Circle all applicable numbers for each resource. (27-29)	Your evaluation of the effectiveness of each resource.** Circle one for each resource. (30)	
a) Self-study of Textbooks, Technical Journals, etc.	(23-24)	(25-26)	1 2 3 4 5 6 7	4 3 2 1 0	(23-30)
b) Technical consultation with Colleagues in own company			1 2 3 4 5 6 7	4 3 2 1 0	(31-43)
c) Technical consultation with Colleagues outside of company			1 2 3 4 5 6 7	4 3 2 1 0	(44-56)
d) Technical Society Meetings			1 2 3 4 5 6 7	4 3 2 1 0	(57-69)
e) Special Supervised Technical Projects			1 2 3 4 5 6 7	4 3 2 1 0	(Dupl 1-8, 4-9) (10-22)
f) Other ______ Specify			1 2 3 4 5 6 7	4 3 2 1 0	(23-35)

*Type of Employer Support

1. Payment for book, supplies, etc.
2. Partial reimbursement for travel, subsistence
3. Full reimbursement for travel, subsistence
4. Release time from work (to be made up by employee)
5. Release time from work (including sabbatical, fellowship, grant, etc.) at full pay
6. Release time from work at partial pay
7. No support provided

**Effectiveness of Resource

4 - Most effective
3 - Very effective
2 - Satisfactory or neutral
1 - Slightly effective
0 - Not effective at all

13. HOW UP-TO-DATE DO YOU CONSIDER YOURSELF IN YOUR TECHNICAL FIELD? CIRCLE APPROPRIATE NUMBER. (36)

4 - Right up-to-date
3 - Almost up-to-date
2 - Moderately up-to-date
1 - Slightly up-to-date
0 - Not up-to-date at all

14. PEOPLE HAVE DIFFERENT OBJECTIVES IN PARTICIPATING IN CONTINUING EDUCATION. PLEASE RATE EACH OF THE FOLLOWING OBJECTIVES IN TERMS OF THEIR IMPORTANCE TO YOU. USE THE FOLLOWING SCALE.

4 - Of highest importance
3 - Very important
2 - Moderately important
1 - Slightly important
0 - Not at all important

(37-48)

	Circle One Number for Each Objective				
a. To maintain your present position in company.	4	3	2	1	0
b. To attain enhanced or authoritative position in your field.	4	3	2	1	0
c. To perform your present job assignment better	4	3	2	1	0
d. To prepare yourself for increased responsibility.	4	3	2	1	0
e. To remedy deficiencies in your initial education.	4	3	2	1	0
f. To prepare yourself for a new job in your current field of specialization.	4	3	2	1	0
g. To prepare yourself for a new job in some other field of specialization.	4	3	2	1	0
h. To attain a salary increase	4	3	2	1	0
i. To fulfill requirements for promotion	4	3	2	1	0
j. To meet expectations or ease pressure of supervisors or management.	4	3	2	1	0
k. For intellectual stimulation.	4	3	2	1	0
l. To gain new insights, explore alternative solutions, obtain fresh ideas, etc.	4	3	2	1	0

15. IF CONTINUING EDUCATION HAS BEEN IMPORTANT, HAS IT, IN YOUR OPINION, BEEN A MAJOR FACTOR IN: (49-60)
(Circle Appropriate Letters)

a. Maintaining your present position in your company
b. Attaining an enhanced or authoritative position in your field
c. Performing your present job assignment better
d. Preparing yourself for increased responsibility
e. Remedying deficiencies in your initial education
f. Preparing yourself for a new job in your current field of specialization
g. Preparing yourself for a new job assignment in some other field of specialization
h. Attaining a salary increase for yourself
i. Fulfilling requirements for promotion
j. Meeting expectations or easing pressure of your supervisor or manager
k. Stimulating you intellectually
l. Gaining new insights, exploring alternative solutions, obtaining fresh ideas, etc.

16. HOW IMPORTANT HAS CONTINUING EDUCATION BEEN IN YOUR PROFESSIONAL GROWTH UP TO NOW? (61-62)

Technical Continuing Education (61)	Circle Appropriate Number	Non-technical Continuing Education (62)
4	Of highest importance	4
3	Very important	3
2	Moderately important	2
1	Slightly important	1
0	Not at all important	0

17. HOW IMPORTANT DO YOU EXPECT CONTINUING EDUCATION WILL BE TO YOUR FUTURE PROFESSIONAL GROWTH? (63-64)

Technical Continuing Education (63)	Circle Appropriate Number	Non-technical Continuing Education (64)
4	Of highest importance	4
3	Very important	3
2	Moderately important	2
1	Slightly important	1
0	Not at all important	0

18. N CONSIDERING THEM FOR YOUR OWN USE, RATE THE FOLLOWING STRUCTURED EDUCATIONAL RESOURCES (DELIVERY YSTEMS) ACCORDING TO YOUR PREFERENCE.

4 - Like very much
3 - Like
2 - Neutral toward
1 - Dislike
0 - Strongly dislike

(65-74)

	Circle One Number for Each Resource				
a. College Courses On-Campus	4	3	2	1	0
b. College Courses, Videobased	4	3	2	1	0
c. Workshops, Short Courses, etc. not In-Company	4	3	2	1	0
d. In-company courses taught by non-employees	4	3	2	1	0
e. In-company courses taught by employees	4	3	2	1	0
f. Broadcast Educational TV	4	3	2	1	0
g. Packaged Media Courses	4	3	2	1	0
h. Programmed Instruction	4	3	2	1	0
i. Correspondence Courses	4	3	2	1	0
j. Other ______	4	3	2	1	0

19. IN CONSIDERING THEM FOR YOUR OWN USE, RATE THE FOLLOWING UNSTRUCTURED EDUCATIONAL RESOURCES (DELIVERY SYSTEMS) ACCORDING TO YOUR PREFERENCE.

4 - Like very much
3 - Like
2 - Neutral toward
1 - Dislike
0 - Strongly dislike

(Dupl 1-8, 5-9) (10-15)

	Circle One Number for Each Resource				
a. Self-study of Textbooks, Technical Journals, etc.	4	3	2	1	0
b. Technical consultation with colleagues in own company	4	3	2	1	0
c. Technical consultation with colleagues outside of company	4	3	2	1	0
d. Technical Society Meetings	4	3	2	1	0
e. Special Supervised Technical Projects	4	3	2	1	0
f. Other ______	4	3	2	1	0

20. IN YOUR OPINION, DOES YOUR IMMEDIATE SUPERVISOR OR MANAGER EXPECT YOU TO PARTICIPATE IN CONTINUING EDUCATION ACTIVITIES?(Circle one)

a. Yes b. No c. Don't know (16)

21. DOES YOUR IMMEDIATE SUPERVISOR OR MANAGER ENCOURAGE YOU TO PARTICIPATE IN CONTINUING EDUCATION ACTIVITIES? (Circle one)

a. Yes b. No (17)

22. WHAT SUBJECTS (SPECIFIC OR GENERAL) WOULD YOU LIKE TO TAKE IN THE NEXT THREE YEARS?

Subjects wanted: (Such as "Transportation of Hazardous Materials" or "Energy Conservation"	Why haven't you taken them already?* Circle all appropriate letters for each subject listed. (31-36)	What delivery system would you prefer?** Circle one for each subject listed. (37)	
	a b c d e f g h	a b c d e f g h i j	(31-37)
	a b c d e f g h	a b c d e f g h i j	(38-44)
	a b c d e f g h	a b c d e f g h i j	(45-51)
	a b c d e f g h	a b c d e f g h i j	(52-58)

*Reasons not taken

a. It is not available
b. It is not available at a convenient time
c. It is not available at a convenient location
d. The delivery system is not appropriate
e. It is too costly as presently offered
f. The level of the available course is too low
g. The level of the available course is too high
h. Other (List in Column)

**Delivery Systems

a. College Courses On-Campus
b. College Courses Videobased
c. Workshops, Short Courses, etc., not In-Company
d. In-company courses taught by non-employees
e. In-company courses taught by employees
f. Broadcast Educational TV
g. Packaged Media Courses
h. Programmed Instruction
i. Correspondence
j. Other (List in Column)

NORTH CAROLINA STATE UNIVERSITY
School of Engineering

SURVEY OF CONTINUING EDUCATION FOR ENGINEERS AND SCIENTISTS

Management Form

Survey Objectives

The Industrial Extension Service (IES), School of Engineering, North Carolina State University, is conducting a study of continuing education (CE) delivery systems in North Carolina. The principal objectives of the study are:

- To identify and describe continuing education resources currently being utilized by engineers and scientists to maintain and extend their professional competence and capabilities.

- To determine the extent of use and the perceived effectiveness of these educational resources in meeting the CE needs of scientists and engineers.

- To identify deficit CE needs of scientists and engineers and the preferred delivery systems.

All information and data on continuing education for engineers and scientists obtained from a company official will be consolidated and published in aggregate form only. Therefore, no individual company data will be identifiable in the study results. Your participation and assistance with this study will be greatly appreciated.

Definitions

Person Completing This Form: A company official who has knowledge of or access to information and data concerning the continuing education of engineers and scientists at this particular plant location should complete this form. Do not include engineers and scientists working at other plant locations. If two different divisions (of the same company) are operating at the same plant location, complete the survey form for your division only.

Engineers and/or Scientists: Employees who hold at least a bachelor's degree in an engineering or scientific field, or who, in the opinion of the respondent are equally qualified as engineers or scientists in some other way, such as by experience or competent performance of engineering or scientific duties, and who spend more than half of their time in any of the following job functions:

research	maintenance
development	planning
testing and evaluation	contract and grant administration
design	data collection
construction	providing or researching of scientific or technical information
inspection	enforcement of standards or regulations
production	other engineering or scientific activities
installation	
operation	

Specifically excluded are engineers and scientists who spend more than half their time in management, sales, advertising, personnel work, teaching and training, or providing medical, psychological, or social services.

Time Period: Include all activities conducted or supported during the last year or last three years where indicated. If more convenient, fiscal periods may be used.

Number of Activities: Count each distinct activity only once. If the same activity is conducted at 3 different times or for 3 different groups of participants, it should be counted as only 1 activity.

Types of Continuing Education Activities To Be Reported

STRUCTURED

College credit courses, graduate or undergraduate, held in college or university facilities

College credit courses, graduate or undergraduate, using videobased instruction, usually held in off-campus facilities

Workshops, short courses, seminars, etc., usually noncredit and sponsored and conducted by universities, professional societies, and/or private organizations. Usually not held in-company

In-company courses taught by non-employees

In-company courses taught by employees

Broadcast educational television courses

Packaged media courses with instruction on film or videotape accompanied by student study and exercise manuals

Programmed instruction courses

Correspondence courses

Other (specify)________________

UNSTRUCTURED

Self-study of textbooks, technical journals, etc.

Technical consultation with colleagues within your company

Technical consultation with colleagues outside your company

Technical society meetings

Special supervised technical projects

Other (specify) ________________

Note: Include only those activities designed to further engineering or scientific knowledge (e.g., management courses should not be reported).

NORTH CAROLINA STATE UNIVERSITY
School of Engineering

SURVEY OF CONTINUING EDUCATION FOR ENGINEERS AND SCIENTISTS

Management Form

Survey Number. . . . . M __ __ __ __ (1-5)

Standard Industrial Classification . . . . __ __ (6-7)

Sample Category. . . . . __ (8)

1 (9)

Survey Questions

1. CIRCLE THE LETTER THAT BEST CHARACTERIZES YOUR PLANT/COMPANY OPERATION? (Single Physical Location) (10)

   a. Primarily engaged in manufacturing and employ engineers and scientists
   b. Primarily engaged in engineering activities, such as consulting
   c. Primarily engaged in scientific research and development activities
   d. Primarily engaged in other activities, but employ engineers and/or scientists

2. HOW MANY TOTAL EMPLOYEES DO YOU HAVE (FULL AND PART-TIME) AT YOUR PLANT/COMPANY LOCATION? (Single Physical Location). . . . . ________ (11-14)

3. HOW MANY OF THESE EMPLOYEES ARE CURRENTLY WORKING AS ENGINEERS OR SCIENTISTS (Per Definition on page 1) . . . . ________ (15-17)

   a. This is an estimate (Circle one) (18)
   b. This is an actual count

4. IDENTIFY THE STRUCTURED EDUCATIONAL RESOURCES (DELIVERY SYSTEMS) THAT HAVE BEEN USED AT THIS LOCATION DURING THE LAST THREE YEARS

Type of educational resource (delivery system)	Enter number of courses utilized according to length		Enter number of courses utilized according to college credit		Type of employer support.* Circle all applicable numbers for each resource (27-30)	Your evaluation of the effectiveness of each resource.** Circle one for each resource. (31)	
	Less than 30 hours	30 hours or more	Credit	Non-credit			
a) College courses On-Campus	(19-20)	(21-22)	(23-24)	(25-26)	1 2 3 4 5 6 7 8 9	4 3 2 1 0	(19-31)
b) College Courses Videobased					1 2 3 4 5 6 7 8 9	4 3 2 1 0	(32-44)
c) Workshops, Short Courses, etc., not In-Company					1 2 3 4 5 6 7 8 9	4 3 2 1 0	(45-57)
d) In-Company Courses taught by non-employees					1 2 3 4 5 6 7 8 9	4 3 2 1 0	(58-70)
e) In-Company Courses taught by employees					1 2 3 4 5 6 7 8 9	4 3 2 1 0	(Dupl 1-8, 2-9) (10-22)
f) Broadcast Educational TV					1 2 3 4 5 6 7 8 9	4 3 2 1 0	(23-35)
g) Packaged Media Courses					1 2 3 4 5 6 7 8 9	4 3 2 1 0	(36-48)
h) Programmed Instruction					1 2 3 4 5 6 7 8 9	4 3 2 1 0	(49-61)
i) Correspondence Courses					1 2 3 4 5 6 7 8 9	4 3 2 1 0	(62-74)
j) Other ______ Specify					1 2 3 4 5 6 7 8 9	4 3 2 1 0	(Dupl 1-8, 3-9) (10-22)

*Type of Employer Support

1. Payment for book, supplies, etc.
2. Partial reimbursement for travel, subsistence
3. Full reimbursement for travel, subsistence
4. Release time from work (to be made up by employee)
5. Release time from work (including sabbatical, fellowship, grant, etc.) at full pay
6. Release time from work at partial pay
7. No support provided
8. Partial tuition or fee reimbursement
9. Full tuition or fee reimbursement

**Effectiveness of Resource

4 - Most effective
3 - Very effective
2 - Satisfactory or neutral
1 - Slightly effective
0 - Not effective at all

5. IDENTIFY THE UNSTRUCTURED EDUCATIONAL RESOURCES (DELIVERY SYSTEMS) THAT HAVE BEEN USED AT THIS LOCATION DURING THE LAST THREE YEARS.

Type of educational resource (delivery system).	Average hours per engineer/ scientists per month.	Approximate number of this type educational resource utilized per month.	Type of employer support.* Circle all applicable numbers for each resource. (28-30)	Your evaluation of the effectiveness of each resource.** Circle one for each resource. (31)	
a) Self-study of Textbooks, Technical Journals, etc.	(23-24)	(25-27)	1 2 3 4 5 6 7	4 3 2 1 0	(23-31)
b) Technical consultation with Colleagues in own company			1 2 3 4 5 6 7	4 3 2 1 0	(32-44)
c) Technical consultation with Colleagues outside of company			1 2 3 4 5 6 7	4 3 2 1 0	(45-57)
d) Technical Society Meetings			1 2 3 4 5 6 7	4 3 2 1 0	(58-70)
e) Special Supervised Technical Projects			1 2 3 4 5 6 7	4 3 2 1 0	(Dupl 1-8 4-9) (10-22)
f) Other ______ Specify			1 2 3 4 5 6 7	4 3 2 1 0	(23-35)

*Type of Employer Support

1. Payment for book, supplies, etc.
2. Partial reimbursement for travel, subsistence
3. Full reimbursement for travel, subsistence
4. Release time from work (to be made up by employee)
5. Release time from work (including sabbatical, fellowship, grant, etc.) at full pay
6. Release time from work at partial pay
7. No support provided

**Effectiveness of Resource

4 - Most effective
3 - Very effective
2 - Satisfactory or neutral
1 - Slightly effective
0 - Not at all effective

6. WHAT TYPES OF REWARDS OR RECOGNITIONS ARE GIVEN WITHIN A REASONABLE TIME TO EMPLOYEES WHO PARTICIPATE IN CONTINUING EDUCATION ACTIVITIES? CIRCLE APPROPRIATE LETTERS. (36-40)

a. Certificate of completion
b. Record of continuing education participation placed in individual's personnel file
c. Pay raise
d. Promotion
e. Other (please specify)______________________

7. ESTIMATE YOUR ANNUAL EXPENDITURE FOR CONTINUING EDUCATION FOR ENGINEERS AND SCIENTISTS DURING THE MOST RECENT 12 MONTHS. (INCLUDE TUITION, MATERIALS, AND RELATED TRAVEL.) DO NOT INCLUDE SALARIES AND EXPENSES FOR YOUR IN-HOUSE CONTINUING EDUCATION STAFF OR EXPENDITURES FOR CAPITAL EQUIPMENT.

a. For tuition reimbursement programs. . . . .$____________ (41-46)

b. For all other activities. . . . .$____________ (47-52)

8. PLEASE RATE ACCORDING TO YOUR PERCEPTION, EACH OF THE FOLLOWING CONTINUING EDUCATION OBJECTIVES IN TERMS OF THEIR IMPORTANCE TO YOUR ENGINEERING AND SCIENTIFIC EMPLOYEES.

4 - Of highest importance
3 - Very important
2 - Moderately important
1 - Slightly important
0 - Not at all important

(53-64)

	Circle One Number for Each Objective				
a. To maintain present position in the company.	4	3	2	1	0
b. To attain enhanced or authority position in their field.	4	3	2	1	0
c. To perform present job assignments better.	4	3	2	1	0
d. To prepare for increased responsibility.	4	3	2	1	0
e. To remedy deficiencies in initial training	4	3	2	1	0
f. To prepare for new jobs in same field of specialization.	4	3	2	1	0
g. To prepare for new jobs in some other field of specialization.	4	3	2	1	0
h. To attain a salary increase.	4	3	2	1	0
i. To fulfill requirements for promotion.	4	3	2	1	0
j. To meet expectations or ease pressure of management for supervisor . .	4	3	2	1	0
k. For intellectual stimulation	4	3	2	1	0
l. To gain new insights, to explore alternative solutions, obtain fresh ideas, etc..	4	3	2	1	0

9. WHAT TECHNICAL SUBJECTS (SPECIFIC OR GENERAL) WOULD YOU LIKE TO HAVE MADE AVAILABLE BY OUTSIDE RESOURCES DURING THE NEXT THREE YEARS?

Subjects wanted: (Such as "Transportation of Hazardous Materials" or "Energy Conservation")	Why haven't your employees taken them already?* Circle all appropriate letters for each subject listed. (65-70)	What delivery system would you prefer?** Circle one for each subject listed. (71)	
	a b c d e f g h	a b c d e f g h i j	(65-71)
	a b c d e f g h	a b c d e f g h i j	(72-78)
	a b c d e f g h	a b c d e f g h i j	(Dupl 1-8 5-9) (10-16)
	a b c d e f g h	a b c d e f g h i j	(17-23)
	a b c d e f g h	a b c d e f g h i j	(24-30)

*Reasons not taken

a. It is not available
b. It is not available at a convenient time
c. It is not available at a convenient location
d. The delivery system is not appropriate
e. It is too costly as presently offered
f. The level of the available course is too low
g. The level of the available course is too high
h. Other (List in Column)

**Delivery Systems

a. College Courses On-Campus
b. College Courses Videobased
c. Workshops, Short Courses, etc., not In-Company
d. In-company courses taught by non-employees
e. In-company courses taught by employees
f. Broadcast Educational TV
g. Packaged Media Courses
h. Programmed Instruction
i. Correspondence
j. Other (List in Column)

APPENDIX B

STATISTICAL ANALYSIS TABLES

Data on the responses of engineers/scientists and managers to various questions are presented in Tables B-1 to B-30 along with the appropriate statistical test performed at a chosen significance level.

The level of significance is defined to be the chance of making an error whenever the hypothesis is rejected (i.e., rejection of a true hypothesis). The level of significance was chosen to be either 2.5 percent, 5 percent, or 10 percent.

The hypothesis tested is explicitly stated in the first few tables. For the remaining tables, the hypothesis being tested is whether the apparent differences in proportions are statistically significant or not.

TABLE B-1. Years Employed as an Engineer/Scientist by Company Size

Size of Industry	Percent of participants		
	3 or under	4 - 9	10 or over
S_2 & S_3	25.24	33.3	41.5
S_1	18.18	24.24	57.58

1. 3 or under: Ho: $P_{S_2 \& S_3} \leq P_{S_1}$

   $Z = 1.82$ significant at 5% level. Reject Ho in favor of the alternative $P_{S_2 \& S_3} > P_{S_1}$

2. 4 - 9: Ho: $P_{S_2 \& S_3} \leq P_{S_1}$

   $Z = 2.13$ significant at 2.5% level. Reject Ho in favor of the alternative $P_{S_2 \& S_3} > P_{S_1}$

3. 10 or over: Ho: $P_{S_2 \& S_3} \geq P_{S_1}$

   $Z = 3.39$ significant at any level. Reject Ho in favor of the alternative $P_{S_2 \& S_3} < P_{S_1}$

Conclusion:

For "10 or over" indicating experienced engineers/scientists and for "4-9," "3 or under" less experienced, we conclude that more experienced engineers can be found among those employed in S_1 rather than in S_2 & S_3 size industries.

TABLE B-2. Distribution of Participants by Principal Industries by Highest Degree Held

SIC Industry	Percent Graduates
22 & 28	6.21
35 & 36	11.81
	Bachelor of Science
36 & 28	80.3
22 & 35	61.3

Ho: $P_{22 \& 28} \geq P_{35 \& 36}$

$Z_G = 1.6$ significant at 6%. Hence reject Ho in favor of

$P_{22 \& 28} < P_{35 \& 36}$

Ho: $P_{36 \& 28} \leq P_{22 \& 35}$

$Z_{BS} = 3.54$ significant at any level. Hence reject Ho in favor of

$P_{22 \& 35} < P_{36 \& 28}$

Conclusion:

Graduate Degree: It appears (at level of significance 6%) that the % of graduate degrees is higher in 35 & 36 than in 22 & 28.

Bachelor of Science: There is a higher concentration of B.S. degrees in 36 & 28 than in 22 & 35.

TABLE B-3. Graduate Degrees by Company Size

Company size designation	Percent of engineer/scientist employees holding graduate degrees
S_3	12.49
S_1 and S_2	7.93

Ho: $P_{S_3} \leq P_{S_1 \ \& \ S_2}$

Z = 1.55 significant at 7% level. Reject Ho in favor of $P_{S_3} > P_{S_1 \ \& \ S_2}$

<u>Conclusion:</u> There are more graduate degrees in S_3 firms than in S_1 and S_2 firms.

TABLE B-4. Professional Certification of Participants by Age Group

Age	Percent who have professional certification
Under 35	13.62
36 and over	18.39

Z = 1.42 significant at 10% level

<u>Conclusion</u>: 35 and over are more likely to be certified than 35 and under.

TABLE B-5: Professional Certification of Participants by Highest Degree Held (Percent)

Highest degree held	Engineering & other
Other degrees	14.98
Master's degree	34.21
Z	2.433

<u>Conclusion</u>: There were proportionally more master's degrees certified than all other degrees (level of significance 2.5%).

TABLE B-6. Participants' Highest Level of Supervisory Responsibility

SIC Industry	Percent of participants: None	Tec..s. or Non-Techs.	Engineers or Scientists
22 & 28	12.6	36.4	42.7
35 & 36	41.7	16.5	35.4

None: Ho: $P_{22\ \&\ 28} \geq P_{35\ \&\ 36}$

Z_N = 5.61 significant at any level. Reject Ho in favor of $P_{22\ \&\ 28} < P_{35\ \&\ 36}$

Techs. ^r Non-Techs: Ho: $P_{22\ \&\ 28} \leq P_{35\ \&\ 36}$

Z_T = 3.83 siginficant at any level. Reject Ho in favor of $P_{22\ \&\ 28} > P_{35\ \&\ 36}$

Engineers or Scientists: Ho: $P_{22\ \&\ 28} = P_{35\ \&\ 36}$

Z_{EN} = 1.23 significant at 12%

Conclusion:

It appears that 35 & 36 are involved in less supervision than 22 & 28.

At the level "Engineers or Scientists," there is not enough evidence to conclude the same result.

TABLE B-7. Average Number of Courses Participated in During the Last Three Years by Field

Area of highest degree	Average no. of courses taken	Variance of mean
Others	3.78	.178929
Engineering	4.88	.1073739

APT*-test: 2.078

df: 43 significant at any level

Conclusion: The average number of courses taken by employees with a degree in engineering was higher than the average number of courses taken by employees with degrees in other fields.

* APT-test = approximate t-test

TABLE B-8. Average Number of Courses Participated in During Last Three Years

Highest level of supervisory responsibility	Average no. of courses	Variance
Others	4.11 (N=193)	22.845
Engineers/scientists and supervisors	5.29 (N=185)	22.434

t-test: 2.41

df: 376 highly significant

Conclusion: On the average, those in "engineers/scientists" and "supervisors" categories are taking more courses than others.

TABLE B-9. Percent of Participants Using Structured Educational Resources During the Last Three Years by Principal Industry

Standard industrial classification	College courses on campus	Workshops/ short courses, not in-company
22 & 28 (N=145)	(18 + 12) 20.68	(42 + 34) 54.48
35 & 36 (N=126)	(23 + 20) 34.12	(30 + 24) 42.86
Z	2.489	1.92
Ho	$P_{22\&28} \geq P_{35\&36}$	$P_{22\&28} \leq P_{35\&36}$

Conclusion: In both cases, the the Z test is significant at 5% level, hence reject Ho in favor of $P_{22\ \&\ 28} < P_{35\ \&\ 36}$ and $P_{22\ \&\ 28} > P_{35\ \&\ 36}$, respectively. Thus, it appears that the percent of employees who take college courses on campus in 35 & 36 is higher than the percent in 22 & 28. Furthermore, it seems that relatively fewer engineers/scientists in 35 & 36 participate in workshops/short courses not in-company than in 22 & 28.

Industry classification	In-company workshops taught by employee	Z	Ho
22 & 28 (N=145)	(24 + 17) 28.26	2.18	$P_{22\ \&\ 28} \leq P_{35}$
35 (N=66)	20.90	.94	$P_{22\ \&\ 28} \geq P_{36}$
36 (N=60)	35.00	1.78	$P_{35} \geq P_{36}$

Conclusion: There is not sufficient evidence to statistically support the apparent differences between 22 & 28 and both 35 and 36. There is, however, sufficient evidence indicating relatively more engineers/scientists participating in in-company workshops taught by employees in 36 than in 35.

Industry classification	In-company workshops taught by non-employee	Z	Ho
22 (N=83)	30.12	1.80	$P_{22} \leq P_{28\&35\&36}$
28&35&36 (N=188)	(11+14+12) 19.68		

Conclusion: It appears that there are relatively more engineers/scientists participating in 22 than in 28 & 35 & 36.

TABLE B-10. Percent of Participants Using Structured Educational Resources During the Last Three Years by Age Group

Age group	College courses on campus	Workshops in-company taught by	
		Non-employee	Employee
35 and under (N=257)	(21 + 60) 31.52	(15 + 49) 24.90	(17 + 61) 30.35
36 and over (N=223)	(25 + 16) 18.83	(27 + 24) 22.86	(26 + 22) 21.53
Z	3.25	.52	2.22

Conclusion: It appears that there are relatively more engineers/scientists participating in both college courses on-campus and workshops in-company employee taught, in the age group 35 and under than in the age group 36 and over. It was also found that both age groups are equally represented in participating in workshops in-company taught by non-employee.

Age group	Workshops not in-company
25 and under (N=59)	35.59
26 and over (N=421)	(99 + 64 + 50) 50.59
Z	2.24

Conclusion: It appears that there are relatively fewer young engineers/scientists (25 and under) than older ones (26 and over) who participate in workshops not in-company.

TABLE B-11. Percent of Participants Using Structured Educational Resources During the Last Three Years by Highest Degree Held

Resources / Highest Degree held	College courses on-campus	Workshops not in-company	In-company courses non-employee taught	In-company courses employee taught
High school (N=18)	11.11 (1)	27.78 (1)	27.78 (2)	22.22 (3)
Assoc. Tech (N=44)	27.27 (4)	40.91 (2)	29.55 (4)	15.91 (1)
Bach. Eng. Tech (N=26)	11.54 (2)	46.15 (3)	34.62 (5)	19.23 (2)
B.S. (N=324)	26.34 (3)	51.24 (4)	23.15 (3)	29.94 (5)
M.A. (N=38)	28.95 (5)	52.63 (5)	10.53 (1)	26.32 (4)

(•) = Rank of the proportions of participants in each resource by highest degree held

$S_2 = 7 + 2(11) + 3(12) = 4(15) = 5(15) = 200$

Note: S_2 is a non-parametric test-statistic for testing the hypothesis that, in each resource, the observed percentages increase in magnitude as the level of education increases, and it is significant at 5%. WOLFE-HOLLANDER, page 372 (k=4, n=5, α=.05); $S_{2(.05)}=197$

Conclusion: Participation in any of the resources appearing in the table above increases with the level of education of the participants. In other words, someone with higher education is more likely to participate in any of the programs than someone with lower education level.

TABLE B-12. Participation in Structured Educational Resources During the Last Three Years

Highest level supervised by participant	Percent of participants	
	College courses on campus	In-company workshops employee taught
Others	24.08	28.21
Supervisors	38.64	6.82
Z	1.91[1]	4.896[2]

Notes: [1]Significant at 5%
[2]Significant at any level

Conclusion: While there were proportionally more in the "supervisor" category taking college courses on campus, there were proportionally less of them participating in in-company workshops, employee taught.

TABLE B-13. Employer Support for College Courses, On-Campus

Company size	Percent receiving this support				
	Payment for books	Full travel	Free release time	Partial tuition	Full tuition
S_2 (167-333)	37.78	33.33	22.22	.0444	46.66
S_1 (1-166)	44.44	36.11	27.78	22.22	44.44
Z (Test)	.606	.185	.573	2.35[2]	.1994

Conclusion: For college courses, on campus, there is no difference in the amount of support offered by S_1 and S_2 companies, except in the case of partial tuition, where S_1 companies are more supportive.

S_1 and S_2	.407	.346	.247	.123	.457
S_3	.2683	.1220	.1220	.1463	.5610
Z	1.57[1]	3.05[1]	1.78[2]	.352	1.09

Conclusion: Comparing S_1 and S_2 (taken as a group) with S_3 companies, S_1 and S_2 companies are more supportive of college courses on campus than S_3 companies in all areas except full and partial tuition, where they are equally supportive.

Notes: [1]Significant at 10%

[2]Significant at < 5%

TABLE B-14. Employer Support for Workshops/Short Courses, Not In-Company

	Percent receiving this support				
Company size	Payment for books	Full travel	Free release time	Partial tuition	Full tuition
S_2 and S_3	47.95	69.18	59.59	3.42	65.75
S_1	38.64	59.09	42.05	3.41	53.41
Z	1.40[1]	1.56[1]	2.64[2]		1.80[2]

Notes: [1]Significant at 10%

[2]Significant at 5%

<u>Conclusion:</u> S_2 and S_3 companies are more supportive than S_1 in all types of support, except partial tuition, where they are equally supportive.

TABLE B-15. Employer Support for College Courses, On-Campus by Level of Supervisory Responsibility

Highest level supervised by participant	Books (percent)	Z
Technician/ non-technical	55.55	2.0395
Others	33.68	(2.5%)

	Percent of participants		
	Travel	Free release time	Full tuition
Others	20.95	18.10	45.71
Supervisors	64.71	35.29	70.59
B	N	N	N

Notes: B = Binomial test

N = Non-significant differences

S = Significant differences

Conclusion: There are proportionally more tech/non-tech supported for book expenses than all others.

For the remaining types of support, although it seems that "supervisors" are supported the most, there is not sufficient data to perform a sensitive enough test to prove the claim.

TABLE B-16. Percent of Participants Using Unstructured Educational Resources During Last Three Years by Highest Degree Held

Resource / Highest degree held	Self study of text-books, journals	Technical consulta-tion in-company	Technical consult. outside company	Special supervised technical projects	Technical society meetings
High School (N=18)	61.11 (1)	55.56 (2)	55.56 (5)	11.11 (2)	16.62 (1)
Assoc. tech degree (N=44)	77.27 (4)	70.46 (5)	40.91 (1)	13.64 (4)	22.73 (2)
Bach engr. tech (N=26)	76.92 (3)	50.00 (1)	42.31 (2)	3.85 (1)	23.08 (3)
B.S. (N=324)	74.69 (2)	63.89 (3)	46.61 (3)	12.96 (3)	29.94 (4)
M.A. (N=38)	81.58 (5)	68.42 (4)	50.00 (4)	23.68 (5)	39.47 (5)

(•) = The rank of the proportions of participants in each resource by highest degree held

$S_2 = 11 + 2(16) + 3(9) + 4(15) + 5(23) = 245$, (16, 9, 15, 23 are the rowwise sum of the ranks)

$S_{2(.05)} = 244$

Conclusion: It appears that the higher the educational level the more likely it is for somebody to be involved in any resource of unstructured education (similar result as in structured education).

TABLE B-17. Percent of Participants Using Unstructured Educational Resources During the Last Three Years by Age Group

Resource / Age group	Self study of text-books, journals	Technical consulta-tion in-company	Technical consult. outside company	Special supervised technical projects	Technical society meetings
25 and under (N=59)	72.88 (2)	62.71 (3)	42.37 (2)	15.25 (3)	22.03 (1)
26 - 35 (N=198)	70.78 (1)	60.60 (1)	38.38 (1)	11.61 (1)	24.24 (2)
36 - 45 (N=118)	78.81 (4)	67.80 (4)	55.93 (4)	11.86 (2)	39.83 (4)
46 and over (N=105)	78.10 (3)	61.90 (2)	54.29 (3)	16.19 (4)	35.23 (3)

(·) = Rank of the proportions of participants in each source by age group

$S_2 = 11 + 2(6) + 3(18) + 4(18) = 149$

$S_{2(.05)} = 145$

Conclusion: It appears that the older the engineer/scientist is, the higher the chance he will be involved in any of the unstructured educational resources.

TABLE B-18. Self Study of Textbooks and Technical Journals by Highest Degree Held

Highest degree held	Average hours per month	Variance of means
Other degrees	11.74	.395124
M.S. & Ph.D.	19.84	9.764

APT-test = $\frac{8.093}{10.15912}$ = 2.539

df = 41 significant at 2.5% level

<u>Conclusion</u>: Graduate degree holders spend more time in self study of textbooks and journals than all others.

TABLE B-19. Distribution of Participants Who Regularly Read Engineering or Scientific Journals or Periodicals by Age Group

Age	None (percent)
25 and under	20.34
26 and over	12.59
Z	1.413

<u>Conclusion</u>: There were proportionally more engineers in the age group 25 and under who did no reading at all than the engineers in the age group 26 and over (level of significance 10%).

Age	7 or more (percent)
45 and under	3.2
46 and over	10.48
Z	2.33

<u>Conclusion</u>: There were proportionally more engineers of age 46 and over who read 7 or more journals (level of significance 2.5%).

TABLE B-20. Distribution of Participants (Percentage) Who Regularly Read Engineering or Scientific Journals or Periodicals by Principal Industry Classification

SIC Industry	1 - 3	4 - 6
22 & 28	57.1	19.3
35 & 36	71.7	14.2

1 - 3: Ho: $P_{22\ \&\ 28} \geq P_{35\ \&\ 36}$

$Z = 3.695$ significant at any level. Reject Ho in favor of $P_{22\ \&\ 28} < P_{35\ \&\ 36}$

4 - 6: Ho: $P_{22\ \&\ 28} = P_{35\ \&\ 36}$

$Z = 1.13$ not significant (cannot reject)

<u>Conclusion</u>: 35 & 36 has about the same proportion of heavy readers (4-6 journals) as 22 & 28.

At moderate reading levels (1-3 journals), 35 & 36 do better than 22 & 28.

TABLE B-21. Personal Evaluation of Current Knowledge in Field by Highest Degree Held

Highest degree held	Mean rating	Variances of mean
Other degrees	2.43	.0021125
M.S. and PH.D. degrees	2.88	.0154365

APT-test: 3.5973

df: 42 significant at any level

Notes: Mean rating = weighted mean with weights being the sample sizes of the means as they appear on Table 34

Conclusion: Those with M.S. and Ph.D. degrees rate themselves higher than those with other degrees.

TABLE B-22. Importance of Continuing Education in Professional Growth Up Till Now

Highest level of supervisory responsibility	Mean ratings	
	Technical	Non-technical
Others	1.97 (N=230) (S^2 = 1.44)	1.62 (N=218) (S^2 = 1.43)
Eng. or scientists and supervisors	2.26 (N=224) (S^2 = 1.22)	2.18 (N=219) (S^2 = 1.4)
t-test	2.72 (df = 452)	4.98 (df = 4.98)

Conclusion: Those in the "eng. or scientists" and "supervisors" categories attribute more importance to continuing education in their professional growth than the others.

TABLE B-23. Does Manager Expect Participation in Continuing Education?

Industry	Percent of management officials	
	Manager expects participation	Manager encourages participation
28	30.64	40.32
22 & 35 & 36	50.48	61.90

Manager expects: Ho: $P_{28} \geq P_{22\ \&\ 35\ \&\ 36}$

$Z = 2.92$ significant at (almost) any level.
Reject Ho in favor of $P_{28} < P_{22\ \&\ 35\ \&\ 36}$.

Manager encourages: Ho: $P_{28} \geq P_{22\ \&\ 35\ \&\ 36}$

$Z = 3.050$ significant at any level.
Reject Ho in favor of $P_{28} < P_{22\ \&\ 35\ \&\ 36}$.

Conclusion: Fewer managers in 28 expect and encourage participation in continuing education than in 22 & 35 & 36.

TABLE B-24. Does Manager Expect Participation in Continuing Education?

Highest level supervised by participant	Manager expects (percent)
Others	41.6
Eng. or scientists and supervisors	48.44
Z	1.499*

*Significant at 10%

Conclusion: It appears that the managers' expectations for participation of their employees in continuing education is about the same for both groups.

Highest level supervised by participant	Manager encourages (percent)
Others	56.15
Supervisors	75.61
Z	2.733**

**Highly significant

Conclusion: Those in the "supervisors" category are encouraged by their managers to participate in continuing education more than the others.

TABLE B-25. Does Manager Encourage Participation in Continuing Education?

Area of highest degree	Manager encourages participation (percent)
Others	45.71
Engineering	62.22
Z	2.9*

*Significant at any level

Conclusion: Those with engineering degrees are encouraged more than the others to participate in continuing education.

TABLE B-26. Comparisons of Support for Structured Educational Resources During the Last Three Years as Reported by Engineers/Scientists and Management Officials

Type of support / Type of resource	1	2	3	4	5	6	7	8
College courses, on campus	1.1 (15%)	1.94 (2.7%)	.49	1.57 (6%)	-.06	-2.03*1 (2.5%)	.36	1.40 (10%)
College courses, videobased								
Workshops, short courses, not in company	2.21 (2.5%)	.5	1.06		-.04			.56
In-company courses taught by non-employees	1.24 (11%)		.54	1.00	.34			1.10
In-company courses taught by employees	-.05	.44	1.25 (11%)		.45			1.65 (5%)

Notes: Blanks indicate not sufficient sample size for testing.

*1 = The hypothesis is $P_{of} \geq P_r$. For the remaining tests the hypothesis is $P_{of} \leq P_r$.

The numbers in parentheses indicate the level of significance needed to reject the hypothesis in favor of the alternative ($P_{of} < P_r$ in *1 and $P_{of} > P_r$ in the remaining).

Type of support:

1 = Payment for books/supplies
2 = Partial reimbursement for travel, subsistence
3 = Full reimbursement for travel, subsistence
4 = Release time from work to be made by employee
5 = Release time from work at full pay
6 = No support provided
7 = Partial tuition
8 = Full tuition

The other structured resources are not addressed in this exercise due to lack of sufficient data.

Reference: Tables 20 and 52

TABLE B-27. Comparisons of Support for Unstructured Educational Resources During the Last Three Years as Reported by Engineers/Scientists and Management Officials

Type of resource \ Type of support	1	2	3	4
Self-study books/journals	4.59 (2.5%)		1.79 (6%)	-4.11 (2.5%)
Technical consultation with colleagues in own company	1.33 (10%)	1.08	.5208	-2.99 (2.5%)
Technical consultation with colleagues outside company	-.22	.843	-.61	-1.40 (10%)
Technical society meetings	2.55 (2.5%)	.90	.59	-1.87 (6%)

Notes: Tests for types of support 1, 2, and 3 test the hypothesis $P_{of} \leq P_r$. The remaining tests test test the hypothesis $P_{of} \geq P_r$.

The numbers in parentheses indicate the level of significance that is sufficient to reject the hypothesis.

Type of support:

1 = Payment for books/supplies
2 = Full reimbursement for travel, subsistence
3 = Release time from work at full pay
4 = No support provided

Reference: Tables 31 and 55

TABLE B-28. Comparisons of Effectiveness Ratings of Structured Educational Resources by Engineers/ Scientists and Management Officials

Hypothesis to be tested: "Mean rating is the same (no difference between engineers'/scientists' and manager's ratings)."

Type of resource	Test statistic	df	Rejection of the hypothesis is declared at the levels: 2.5%	5%	10%	15%	There is not sufficient evidence to reject the hypothesis
On campus courses	T = -2.645	140	X	X	X	X	
Videobased courses	T = -.845[*1]	18					X
Workshops, short courses not in-company	APT = -.388	50.9					X
In-company courses taught by non-employee	T = -1.527[*1]	122					X
In-company courses taught by employee	T = .937	132					X
Educational TV	T = -.482[*1]	23					X
Packaged media courses	T = -.604[*1]	19					X
Programmed instruction	T = .1048[*1]	36					X
Correspondence courses	T = 1.484[*1]	20				X	

Notes: T = t-test for the difference of 2 means (for populations that have equal variances)

APT = approximate t-test for the difference of 2 means (for populations with unequal variances) based on the (SAS) "T-TEST PROCEDURE"

*1 = Not much weight should be placed upon these tests due to small sample sizes involved in the computation of at least one of the 2 compared means.

Reference: Tables 24 and 53

TABLE B-29. Comparisons of Effectiveness Ratings of Unstructured Educational Resources by Engineers/Scientists and Management Officials

Hypothesis to be tested: "Mean rating is the same (no difference in engineers'/scientists' and manager's views)."

Type of resource	Test statistic	df	Rejection of the hypothesis is declared at the levels: 2.5%	5%	10%	15%	There is not sufficient evidence to reject the hypothesis
Self-study of textbooks	T = 1.26	368					X
Technical consultation with colleagues in own company	T = 1.57	308				X	
Technical consultation with colleagues outside company	T = .38	223					X
Technical society meetings	APT = 1.658	41.9			X	X	
Special supervised technical projects	T = -.1059*1	68					X

Notes: T = t-test for the difference of 2 means (for populations with the same variance)

APT = approximate t-test for the difference of 2 means based on the (SAS) "T-TEST PROCEDURE"

*1 = not much weight should be placed upon this test due to small sample sizes involved in the computation of at least 1 mean

Reference: Tables 32 and 56

TABLE B-30. Comparisons of Objectives for Participating in Continuing Education as Reported by Engineers/Scientists and Management Officials

Hypothesis to be tested: "Mean ratings are the same (employees and employers share the same opinion)."

Objective	Test statistic	df	Rejection of the hypothesis is declared at the levels: 2.5%	5%	10%	15%	There is not sufficient evidence to reject the hypothesis
Gain new insights	T = 1.329	531					X
Perform job better	T = .5124	531					X
Prepare for increased responsibility	APT = -1.7	88.9			X	X	
Attain enhanced position	T = .6986	529					X
Intellectual stimulation	T = 3.876	528	X	X	X	X	
Remedy deficiencies in initial education	APT = 1.719	77.7			X	X	
Maintain present position	T = 1.243	526					X
Attain salary increase	T = 1.905	527			X	X	
Prepare for new job	APT = -2.045	79.1		X	X	X	
Requirements for promotion	T = -.083	526					X
Meet expectation of management	T = -.647	524					X
Prepare for new job in other field	APT = -1.83	78.7			X	X	

Notes: T = t-test for the difference of 2 means (for populations with the same variance)
APT = approximate t-test for the difference of 2 means based on the (SAS) "T-TEST PROCEDURE"

Reference: Tables 35 and 58

APPENDIX C

LISTING OF DESIRED COURSES

Engineers/Scientists
Management Officials

ENGINEERS/SCIENTISTS -- LISTING OF DESIRED COURSES

Area	Field	No. of requests	Total
Biology	Immunology	1	
	Tissue Culture	1	
	Molecular Genetics/Engineering	2	
	Microbial Metabolism	1	
	Aerobic/Anaerobic Digestion	2	7
Chemical Engineering/ Chemistry	Paints & Coatings	1	
	Plastics	13	
	Polymer Chemistry	6	
	Hazardous Wastes & Materials	24	
	Waste Water Management	13	
	Toxicology (Industrial & Environmental)	6	
	Pollution Control	5	
	Aerosols (Fluorocarbons & Ozone)	2	
	Adhesives	1	
	Piping Design	2	
	Distillation Operations	1	
	Biochemistry	1	
	Analytical Chemistry	2	77
Civil Engineering	Civil Engineering	3	
	Structural Steel Design	2	
	Concrete Design	2	
	Sewage Plant Design	2	
	Municipal Systems Planning	1	
	Surveying	1	11
Computer Science	Computer Science -- Technology	54	
	Computer Programming	32	
	Graphics & Layout; Models	4	
	Systems Analysis	1	
	Logic Systems	1	
	Minicomputer App. & Design	6	
	Microprocessor App. & Design	10	
	Data Processing & Analysis	5	
	GC-MS Data, Interpretation of	1	
	Computer Applications	2	116
Degree	M.B.A.	16	
	B.S.	2	
	Bachelor of Engineering	2	
	M.S.E.E.	4	
	M.S.M.E.	5	
	Chemical Engineering (Bachelor's and Master's)	7	
	B.E.T.	1	37

Area	Field	No. of requests	Total
Earth Science	Geotechnical Engineering/Geology	3	
	Environmental Engineering	3	
	Sedimentation	1	7
Economics	Economics (general)	7	
	Marketing	11	
	Accounting	14	
	Finance	8	40
Electrical Engineering	General Electrical Engineering courses	5	
	Power Engineering	4	
	Electronics	30	
	Transformer Design	1	
	Power Systems Analysis	3	
	Industrial Power Control	3	
	Analog Semiconductor Applications	1	
	Magnetic Encoding	1	
	OC Motors	1	
	Telephony	1	
	Industrial Lasers	1	
	Lightwave Communication	1	
	Electrical Design	1	
	Instrumentation	3	
	Transmission	2	58
Energy	Alternate Energy Sources	18	
	Energy Systems	4	
	Erergy Conservation	46	68
General	Workshops & Update Sessions on general IE developments, chemical engineering, new products, machinery, process control techniques	20	
	Patent Laws	2	
	Applied Physics	2	24
Industrial Engineering	Engineering Economics	10	
	Value Engineering	4	
	Manufacturing Engineering	1	
	Process Engineering	2	
	Materials Handling	14	
	Inventory Control	2	
	Floor Space Utilization	1	
	Quality Control	4	
	Product Testing	1	
	Quality Assurance	2	
	Statistical Quality Control	2	
	Work Sampling	1	
	Value Analysis	2	
	Manufacturing Processes	2	
	Capital Equipment Cost Estimation	3	
	Labor Budget Assembly & Organization	2	

Area	Field	No. of requests	Total
Industrial Engineering (continued)	Cost Reduction/Control	5	
	Safety	5	
	Simulation	1	
	Cost Analysis	3	
	Fire Protection & Fighting System	1	
	Queuing Theory	1	
	Material Requirements Planning	1	
	Industrial & Shop Maintenance	3	
	Ergonomics	1	
	Time Management, MTM, MOST	22	
	Increased Productivity	3	
	Productivity Control	2	
	Indirect Labor Measurement	1	
	General IE Courses	21	
	Economic Production Design	1	124
Management	Engineering Management	19	
	Manufacturing Management	4	
	Project Management	10	
	Maintenance Management	4	
	Industrial & Technical Management	11	
	Business Administration & Management	34	
	Wage & Salary Administration	1	
	Scheduling	1	
	Effective Use of Personnel	1	
	Stress Management	2	
	Supervision	22	
	Motivation	5	
	Training Methods	2	
	Psychology	4	
	Business Law	1	
	Human & Industrial Relations	8	
	Communications	4	
	Miscellaneous	11	144
Material Engineering	Mining Engineering	4	
	Material Science	4	
	Material Strength	2	
	Metal Fabrication	1	
	Metal Forming	2	
	Metal Corrosion	1	
	Welding	4	
	Sheet Metal	2	
	Properties of Steel	1	
	Plating	1	
	Metallurgy & Metallography	6	
	Advanced Composites	2	30
Mathematics	Advanced	15	15

Area	Field	No. of requests	Total
Mechanical Engineering	HVAC Systems & Theory	9	
	Air Conditioning Maintenance	2	
	Refrigeration & AC	3	
	Heat Transfer	4	
	Thermodynamics	5	
	Filtering & Lust Removal	3	
	Air Flow Characteristics	3	
	Humidification Systems	1	
	Plant Engineering	1	
	General Mechanical Engineering	3	
	Automotive Engineering	3	
	Design Engineering	1	
	Aeronautical Engineering	1	
	Drafting, Technical Drawing	5	
	Machine Design	10	
	Industrial Audio Design & Appl.	1	
	Vacuum or Blower Design	2	
	Die Design	4	
	Pneumatics	4	
	Kinetics	1	
	Boilers	6	
	Hydraulics	6	
	Fluidics	4	
	Lubrication	1	
	Robotics, Automation	4	
	Pump Technology	1	
	Carbide Cutting Tools	1	
	Acoustics	1	
	Vibration	1	
	CAD/CAM	1	
	Failure Analysis	1	
	Mechanics	2	
	Gear Technology	1	
	Blueprint Reading	1	
	Surface Analysis Technology	1	
	Geared Power Trains	1	99
Miscellaneous	Government Regulations	6	
	Government Resource Utilization	1	
	Utilization of Foreign Technology in U. S. Industry	1	
	Metrology	1	
	Roofing	2	
	Federal Income Tax Policy	1	
	TOSCA Act	1	13
Mixed	Marine Science:		
	Fiberglass	1	
	Hull Structural Design	2	
	Use of Marine Materials	1	
	Navigation	1	5

Area	Field	No. of requests	Total
Social Sciences	Anthropology	1	
	Religion	2	3
Statistics	Statistics & Analysis	8	8
Textiles	General Textile Courses	5	
	Color Formation by Instrumentation	2	
	Dyes	3	
	Fiber Identification	2	
	Testing	3	
	Textile Chemistry	4	
	Textile Engineering	3	
	Textile Management	4	
	Texturing	1	
	Yarn Processing	3	30
Review Courses for P.E. Exam		8	
Review Courses for E.I.T. Exam		2	10
TOTAL			926

MANAGEMENT OFFICIALS -- LISTING OF DESIRED COURSES

Area	Field	No. of requests	Total
Chemical Engineering	Fiberglass	2	
	Polymer Chemistry	1	
	Plastics	2	
	Handling/ID/Transportation & Disposal of Waste & Hazardous Materials	13	
	Manufacturing Epoxies	1	
	Water-Based Industrial Paint	1	20
Civil Engineering	Water Systems (Feed and Waste)	1	1
Computer Science	General Applications	4	
	Design by Computer	1	
	Programming	2	
	Instrumentation & Computer Control	1	
	Microprocessors in Manufacturing	1	9
Economics	Financial Management for Engineers	1	
	Market Forecasting for Engineers	1	2
Electrical Engineering	General EE Classes, Electronics	2	
	Permanent Magnet Motor	1	
	Printed Circuit Board Manufacturing	1	4
Energy	Energy Conservation	10	
	Environmental Problems	1	
	Inorganic Chemistry (Environment-related)	1	12
General	Workshops & Update Sessions on new materials & technology	3	
	Weekend or Evening programs leading to undergraduate & graduate engineering degrees	2	
	Patent Law/Process	1	6
Industrial Engineering	Basic IE Classes	6	
	Time & Motion Studies, MTM, MOST	8	
	Capital Planning	1	
	Basic Cost Accounting & Cost Analysis	1	
	Manufacturing Economics	2	
	Product Budgeting	1	
	Product Safety Evaluation	1	
	Productivity	5	
	Quality Control	1	
	Ergometrics or Ergonomics	1	

Area	Field	No. of requests	Total
Industrial Engineering (continued)	Equipment Evaluation	1	
	Value Engineering	1	
	Metrics	1	
	Distribution Systems	1	
	Methods Analysis	1	32
Management	Personnel Mgmt./Tech. Mgmt./Gen. Mgmt.	4	
	Leadership, Communications	3	
	Business Law	1	
	Management by Objectives	1	9
Materials Engineering	Metal Coatings	1	
	Flow Solder Technology	1	
	Metallurgy	1	3
Mechanical Engineering	Instrumentation Design & Maintenance	3	
	Product Design	2	
	Boilers (Efficiency, Training Operators)	2	
	Programming Controllers	1	
	NC versus Manual or Programmable Mach. Tools	1	
	General ME Classes	1	
	Air Exchange Systems	1	
	Plant Engineering	1	
	Advanced Mechanical Drafting	1	
	Fluid Power Design & Systems	1	
	Hydraulics	1	
	Noise Control	1	
	Refrigeration	1	
	Heat Transfer	1	
	Solar Heating	1	
	Compressed Air Technology	1	
	Robotics	1	21
Miscellaneous	Elementary General Physics	1	
	Federal & State O.S.H.A. Regulations	1	2
Statistics	Statistics for Manufacturing	1	
	Statistical Solutions to Industrial Problems	1	2
Textiles	General Textiles	1	
	Sewing Industry Equipment	1	2
TOTAL			125

APPENDIX D

DETAILED STATISTICAL TABLES FOR TECHNICIANS AND TECHNOLOGISTS

The following are detailed statistical tables for technicians and technologists who were labeled as engineers but who did not meet the educational requirements of four years of college or comparable experience.

TABLE D-1. Standard Industrial Classification

SIC code	Industry	Percent of participants (N=89)
22	Textile mill products	16.8
23	Apparel and finished products	19.1
24	Lumber and wood products	3.4
25	Furniture and fixtures	7.9
28	Chemicals and allied products	6.7
30	Rubber and miscellaneous plastic products	4.5
33	Primary metal industries	1.1
34	Fabricated metal products	3.4
35	Machinery, except electrical	16.8
36	Electrical and electronic machinery	16.8
37	Transportation equipment	3.4

TABLE D-2. Sample Category

Size	Percent (N=88)
Large	31.8
Medium	37.5
Small	30.7

Table D-3. Age of Respondents

Age	Percent (N = 89)
25 and over	5.6
26 to 35	46.1
36 to 45	33.7
46 and over	14.6

Table D-4. Highest Degree Held

Degree	Percent (N = 87)
High school	39.1
Associate/Technical	50.6
Other	10.3

Table D-5. Professional Certification

Certification	Percent (N = 89)
Engineering	6.7
Other	5.6
None	87.6

Table D-6. Comparison of Years Employed with Present Organization and as an Engineer

Number of years employed	Percent of participants: With present organization (N=89)	Percent of participants: As an engineer (N=87)
3 or under	39.3	19.5
4 to 9	25.8	33.3
10 or over	34.8	47.1

Table D-7. Current Level of Supervisory Responsibility

Level of responsibility	Percent of participants (N=89)
No supervisory responsibility	27.0
Supervision of technicians/ non-tech. personnel	30.3
Supervision of engineering/ scientific personnel	37.0
Management of supervisory personnel	5.6

Table D-8. Current Level of Technical Responsibility

Level of responsibility	Percent of participants (N=88)
Perform limited assignments with specific directions	4.5
Perform assignments with limited direction	21.6
Perform most work independently	44.3
Work independently extending known techniques	10.2
Technical direction and review of others' work	19.3

Table D-9. Number of Journals Read

Number of journals read	Percent of participants (N=89)
None	24.7
1 to 3	57.3
4 to 6	16.8
7 or more	1.1

Table D-10. Number of Colleagues Consulted Outside of Own Organization

Number of colleagues	Percent of participants (N=89)
None	45.0
1 to 3	34.8
Over 3	20.2

Table D-11. Participation in Structured Educational Resources During the Last Three Years

Type of resource	Percent < 30 hours (N=89)	Percent > 30 hours (N=89)	Percent at either level
College courses, on campus	15.7	11.2	24.7
College courses, videobased	1.1	0	1.1
Workshops, short courses, not in-company	31.5	7.9	34.8
In-company courses taught by non-employees	15.7	5.6	19.1
In-company courses taught by employees	13.4	10.1	21.3
Educational TV courses	3.4	1.1	4.5
Programmed instruction	3.4	1.1	4.5
Correspondence courses	4.5	2.2	6.7
Packaged media courses	4.5	1.1	5.6
Other	1.1	0	1.1

Table D-12. Average Number of Classes Participated in During the Last Three Years

Type of resource	N*	Mean	SD**	N*	Mean	SD**	N*	Mean	SD**
College courses, on campus	14	6.9	11.7	10	2.7	3.7	22	5.6	9.6
College courses, videobased	1	1.0	--	0	0	0	1	1.0	--
Workshops, short courses, not in-company	28	2.9	2.6	7	1.4	1.1	31	2.9	2.5
In-company courses taught by non-employees	14	3.2	3.1	5	1.6	0.9	17	3.1	2.9
In-company courses taught by employees	9	1.3	0.7	12	2.7	2.7	19	2.3	2.5
Educational TV courses	3	1.0	0	1	1.0	--	4	1.0	0
Packaged media courses	4	3.0	2.1	1	1.0	--	5	2.6	2.1
Programmed instruction	3	4.0	5.2	1	1.0	--	4	3.2	4.5
Correspondence courses	4	3.5	4.4	2	1.0	0	6	2.7	3.6
Other courses	1	1.1	--	0	--	--	1	1.0	--
Total number of all courses							58	6.2	11.3

* Number of respondents
** Standard deviation

Table D-13. Employer Support for Structured Educational Resources

Type of resource	Percent of those participating receiving this support								
	Payment for books/supplies	Partial reimbursement for travel, subsistence	Full reimbursement for travel, subsistence	Release time from work to be made up by employee	Release time from work at full pay	Release time from work at partial pay	No support provided	Partial tuition or fee reimbursement	Full tuition or fee reimbursement
College courses, on campus	13.64	4.55	22.73	4.55	9.09	0	31.82	4.55	31.82
College courses, videobased	0	0	0	0	0	0	0	0	0
Workshops, short courses, not in-company	58.07	3.23	58.07	3.23	58.07	0	6.45	0	64.52
In-company courses taught by non-employees	52.94	5.88	29.41	11.77	64.71	0	0	0	35.29
In-company courses taught by employees	26.32	0	26.32	0	52.63	0	5.26	0	36.84
Educational TV courses	0	0	0	0	25.00	0	0	0	75.00
Packaged media courses	40.00	0	0	0	20.00	0	0	0	0
Programmed instruction	50.00	0	25.00	0	25.00	0	25.00	0	25.00
Correspondence courses	33.33	0	16.67	0	33.33	0	16.67	0	66.67
Other	100.00	0	100.00	0	100.00	0	0	0	0

Table D-14. Evaluation of Effectiveness of Structured Educational Resources

Type of resource	Number of participants	Mean rating*	Standard deviation
College courses, on campus	21	2.71	0.90
College courses, videobased	2	2.50	0.71
Workshops, short courses, not in-company	26	2.92	0.85
In-company courses taught by non-employees	13	2.92	0.64
In-company courses taught by employees	15	2.47	0.64
Educational TV courses	3	3.67	0.58
Packaged media courses	3	3.00	1.00
Programmed instruction	4	2.75	0.95
Correspondence courses	5	2.20	1.48
Other	1	2.00	0

*Rating Values:
4-most effective
3-very effective
2-satisfactory or neutral
1-slightly effective
0-not effective at all

Table D-15. Participation n-Structured Educational Resources During the Last Three Years

Type of resource	Percent of respondents participating in activity (N=89)	Average number of hours spent per month	Standard deviation	Average number of this type resource utilized per month	Standard deviation
Self-study of textbooks/journals	64.05	13.26	15.75	4.22	5.18
Technical consultation with colleagues in own company	50.56	20.93	22.67	8.46	14.71
Technical consultation with colleagues outside company	37.08	6.39	4.89	4.57	4.25
Technical society meetings	8.99	1.63	0.74	3.00	5.29
Special supervised technical projects	17.98	31.00	31.97	2.75	2.38
Other	0	0	0	0	0

Table D-16. Employer Support for Unstructured Educational Resources

Type of resource	Of those participating, percent receiving this support: Payment for books/supplies	Partial reimbursement for travel, subsistence	Full reimbursement for travel, subsistence	Release time from work to be made up by employee	Release time from work at full pay	Release time from work at partial pay	No support provided
Self study books/journals	47.37	0	5.26	0	7.02	0	33.33
Technical consultations with colleagues in own company	15.56	0	17.78	0	20.00	0	17.78
Technical consultations with colleagues outside company	9.09	3.03	15.15	0	18.18	0	18.18
Technical society meetings	12.50	0	50.50	0	37.50	0	0
Special supervised projects	12.50	0	12.50	0	18.75	0	6.25
Other	0	0	0	0	0	0	0

Table D-17. Evaluation of Effectiveness of Unstructured Educational Resources

Type of resource	Number of participants	Mean rating *	Standard deviation
Self study of textbooks/journals	52	2.79	0.78
Technical consultations with colleagues in own company	42	3.21	0.65
Technical consultations with colleagues outside of company	31	2.87	0.81
Technical society meetings	8	3.50	0.54
Special supervised technical projects	14	3.57	0.51
Other	0	0	0

*Rating values:
4 - most effective
3 - very effective
2 - satisfactory or neutral
1 - slightly effective
0 - not effective at all

Table D-18. Status of Personal Knowledge in Technical Field

Degree of currency	Percent of participants (N=89)
Right up-to-date (4)	5.95
Almost up-to-date (3)	30.95
Moderately up-to-date (2)	42.86
Slightly up-to-date (1)	16.67
Not up-to-date at all (0)	3.57

Mean 2.19

Standard Deviation 0.91

Table D-19. Participant Objectives for Continuing Education

Objective	Number of participants	Mean rating *	Standard deviation
Gain new insights, explore alternative solutions	86	3.37	0.70
Perform your present job assignment better	88	3.40	0.84
Prepare for increased responsibility	85	3.28	1.01
Attain enhanced position in your field	85	2.78	1.08
Intellectual stimulation	87	2.83	0.94
Remedy deficiencies in initial education	87	3.17	0.91
Maintain your present position in company	86	2.69	1.19
Attain salary increase	85	2.71	1.28
Prepare for a new job in current field	86	2.54	1.24
Fulfill requirements for a promotion	86	2.58	1.39
Meet expectations of management	86	2.16	1.34
Prepare for a new job in another field	86	1.85	1.31

*Rating values: 4 - of highest importance
3 - very important
2 - moderately important
1 - slightly important
0 - not at all important

Table D-20. Areas Where Continuing Education Has Been a Major Factor for Participants

Reached objective aided by continuing education	Percent of participants (N=89)
Performing present job assignment better	59.55
Gaining new insights, exploring alternative solutions	59.55
Stimulating intellectually	48.32
Preparing for increased responsibility	47.19
Remedying deficiencies in initial education	51.69
Attaining enhanced position in field	26.97
Maintaining present position in company	34.83
Attaining a salary increase	26.97
Fulfilling requirements for promotion	22.47
Preparing for new job in current field	19.10
Preparing for new job in different field	13.48
Meeting expectations of management	17.98

Table D-21. The Importance of Continuing Education in Professional Growth Up to Now and Expectations for Future Growth

	Number of participants	Mean rating*	Standard deviation
Importance in growth up to now			
Technical	87	2.25	1.31
Non-technical	75	1.88	1.15
Expected importance to future growth			
Technical	84	2.77	1.08
Non-technical	77	2.33	1.04

*Rating values: 4-of highest importance
3-very important
2-moderately important
1-slightly important
0-not at all important

Table D-22. Structured Educational Resources Rated According to Personal Preference

Type of resource	Number of participants	Mean rating *	Standard deviation
College courses, on campus	84	2.82	1.10
College courses, videobased	81	2.16	0.99
Workshops, short courses not in-company	87	2.99	0.90
In-company courses taught by non-employees	86	2.86	0.92
In-company courses taught by employees	82	2.28	0.10
Educational TV courses	81	2.17	0.86
Packaged media courses	81	2.11	0.82
Programmed instruction	81	2.48	0.90
Correspondence courses	84	2.25	0.99
Other	7	2.29	0.95

*Rating values:
4 - like very much
3 - like
2 - neutral toward
1 - dislike
0 - strongly dislike

Table D-23. Unstructured Educational Resources Rated According to Personal Preference

Type of resource	Number of participants	Mean rating *	Standard deviation
Self-study textbooks/journals	87	3.08	0.78
Technical consultations with colleagues in own company	88	3.14	0.73
Technical consultation with colleagues outside company	86	2.98	0.72
Technical society meetings	82	2.40	0.91
Special supervised technical projects	83	2.71	0.83
Other	2	2.00	0

*Rating values: 4 - like very much
3 - like
2 - neutral toward
1 - dislike
0 - strongly dislike

Table D-24. Reasons Participants Have Not Participated in Continuing Education Previously

Reason for not taking particular course	Percent of participants(N=60)
It is not available	33.33
Not available at a convenient time	35.00
Not available at a convenient location	48.33
Delivery system not appropriate	0
Too costly as presently offered	6.67
Level of available course too low	5.00
Level of available course too high	0
Other	8.33

Table D-25. Preferred Delivery System for Taking Particular Course Within the Next Three Years

Delivery system	Percent of participants (N=60)
College course, on campus	41.67
College course, videobased	6.67
Workshops, short courses, not in-company	33.33
In-company courses taught by non-employees	3.33
In-company courses taught by employees	1.67
Educational TV courses	1.67
Packaged media courses	1.67
Programmed instruction	6.67
Correspondence courses	3.33