NAME OF AUTHOR......ROBERT KIRBY CROCKER......................

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(Signed) R. K. Crocker

PERMANENT ADDRESS:

Department Curriculum & Instruction,
Faculty of Education,
Memorial University of Nfld.
St. John's, Nfld.

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A SYSTEM FOR DETERMINING KNOWLEDGE REQUIREMENTS IN ELECTRONICS TECHNOLOGY

by

Robert Kirby Crocker

A THESIS

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "A System for Determining Knowledge Requirements in Electronics Technology," submitted by Robert Kirby Crocker in partial fulfilment of the requirements for the degree of Doctor of Philosophy.

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Supervisor

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External Examiner

Date . August 4, 1969

ABSTRACT

The general purpose of the study was to examine electronics technology occupations from the point of view of required knowledge in the fields of physics, electricity, and electronics.

The above general aim required the development of a methodology designed to yield solutions to the following three primary problems:

1. It was necessary to determine the extent to which the various topics into which a subject is conventionally divided formed a meaningful structuring of the subject from the point of view of technicians.
2. On the basis of job classification, it was necessary to isolate groups of technicians having similar subject matter requirements.
3. It was necessary to determine the specific topic requirements for each of the above groups.

Several secondary problems manifested themselves which were related to the above major problems: A comparison was made between electronics instructors and technicians regarding subject matter requirements. The relationship of required knowledge to degree of generality of subject matter was explored. The effects of variables other than job classification on technicians' perceptions of subject matter requirements were also investigated.

The basic data collection device consisted of a series of three Q-sort instruments. The Q-sort cards consisted of subject matter items designed to represent a sampling of content from each of the three subject areas under investigation. The three Q-sort instruments were applied to a sample of one hundred electronics technicians and a sample

of fourteen electronics instructors, all located in Alberta.

The first major problem was approached by means of a factor analysis of the intercorrelations among items in each Q-sort. The second problem required an analysis of intercorrelations among persons in order to determine the extent of agreement regarding subject matter requirements among persons within possible groups, as compared to the extent of agreement between groups. The third problem was analyzed by means of a series of one way analyses of variance.

For the first problem the analysis indicated that factors could be identified for the electronics instrument which corresponded to an hypothesized topical outline of the subject. The identification of factors was somewhat tenuous for the physics and electricity instruments. Results could not be considered as supporting the topics hypothesized as representing an outline of these subjects, nor did credible alternatives to these topics emerge.

Results in relation to the second problem revealed that well defined groups existed in the areas of broadcast, communications, navigational aids, and computers, on the basis of job classification by type of equipment used. A job classification by type of work revealed that technicians in the field of research and development had requirements for electronics which were significantly different from the requirements of other technicians. No groups were isolated with respect to the physics and electricity sorts for the two job classifications noted above, with the exception of broadcast technicians by the electricity sort.

Study of the third problem revealed, in general, that electronics topics related to the specialization of a particular group were assigned the highest mean ratings by that group. Basic electronics topics tended to receive intermediate mean ratings. Specialized topics unrelated to the type of equipment used by a group tended to receive significantly lower mean ratings by that group. Electricity requirements tended to be strongly oriented towards circuits rather than fields for all respondents. For physics the waves topic received a significantly higher mean rating than did other topics. Topics related to atomic and nuclear physics, optics, and basic mechanics and heat received intermediate ratings. Kinetic-molecular theory, advanced mechanics, and relativity all received significantly lower mean ratings.

The following results pertain to the secondary problems: Significant overall differences were found between technicians and instructors in responses to the electricity and electronics sorts. An analysis of responses on the basis of degree of generality of card items revealed that for instructors a clear tendency existed in the case of electronics towards increased mean rating with increased generality. For the electricity sort the tendency was towards lower mean ratings for more general items, for both technicians and instructors. No clear trends with respect to generality of items resulted from the physics sort. With a few minor exceptions, no systematic effects on responses existed for variables other than job classification.

In general, the findings of this study were supportive of the programs currently offered by the two Alberta technical institutes. The results, however, indicated the desirability of adding a specialized course in computers to the programs of both institutes.

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The cooperation and assistance of a large number of persons is necessary in bringing a study such as the present to a successful conclusion. In particular, the author is indebted to the following individuals and groups:

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CHAPTER I

THE PROBLEM IN PERSPECTIVE

There are many indications that over a period of two or three decades a rapid evolution, one might almost say revolution, has taken place in the structure of occupations associated with industrial production and related service occupations. This evolution has brought into prominence a new class of worker located, at least from the point of view of currently accepted educational requirements, somewhere between the two traditional levels of craftsman and professional. In fact it is perhaps not overstating the situation to say that, as mechanization and automation is replacing the craftsman and unskilled worker, the technician has come into his own as an essential person in research and development, production, operation, and maintenance of the complex equipment which characterizes a technologically based industrial society. The feelings of unions and others concerned with worker displacement notwithstanding, it is probably safe to say that automation and associated changes have not led to an overall elimination of workers but simply to a reorientation of the types of education and training required of workers.

Just as industrial production has become more and more directly concerned with technological applications arising from scientific research, so the worker has discovered that a greater degree of scientific and technical knowledge is required if he is to have a place in industry. The key to distinguishing between the craftsman and the technician lies in the difference between knowledge and skills. More technically, it might be argued that the activities of the craftsman lie almost entirely in the psychomotor domain while those of the technician are, to varying degrees, in the cognitive domain, in particular in the domain of scientific and technical knowledge.

While the question of the relative importance of the cognitive and psychomotor domains in technical occupations is of considerable significance, the present study has been concerned entirely with the cognitive domain. A basic assumption has been that cognitive activity plays an important part in a field such as electronics technology. The general aim of the study was the exploration of a methodology for the analysis of the cognitive aspects of electronics technology occupations and the application of this methodology to a sample of electronics technicians employed in Alberta industrial and service organizations.

The Use of Job Analysis

In many areas of work, systematic job analysis has been carried out for a number of purposes, principally in order to determine proper job classifications, to determine equitible pay scales, and to improve the efficiency of job performance. Time and motion study, whereby the actions of a worker are recorded during a series of short time intervals, is typical of the techniques used for such purposes.[1]

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[1] R. L. Morrow, Motion Economy and Work Measurement. (New York: Ronald Press, 1957).

By breaking a task into such small components, questions can be answered regarding essential or superfluous worker activities, the amount of physical exertion involved, or the type of skills required. Other techniques used for similar purposes include various types of checklists and rating scales, all of which involve either direct observation of the worker at his task or soliciting the cooperation of the worker in recording the elements of the job.

The rapid growth of technological occupations and the educational problems involved in ensuring a supply of competent workers for such occupations imply that some importance be attached to the possibility of the use of job analysis to determine the training requirements for these occupations. Although the question of skills is inherent in conventional job analysis techniques, these techniques are not well adapted to the broader problem of determining educational requirements in complex jobs which are characterized more by knowledge than by skills. It is evident that any scheme for the analysis of technological occupations for educational purposes must deal with the knowledge, in the form of scientific principles and their applications, which underlies the specific job in which a technician may be engaged. It is further apparent that the degree to which a technician uses such knowledge may not be immediately obvious from direct observation of the technician at work.

In this study an attempt was made both to develop further a methodology which has shown some promise in the analysis of technical occupations and to apply this methodology in a previously undeveloped context. Specifically, the subject areas of physics, electricity, and electronics were investigated with respect to occupations in the field of electronics technology. The job analysis technique used was an adaptation of the Stephenson Q-sort[2] as originally used in technical job analysis by Barlow and Schill[3]. From a methodological standpoint, two areas were of major interest. First, it was necessary to develop and validate a series of Q-sort instruments specifically designed for the areas concerned. Second, the question of appropriate techniques of statistical analysis was the subject of some attention. From the point of view of the specific technical field under investigation, the primary problem was the development of a picture of overall subject matter requirements and the exploration of the possible existence of areas of specialization within the field.

Significance of the Study

In the preceeding section, mention was made of the limited value of conventional job analysis techniques for the study of complex technological occupations. In discussing the limitations of classical learning theory as applied to training for such occupations, Gagné argues that occupations characterized by a high level of knowledge and a low level of manipulative skill require new forms of

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[2]William Stephenson, The Study of Behavior. (Chicago: University of Chicago Press, 1953).

[3]Melvin L. Barlow and William J. Schill, The Role of Mathematics in Electrical-Electronic Technology. (Los Angeles: Division of Vocational Education, U.C.L.A., 1962).

occupational analysis based on factors other than "operations" or "jobs".[4] This argument also indicates that the factors forming the basis of new techniques must involve knowledge rather than skills. To the extent that skills are used in the occupations referred to, these may be analyzed by applying established techniques.

Taking a somewhat broader point of view, Brandon and Evans emphasize that "more than most other types of education, vocational education must change its structure and content to adapt to rapidly changing occupational requirements."[5] Acceptance of this statement implies that ways must be found to evaluate current occupational requirements and to relate this information to the curriculum in technical education programs. In the face of rapidly changing job requirements, it is useful to consider two functions of technical education. First, even if a technical education curriculum could be brought completely up to date with requirements at a given time, the technical school graduate would still be faced with the problem of adapting to changes which could not possibly have been foreseen at the time of his graduation. It is therefore essential that the technician be furnished with the background necessary to facilitate this adaptation. Second, it is the function of the training program

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[4]Robert M. Gagné, "Military Training and Principles of Learning." American Psychologist, 17: 82-91, 1962.

[5]George L. Brandon and Rupert N. Evans, "Research in Vocational Education," Vocational Education, Melvin L. Barlow ed. Sixty-fourth Yearbook of the National Society for the Study of Education. (Chicago: University of Chicago Press, 1965), p. 263.

to make the technician competent in a specific job or job area which exists at the time of his entry into the work force, in order that he may fit into his field with a minimum of on-the-job training.

In a broad sense, the present study was concerned with both these aspects of technical education. Electronics technology possesses, perhaps to a more extreme degree than most other areas, characteristics which tend to be associated with the recently developed technical occupations. The field is scientifically based, it is rapidly changing both in the scientific principles used and in the range of application of these principles, and it is becoming more and more essential to the way of life in industrialized societies. Any methodology which is developed for the analysis of electronics occupations in terms of basic knowledge and possible areas of specialization, can form a paradigm for use in other technological areas.

Although considerable effort has been expended in attempts to determine training requirements for technical occupations, much of the work has been qualitative and descriptive in nature. Similarly, a great deal of effort has gone into the development of detailed curriculum guides for technical programs with no evidence, other than the opinions of the developers, that these guides in any way reflect the true requirements in the field. It can be argued that factors other than the analysis of specific jobs must be taken into account in designing technical curricula. Nevertheless, if the assumption is accepted that technical education is job-oriented rather than general in nature, it follows that no curriculum can be fully justified unless it makes explicit use of information concerning job requirements in the field for which the curriculum is being designed.

The relatively few attempts which have been made to obtain quantitative data on knowledge requirements for technical jobs may be criticized on several grounds. While a detailed discussion of these studies is deferred to Chapter II, it is pointed out at this stage that these studies suffer from such problems as the attempt to cover too much subject matter with a single instrument, the use of inappropriate subject matter, and the failure to capitalize on the full potential of the data. A notable contribution to methodology has, however, been made by Schill and his collaborators in adapting the Q-sort technique to job analysis. Part of the aim of the present study was to examine Q-methodology in some detail and to further develop its adaptation in what was felt was a context more in keeping with the nature of the method. In particular, the type of statistical analysis applied in previous studies was not deemed appropriate for the questions under investigation in the present study.

In a much more narrow sense, the study is significant in that the question of possible areas of specialization within a field such as electronics technology has not previously been explored. It is obvious that electronics continues to find application in an ever increasing number of specialized areas, resulting either from the expansion of knowledge in electronics itself or from the application of conventional electronics to new areas. In the former category one might place the rise of the computer industry, which has been the direct result of the expansion of the electronics field itself. In the latter category are found applications of electronics to fields such as medicine, seismology, or industrial control, which may require no new developments in electronics but involve the discovery of new uses for electronic devices and knowledge. These areas represent significant departures from early uses of electronics which tended to be strongly oriented towards communications. It is in the context of the exploration of a specific field such as electronics that it was felt that the use of Q-methodology could contribute a great deal more than it could in broader contexts. The developmental and applied aspects of the study are thus complementary.

Questions Under Investigation

Physics, electricity, and electronics were regarded as separate subject areas for purposes of the development and application of the Q-sort instruments. It is obvious, of course, that electricity and electronics are simply specialized aspects of the parent discipline, physics. Since, however, the degree of the depth of knowledge in the specialized areas required of technicians was likely to be considerably greater than for physics as a whole, the separation into three areas could be justified. This question is discussed in more detail in Chapter III. For the present it is necessary to note only that the questions under investigation pertain to the three separate subjects, with a separate analysis being carried out for each subject. Among the most important of the questions raised are the following:

1. Is it possible to develop clusters of subject matter elements which may be regarded as forming a meaningful structure of the subject as viewed by technicians? In particular, to what extent do any such clusters agree with topics into which the subject is conventionally divided?
2. Are there well defined jobs or job clusters within electronics technology as determined by the homogenity of response to the instruments by members of possible clusters?
3. What is the relative importance of certain clusters of subject matter elements for particular groups of technicians, and how do perceptions of this relative importance vary with job classification?
4. To what extent do electronics instructors and technicians agree both on overall response to the instruments and on response to specific item clusters?
5. What are the effects on response of such variables as age, salary, amount of formal education, source of training, range of experience, and tenure of employment?

As the first three questions imply, the possibility of identifying well defined groups of technicians on the basis of job classification was of major interest. It was anticipated that such groups would be defined primarily on the basis of responses to the electronics instrument, thus making this instrument the one of most direct concern. Physics and electricity were regarded as prerequisites to electronics. Requirements in these areas were therefore not expected to vary with job classification to the same extent as electronics. This did not, however, preclude the possibility of certain secondary variables, as listed in question 5, influencing responses to these instruments.

Questions relating to the general effectiveness of Q-methodology as a means of determining knowledge requirements in technical occupations were, of course, implicit in all phases of the design, execution, and analysis. Although these questions were not dealt with as explicitely as were the preceding questions, it is clear that the methodology is effective only to the degree that it can give meaningful answers to the above explicit questions. An attempt is made in the final chapter to summarize certain points concerning the scope and limitations of the method and of the statistical techniques used, and to point out areas in which simple procedural changes may enhance the methodology.

Overview of Method

The basic data collection instrument consisted of a series of three decks of cards, the cards containing items of subject matter in physics, electricity, and electronics. Card items were designed to provide a structured sampling of the major topics within each field. In the conventional Q-sort manner, respondents were required to sort the cards on a nine point scale according to a predefined distribution. All cards could be examined before committing any card to a particular point on the scale. The scale was thus a relative one with all items effectively being compared with all others before being assigned a place on the scale relative to the others. The use of the predefined distribution eliminated purely individual perceptions of the measuring scale as a whole, at the expense of loss of information concerning the absolute value of items and concerning individual differences.

A sample of one hundred electronics technicians employed in Alberta industrial and service organizations was obtained by soliciting the support of appropriate officers in these organizations. Technicians were interviewed on an individual or small group basis after arranging details of scheduling with immediate supervisors or the technicians themselves. After briefing the individuals on the aims and procedures of the study and collecting preliminary data relating to the various classification variables, technicians were asked to sort the card decks in response to a specific question for each deck. For comparison purposes, the same information was gathered from a sample of fourteen instructors of electronics technology at the two Alberta technical institutes.

Respondents were grouped on the basis of various classification variables and the responses of different groups to the overall instrument were compared by analysis of the within-group intercorrelations and the intercorrelations between group members and non-members. Factor analysis was used to determine whether responses were made on the basis of an hypothesized clustering of items. The factor analysis was thus essentially a dependency analysis as proposed by Stephenson,[6]

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[6]Stephenson, op. cit.

although the possibility of patterns of relationship other than the hypothesized pattern was not overlooked. In general, meaningful factors were found and well defined groups isolated only for the electronics sort. For these well defined groups, a specific analysis of responses was carried out by means of analysis of variance, first for all groups on each separate factor, and then for all factors on a single group. For the physics and electricity sorts, the response of the sample as a whole was of primary importance. The responses of instructors as compared to technicians, and the initial unforced three-category sorts carried out in order to facilitate the comparison of items by the respondents, were also analyzed.

Limitations

Although the methodology used was selected because of its possible potential for application to a wide range of situations, the study was limited to the investigation of three subject areas, physics, electricity, and electronics, within a single technical field, that of electronics technology. Mathematics, the other subject area generally considered as being essential to technical occupations was excluded partly because mathematics requirements have already been investigated in more detail than other areas and partly because of practical limitations in terms of technician time. Other related subjects such as English were excluded because, even though they may be important in the occupations of interest, these subjects may be considered as part of general education and there is some question regarding their inclusion in technical programs.

By limiting the study to one field of technology, and by using separate card sort instruments for the three areas under investigation, it was possible to overcome a major drawback inherent in previous studies. This drawback was the severe restrictions in the statistical treatment which resulted from the inclusion of a wide range of subject matter within a single instrument. Thus for a given area of technology, the instrument would contain a large number of items totally unrelated to that technology. This gave rise to a discontinuity which precluded the sorting of all items onto a continuous scale. The limitation imposed upon the present study permitted the inclusion of more detail in a single instrument, thus enabling variations in requirements within a single technology to be investigated.

The above limitations were deliberately imposed and can be justified on the basis of the advantages outlined. A more severe limitation from the point of view of generalization lies in the nature of the population from which the technician sample was drawn. It was found that a majority of Alberta technicians work in service rather than in research and development or production occupations. Furthermore, for the most part, these technicians do not work under the direct supervision of an engineer or scientist. The question of the existence of more than one level of technician has recieved some attention elsewhere[7, 8]. Because a relatively small number of technicians

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[7]Christy A. Murphy, Technician Need Study: Vermillion County, Illinois. (Urbana: University of Illinois, 1964), p. 5.

[8]Norman C. Harris, "Science and Mathematics Courses," Science Education News. (Washington: American Association for the Advancement of Science, December, 1968), pp. 3-4.

involved in the study could be classed as engineering technicians, the results may not be directly applicable to a training program which has as its main function the training of engineering rather than service technicians. Results must be interpreted in the light of detailed information on the type of jobs taken by graduates of a particular program.

A Broader Study and a Model

The study was originally conceived in relation to a broader project being conducted by members of the Department of Secondary Education, University of Alberta, in cooperation with the Northern Alberta Institute of Technology. The major aim of the overall project was the development of a system for improving the relation between technical education and job requirements. This system was envisaged in terms of the use of feedback from a job analysis procedure to effect modifications in curriculum content. The continuous operation of the system could, through the use of a modular breakdown of course content, enable the training program to bear a close relation to job requirements without the necessity for periodic major changes. To facilitate the system, course content and instructional procedures were to be organized into a "data bank" permitting easy access and modification.

The flow diagram of Figure 1 indicates some possible interrelationships among the major components related to technical education. The broken lines indicating direction of flow are intended to represent simply a time sequence while solid lines indicate more of a dependency relationship.

This model will perhaps serve to indicate the importance of keeping in mind the system as a whole. The assumption that job requirements should be the major determinant of the technical curriculum leads to the direction of flow of decisions from the job to the curriculum, with the job analysis scheme being based on existing knowledge related to the field. The aim is to describe the job in terms of the related field of knowledge and to have this description determine the curriculum. Suppose, for example, that the job analysis aspect of the model were missing. In the absence of this phase it is easy to see how job requirements could eventually

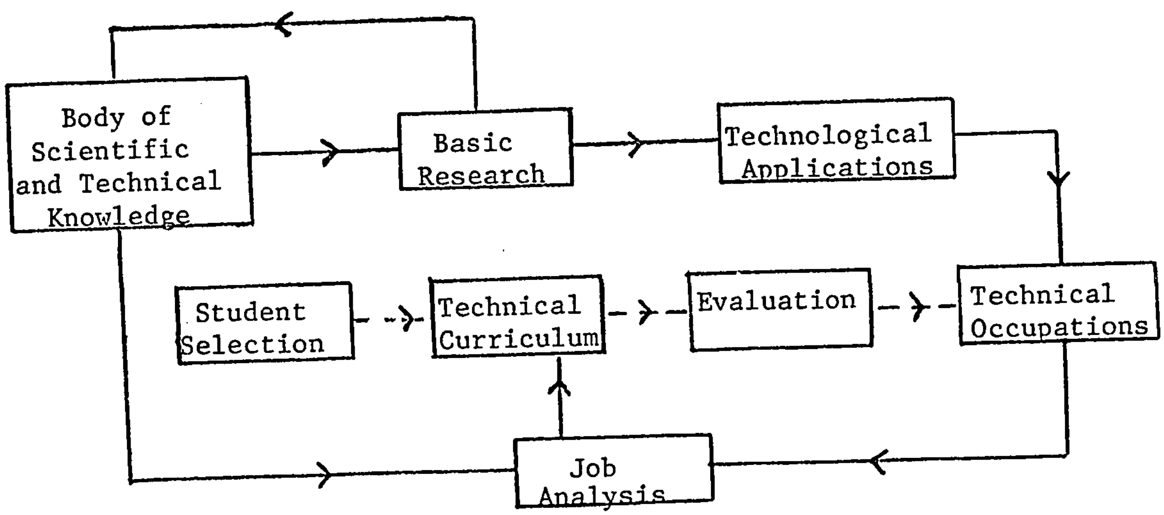

Figure 1

Interrelationship of Components in Technical Education System become defined in terms of a curriculum which has become established. The dependency thus becomes reversed, resulting in an acceptance of the status quo as far as the curriculum is concerned. It is interesting to speculate on the extent to which, at least in the views of employers, job requirements may in fact be defined in terms of an existing training program.

CHAPTER II

REVIEW OF RELATED LITERATURE

Literature bearing on this study may be regarded as coming from two major areas. In the area of technical education, research studies and more general works concerning the growth of technical occupations, the definition of technicians, and the identification of areas of work, are relevant in establishing a broader context for the study and in clarifying some of the terminology. Of more direct importance are studies bearing directly on technical curriculum, particularly in electronics technology, and studies concerning the analysis of technical occupations.

The second major area concerns the use of Q-methodology. Since much of the research into this methodology and most of the applications are in such areas as psychotherapy and personality development, which are far removed from the present context, no attempt has been made to review all possible applications. The review is confined to the foundations of the method, to literature relevant to statistical analysis of Q-type data, and to direct application of the method in job analysis. The aim has not been to add to the controversy which surrounds the method but to establish a basis for the present application.

I TECHNICAL EDUCATION

General

The changing character of occupations associated with the rise of technology has been referred to in Chapter I. The essential nature of this change has been summarized in the following statement of the Educational Policies Commission:

> More than ever before, and for an increasing proportion of the population, vocational competence requires developed rational capacities. The march of technology and science in the modern society progressively eliminates the positions open to low-level talents. The man able to use only his hands is at a growing disadvantage as compared with the man who can also use his head. Today even the simplest use of hands is coming to require the simultaneous use of the mind.[1]

At an even broader level, Galbraith[2] has stressed the importance of the "technostructure" in modern large scale industrial enterprise. Although the term technostructure in Galbraith's sense refers to specialists of all sorts including professional management, scientific, and engineering personnel, it is evident that the rise of technology has wrought a vast change in the types of workers required by industry and that the importance of technically competent personnel cannot be overestimated.

A transition of views concerning the nature of technical

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[1]Educational Policies Commission, The Contemporary Challenge to American Education. Washington: National Education Association, 1958. (Quoted in Barlow, (ed.), Vocational Education, Sixty-fourth Yearbook of the National Society for the Study of Education, Chicago: University of Chicago Press, 1965), p. 10.

[2]John Kenneth Galbraith, The New Industrial State, (Boston: Houghton Mifflen, 1967).

education, corresponding to the transition of occupations, is evident from the following statement by Lowe:

> We used to say "we train the man for the job." Later we modified this statement to say "training for job clusters." But the truth of the matter is that we do not know for sure where our graduates will go to find jobs, that the requirements of a cluster of jobs will remain unchanged, or that any job will long remain. . . . It is safe to say that many technicians will find that their education has just begun . . . after graduating from our programs.[3]

This statement also emphasizes some of the problems which arise in technical curriculum building. One requirement is clearly that some evidence is needed on the nature of the occupations in which graduates of a particular training program will find themselves. Information concerning the basic knowledge needed to adapt to changes is also required.

The importance of these points for curriculum development is, essentially, that methods must be devised to deal with the problems associated with occupational areas which are characterized by the application of knowledge, particularly scientific knowledge, and by the rapidity with which change takes place. Conventional job analysis based on observation of the worker at his task was predicted on the idea that skills rather than knowledge constituted the main variable in job performance. In technological occupations the reverse is surely the case.

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[3]Charles E. Lowe, "Modern Vocational Electronics Training," *Industrial Arts and Vocational Education*, 53: 46-50, 1964.

Definition of Technician and Areas of Work

A good deal of early work in technical education was centered around the definition of the term technician and the identification of areas of work in which technicians are found. Surveys such as those of Brandon,[4] Murphy and Wahl,[5] and Murphy[6] are typical. Although these studies were local in scope and yielded only descriptive data, they represent essential first steps in the analysis of technical occupations. For example, as has been pointed out by Schill and Arnold,[7] it has been found that two criteria may be used in the attempt to define a technician: first that of training and education, and secondly that of function and skill level.

A definition of technician in terms of education and training is unsatisfactory in the present context since it is precisely the type of education and training required which is the object of the analysis. The criterion of work function is more satisfactory since this permits the inclusion of personnel with widely different backgrounds of education and experience who are performing essentially the same functions. The definition of technician proposed by the

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[4]George L. Brandon, Twin Cities Technicians. (East Lansing: College of Education, Michigan State University, 1958).

[5]Christy A. Murphy and Edward C. Wahl, Technicians in Engineering: Lake County, Illinois. (Urbana: University of Illinois, 1967).

[6]Christy A. Murphy, Technician Need Study: Vermillion County, Illinois. (Urbana: University of Illinois, 1964).

[7]William J. Schill and Joseph P. Arnold, Curricula Content for Six Technologies. (Urbana: University of Illinois, 1965). p. 6.

President's Committee on Scientists and Engineers has been widely used and offers a useful summary of the functions of the technicians.

> The engineering or scientific technician is usually employed in (1) research and development; (2) production, operation, or control; (3) installation, maintenance, or sales. When serving in the first of these functional categories, he usually follows a course prescribed by a scientist or engineer but may or may not work closely under his direction. When active in the third category, he is frequently performing a task that would otherwise have to be done by an engineer.
>
> In executing his function, the scientific or engineering technician is required to use a high degree of rational thinking and to employ post-secondary-school mathematics and principles of physical and natural science. He thereby assumes the more routine engineering functions necessary in a growing technologically based society. He must effectively communicate scientific ideas mathematically, linguistically, and graphically.[8]

In addition to the above general definition, some workers have found it useful to define certain levels of technical activity. A commonly used set of levels is that originally proposed by Dobrovolny.[9] The engineering technician is one who works primarily with the engineer, usually in research and development. The industrial technician is more closely connected with production problems within the industry. The technical specialist is defined as a technician

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[8] U.S. OFfice of Education, Organized Occupational Curriculums in Higher Education. (Washington: U.S. Government Printing Office, 1961), p.3.

[9] Jerry S. Dobrovolny, Development of Technical Institute Education and its Impact on Engineering. Paper presented at the annual meeting of the Technical Drawing Association, New York, 1960. Quoted in Schill and Arnold, op. cit., p. 5.

who has developed a high degree of skill in one major task which constitutes his primary function. In addition, Schill and Arnold[10] define management personnel, in the narrow sense of technically competent management, as a fourth level of technician. It may be of interest to speculate that at the engineering technician level the functions of the technician overlap somewhat those of the engineer, while at the technical specialist level they may overlap those of the craftsman, with perhaps a higher degree of skill in a much narrower range of activities.

In defining the electronics technician it is necessary to add to the above formulations the specific areas of work which may be regarded as making up the electronics field. The U.S. Office of Education has defined four major areas in which electronics technicians might be expected to work:

1. Research and development technician: The technician working directly with scientists and engineers in developing new devices or doing basic research.

2. Sales and Service Technician: A technician representing a company and its products to a customer. He advises the customer and is capable of installing, operating, troubleshooting, and training the customer's personnel to service and maintain equipment located at the customer's installation.

3. Operations Technician: The technician working in a manufacturing facility that maintains automated equipment; checking and troubleshooting electronic control devices and systems; and training skilled plant workers in the operation of electronically controlled equipment.

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[10] Schill and Arnold, _op. cit._, p. 6.

4. Communications Technician: A technician working in broadcast and television installations, microwave networks, or mobile two-way communications systems.[11]

A more elaborate breakdown has been developed by Barlow and Schill as a result of their survey of mathematics requirements in electronics technology. Barlow and Schill offer a nine-category job classification scheme within the three broad areas of manufacture, engineering, and service. The nine categories are: (1) testing, (2) field service, (3) plant maintenance, (4) instrument maintenance, (5) research and development, (6) design drafting, (7) communications, (8) computers, (9) radio and television.[12]

While both of these attempts to classify electronics technicians give some insights into the nature of the field, both suffer from the same weakness in that two variables are mixed in defining the categories. Thus, in the U.S.O.E. scheme, the sales and service and communications categories, for example, need not be exclusive. Similarly in the Barlow and Schill classification a field service technician, for instance, can work in areas such as instrument maintenance, communications, or computers. The problem lies in the confusion of type of work with type of equipment. In the classification scheme used in this study, these two variables are separated.

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[11] U.S. Office of Education, Electronics Technology, A Suggested Two Year Post High School Curriculum. (Washington: U.S. Government Printing Office, 1966), p. 3.

[12] Melvin L. Barlow and William J. Schill, The Role of Mathematics in Electrical-Electronics Technology. (Los Angeles: Division of Vocational Education, U.C.L.A., 1962), pp. 29-31.

The Technical Curriculum

A great deal of material exists which attempts to outline the characteristics, particularly the science and mathematics requirements, of programs for the training of technicians. These range from brief statements of requirements in specific subject areas to broad outlines covering all areas and detailed curriculum guides for particular technologies.

As a preliminary to a detailed outline of a two-year electronics technology program, the U.S. Office of Education gives five areas in which a technician might be expected to be competent:

1. Facility with mathematics; ability to use algebra and trigonometry as tools in the development of ideas that make use of scientific and engineering principles; and an understanding of though not necessarily facility with higher mathematics through analytical geometry, calculus, and differential equations, according to the requirements of the technology.

2. Proficiency in the application of physical science principles, including the basic concepts and laws of physics and chemistry that are pertinent to the individual's technology.

3. An understanding of the materials and processes common to the technology.

4. An extensive knowledge of a field of specialization, with an understanding of the engineering and scientific activities that distinguish the technology of the field. The degree of competence and the depth of understanding should be sufficient to enable the individual to do such work as detail design, using established procedures.

5. Communications skills that include the ability to interpret, analyze, and transmit facts graphically, orally, and in writing.[13]

More generally, Dobrovolny proposes that the engineering

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[13] U.S. Office of Education, Electronics Technology, op. cit. p. 4.

technology curriculum should be so structured as to prepare the graduate to enter a job and be productive with a minimum of on-the-job training, to provide the background to permit him to keep abreast of change, and to enable him, with experience, to advance to positions of increased responsibility.[14] Dobrovolny further states that the theory portion of the program requires mathematics through calculus and some differential equations, while the practical part requires a knowledge of instruments, testing and measuring techniques, and the ability to solve practical problems.[15]

In a conference on science in technical education sponsored by the Commission on Science Education of the American Association for the Advancement of Science, an attempt was made to develop a consensus of opinion concerning mathematics and science requirements for technicians. In the report of this conference, as elsewhere, the question of levels of technical activity is of some importance, with two levels, the "engineering technician" and the "industrial technician" being identified.[16] For both of these levels, however, the consensus was that mathematics and science should not be the conventional college

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[14] Jerry S. Dobrovolny, Electronic Technology. (Springfield: Illinois Board of Vocational Education, and Urbana: University of Illinois, 1967), p. 2.

[15] *Ibid.*, p. 6.

[16] American Association for the Advancement of Science, Technical Education. (Report by the Commission on Science Education. Washington: American Association for the Advancement of Science, 1968), p. 14.

type courses but should be oriented towards the applied aspects of these subjects.[17]

In a paper prepared for this conference,[18] Frank emphasizes certain highly practical mathematics objectives for a technical curriculum. These objectives include approximation methods, elementary statistics, and graphical representation. In science, Frank advocates the placing of emphasis on areas dictated by the demands of the technology. "For example, in physics one could start with dynamical ideas needed for the understanding of the machines and mechanical devices with which the students work."[19] The setting up of physical models of real processes is proposed, as well as the use of manufacturing equipment as a basis for laboratory investigations.

In a similar paper, Harris outlines a mathematics course covering topics ranging from simple algebra to analytic geometry and trigonometry, complex numbers, and advanced graphical analysis. No calculus is included in this outline. Harris agrees with Frank concerning the basic orientation of science courses. Content should emphasize mechanics, heat, and electricity, with reduced emphasis on

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[17] Ibid., p. 13.

[18] N. S. Frank, in "Science in Technical Education," Science Education News. (Washington: American Association for the Advancement of Science, December, 1968), p. 2.

[19] Ibid.

modern physics.[20]

The U. S. Office of Education has prepared a suggested two-year electronics technology curriculum.[21] Physics topics included in this guide emphasize mechanics, heat, and electricity. Mathematics topics include algebra and trigonometry and applied calculus. Electronics courses cover the conventional sequence, beginning with basic electronics and proceeding to specialized courses in such areas as instrumentation, communications, and computers. Other related subjects included in the curriculum are communications skills, technical reporting, drawing, and industrial economics and organization.

A curriculum guide for electronics technology developed jointly by the Illinois Board of Vocational Education and the University of Illinois is somewhat more detailed than the preceeding guide and treats the subject areas at a distinctly more advanced level. Mathematics to the level of introductory differential equations is included. Physics courses emphasize the structure of matter and also deal in some detail with optics, electricity, and high energy physics. The physics in this program is distinctly modern in orientation. An obvious difference between this and the U.S. Office of Education guide is the offering of options, in the final stages of the program, in such specialties as

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[20]Norman C. Harris, in "Science and Technical Education," Science Education News. (Washington: American Association for the Advancement of Science, December, 1968), pp. 3-4.

[21]U.S. Office of Education, Electronics Technology, op. cit.

power, computers, communications, instrumentation, and control systems.[22]

All of the above approaches to the curriculum are subject to criticism on the grounds that they represent only the opinions of "experts" and are not based on definitive research concerning job requirements. The lack of agreement which appears at several points attests to the element of subjectivity and no doubt reflects the biases of particular individuals. Phipps and Evans, in a recent review of the research in technical curriculum development, emphasize the lack of validity of the curriculum guide approach. "This procedure can be justified but it has some definite limitations. It is questionable when no validation studies are conducted to confirm the wisdom and biases of the 'experts.' . . . Studies should be conducted, however, to evaluate the guides and the subject matter they contain."[23]

In the absence of definitive research, it is understandable that the curriculum guide would serve a useful purpose, since practical decisions concerning the curriculum must be made by those responsible, whether or not any evidence exists to validate these decisions. Nevertheless, the developers of curriculum guides are under an obligation to make explicit use of such evidence as does exist, and to point out the limitations of guides based on less than a complete examination of job requirements.

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[22]Dobrovolny, Electronic Technology, op. cit.

[23]Lloyd J. Phipps and Rupert N. Evans, "Curriculum Development." Review of Educational Research, 38: 367-381, 1968.

Research in Technical Curriculum--Job Analysis

More than for most other forms of education, the aim of technical education is relatively clear. That technical education should be job-oriented rather than general in nature is a well established principle, indeed is almost a definition. One important implication of this is, as Crawford points out, that "designs of technical education or training curricula should therefore find their origin in a thorough understanding of the requirements for human performance in areas of work."[24] Further, "the effectiveness of resulting training is to be measured in terms of how well graduates meet these requirements."[25] Although Crawford neglects to mention the broader problem of the necessity for the training program to enable the worker to adapt to possible changes in his field, it might be argued that a necessary prerequisite to dealing with this problem is a thorough knowledge of the requirements in a field at a particular time, and of trends in the field over a period of time. In any case, the importance of obtaining precise knowledge of job requirements cannot be overemphasized.

The U.S. Office of Education has addressed itself in general

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[24]Meredith P. Crawford, "A New Approach to Training Programs," Science Education News. (Washington: American Association for the Advancement of Science, December, 1968), pp. 5-6.

[25]Ibid.

terms to the problem of job analysis techniques. Three stages in the analysis of any job are identified: (1) the job must be completely and accurately defined; (2) the tasks or job elements which describe the duties and worker actions required in performing the job must be complete and accurate; (3) the knowledge and skills which are required for each job element must be analyzed.[26] For purposes of analysis designed to determine knowledge requirements, the first two steps are perhaps best combined as part of the process of job description. The last step is the crucial one for curriculum purposes.

Many studies of technical occupations were not specifically curriculum studies but included items relevent to knowledge and skills in the questionnaires, rating scales, or checklists typically used as instruments. The studies by Brandon,[27] Murphy and Wahl,[28] and Murphy[29] already cited are typical examples. Studies by Weede,[30]

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[26] U.S. Office of Education, Job Descriptions and Suggested Techniques for Determining Courses of Study in Vocational Educational Programs: Electrical and Electronic Technology. (Washington: U.S. Government Printing Office, 1960), p. 1.

[27] Brandon, Twin Cities Technicians. op. cit.

[28] Murphy and Wahl, Technicians in Engineering. op. cit.

[29] Murphy, Technician Need Study. op. cit.

[30] Gary Dean Weede, Electronic Technician Personnel and Training Needs in Iowa Industry. E.D.R.S. Document ED 020 314. (Ames: Iowa State University of Science and Engineering, 1967).

Laws,[31] and Brown,[32] were more specifically designed for curriculum purposes. A detailed review of these studies is not given since the data collection techniques and, more specifically, the analysis techniques, were judged inadequate other than for providing certain descriptive data and a broad general picture of requirements.

Analysis of results was sometimes confined to a reporting of frequencies of occurrence of the different responses by the various groups under study.[33] In some instances a rank ordering of items was attempted.[34,35] This ranking was normally accomplished by the assignment of weights to the different responses and summing the weighted responses for each item over all individuals. This technique suffers from the weakness that sums are seriously affected by imbalances in the sample, such as the existence of an inordinate number of individuals from a specific job even though this number may, in fact, represent the true state of affairs in the population. Furthermore, these techniques do not lend themselves to statistical tests of the

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[31] Norman G. Laws, Mathematical Expectations of Technicians in Michigan Industries. E.D.R.S. Document ED 017 632. (Lansing, Michigan: State Department of Public Instruction, 1966).

[32] Bill W. Brown, Characteristics of Outstanding Engineering Technicians in Arizona. E.D.R.S. Document ED 016 840. (Phenix: Arizona State Department of Vocational Education, 1967).

[33] Brandon, Twin Cities Technicians. op. cit.

[34] Murphy, Technician Need Study. op. cit.

[35] Weede, Technician Personnel and Training Needs. op. cit.

degree of agreement among groups or the relative importance of items or groups of items.

A study conducted by Brandon[36] was specifically designed to explore the problem of a research design for technical curricula. The question of occupational analysis appeared to be of primary importance. A research design was proposed in terms of a matrix model with specific technical jobs on one dimension and skills and concepts forming the second dimension. On the surface this model appears to be the same as that used in conventional job analysis and applied in the studies cited above. The study is noteworthy, however, in that an examination of the model in the abstract led to the suggestion of analysis techniques such as the use of intercorrelations, cluster analysis, and factor analysis. These suggestions anticipate many of the techniques which only recently have shown signs of widespread use in this area.[37]

A study by Stewart and Workman[38] is unique in its use of the critical incidents technique to obtain data on the mathematics and science requirements of technicians. Individuals in a sample of

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[36] George L. Brandon, Explorations in Research Design: Curricula for Technicians. (East Lansing: Educational Publication Services, College of Education, Michigan State University, 1960).

[37] Phipps and Evans, "Curriculum Development." op. cit.

[38] Lawrence H. Stewart and Arthur D. Workman, Mathematics and Science Competencies for Technicians. (Sacramento: Bulletin of the California State Department of Education, Vol. 29, December, 1960).

chemical and electronics technicians in California industries were asked to submit reports of incidents in their work which involved critical science and mathematics knowledge. These incidents were classified into subject matter topics and the frequency of occurrence of the various topics tabulated.

Only a relatively few incidents which could be classified as critical were reported. Although the investigators recognized the possibility of other explanations, this result was interpreted as implying that the work of the technician does not require critical skills. Two further points resulting from this study are of interest. First, the investigators report that "the nature and extent of the data . . . failed to indicate that technicians at any level really use high-level mathematics and science skills."[39] Second, the comments of supervisors, together with the shortage of critical incidents, were taken to mean that "while hiring specifications often prescribe certain mathematical and scientific skills, there is frequently little relationship between these requirements and the work actually performed by technicians."[40] This tends to substantiate an observation made earlier[41] that training programs, once they become established, may set the pattern for what employers regard as the

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[39] Ibid., p. 36.

[40] Ibid.

[41] Cf. p. 16.

requirements for the job.

A study by Barlow and Schill[42] on the mathematics concepts required in electrical-electronics technology is in many ways an example of the type of research that is required. This study used a random sample of technicians in California industry and represented the first use of the Q-sort as a data collection instrument in the context of job analysis. The Q-sort consisted of a deck of sixty-six cards, each card containing a mathematics problem. Technicians were required to respond to the instrument in terms of the degree of similarity of the problems presented to problems they were likely to encounter in their work.

By means of an analysis of the intercorrelations among the respondents, relatively strong agreement was found among technicians on the required concepts. It was further found that the ordering of concepts by technicians strongly agreed with a logical order of instruction as determined by an instructor sort. An increase in mean within-group correlation when technicians were grouped by job classification and by amount of formal mathematics led to the conclusion that responses to the sorts varied with these two methods of classification. The coefficient of concordance was used to test the significance of agreement among persons within each job classification. While this statistic provides a legitimate test of within-group agreement, it tells nothing about the difference between within-group and overall responses. Furthermore, the mean correlation, when this mean is not near

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[42]Barlow and Schill, <u>The Role of Mathematics</u>. <u>op</u>. <u>cit</u>.

zero, does not provide an adequate measure of the true extent of agreement among variables because of the skewness of the sampling distribution of a nonzero correlation coefficient.

From the point of view of methodology and administrative procedures, this study provides an appropriate model upon which to base further research. In particular, the Q-sort has some distinct advantages over the questionnaire or checklist. It is felt, however, that the statistical techniques used fell somewhat short of realizing the full potential of the data. No test of significance exists for the difference between two coefficients of concordance. In the absence of such a test, the conclusion that job classification and formal education were significant independent variables was not warranted.

A further study by Barlow and Schill[43] on the role of the physical sciences in electrical-electronics technology is not as satisfactory methodologically as the mathematics study, mainly because the questionnaire method did not yield a complete return (60% for technicians), and because the list of physical science principles was, as recognized by the investigators, less than satisfactory for this particular application. Significant differences in responses were reported when technicians were grouped by job classification. Similar significant differences appeared between technician responses, instructor responses, and the responses of an expert jury. It was reported that instructors and the expert jury tended to rate items more highly on

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[43] Melvin L. Barlow and William J. Schill, The Role of the Physical Sciences in Electrical-Electronics Technology. (Los Angeles: Division of Vocational Education, U.C.L.A., 1965).

the scale than did technicians. The precise statistical technique leading to these conclusions was, however, not reported.

Items were classified into broad topics and the mean rank orders of items within each topic for each of the above three groups were correlated. It was found that significant agreement existed on the relative importance of items within topics and on the overall relative importance of topics. Thus it appears that, while absolute differences existed among groups, these groups agreed strongly on relative importance. An interesting statistical point here concerned the conversion of correlations to Fisher's Z and the testing for significance of the mean value of Z. This procedure avoids the distributional problem associated with the use of mean correlations.

On a broader level, a study by Schill and Arnold[44] was concerned with knowledge in six broad technical fields. In this study the card sort technique was again used, reinforcing the view that such a technique is a valuable tool. In this case, however, the sort instrument had to contain such a broad range of items to cover all technologies that no one respondent could be expected to be familiar with all the items. Thus, the items unrelated to an individual's field had to be sorted into one pile, resulting in a distortion of the sort pattern and imposing certain restrictions upon the subsequent analysis resulting from the fact that each respondent in effect responded to a different number of items.

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[44]Schill and Arnold, Curricula Content for Six Technologies op. cit.

In general, it was found that it was possible to identify a common core of knowledge required in all the technologies. Such knowledge included oral and written communication, algebra, plane and solid geometry and trigonometry, sketching and preparation of schematics, and measurement as a means of controlling systems. Further, through the use of factor analysis, it was possible to identify items specific to certain technologies.

Like the mathematics study of Barlow and Schill, this study is a model of careful design and effective execution. The major drawback was the scope of the instrument as a whole, and the broadness of the individual items.

As part of this study, Arnold[45] investigated the responses of technically competent management personnel to the instrument. The aim was to determine whether management differed from technicians both in number of cards selected as related to the technology and in degree of generality of the items selected. It was found that, in general, technicians and management did not differ significantly on either of these variables. Furthermore, no differences were found when management were classified on the basis of such variables as age, educational attainment, tenure of employment, and company size.

II Q METHODOLOGY

At the outset, it is necessary to make a distinction between

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[45] Joseph P. Arnold, "Technical Education Curricular Recommendations by Management Representatives of Manufacturing Establishments in Illinois." Unpublished Doctoral Dissertation, University of Illinois, 1965.

Q-technique and the use of Q-sorts. The Q-sort is a data collection instrument which does not, in itself, determine the method of analysis. The question of what, in fact, may be called Q-technique has been the subject of much controversy. In order to make the distinction required here it is necessary only to consider Q-technique as a method of analysis, as distinct from data collection.

An attempt to standardize terminology has been made by Cattell through the use of a generalized data matrix.[46] As will be seen, however, the controversy is more than a matter of semantics. Since the use of Q-sorts arose in the context of the development of Q-technique, it is convenient to designate as Q-methodology any procedure which involves either the use of Q-sorts or the correlation between persons, even though these may be used in combination with other data collection or analysis methods.

Basic Issues in Q-Methodology

Since the historical development of Q-methodology has been well documented,[47] no attempt is made here to trace this development. In order to place the method in perspective, however, it is necessary to raise certain points concerning the foundations of the method. Stephenson, the originator and principal exponent of the method, maintains that, as a fundamental approach to analysis, Q has an entirely

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[46] R. B. Cattell, "The Three Basic Factor-Analytic Research Designs--Their Interrelations and Derivations," Psychological Bulletin, 49: 499-520, 1952.

[47] O. H. Mowrer, "Q-Technique--Description, History, and Critique," Psychotherapy: Theory and Research, O. H. Mowrer, ed. (New York: Ronald Press, 1953), pp. 316-375.

different orientation from conventional R-technique. In this connection Stephenson raises certain fundamental questions concerning the nature of scientific investigation in general, and of psychological research in particular.[48]

The nature of the data dealt with in psychological research may be clarified by considering the covariation chart developed, and recently generalized, by Cattell.[49,50] This chart in its original form, as shown in Figure 2, suffices for most practical purposes, although the terms "conditions" or "circumstances" may sometimes be used instead of occasions. Without adding further dimensions, the chart may be broadened in scope by using the terms "entities" and "attributes" in place of persons and tests respectively.[51] According to Cattell, Q and R-techniques operate on the same matrix of data, that of persons by tests. The distinction lies simply in whether the matrix is analyzed by rows or by columns.

Stephenson, however, considers Q and R as dealing with different matrices, based on different sets of postulates.[52] The source of

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[48]William Stephenson, The Study of Behavior. (Chicago: University of Chicago Press, 1953), pp. 22-26.

[49]R. B. Cattell, "The Three Basic Factor Analytic Research Designs," op. cit.

[50]R. B. Cattell, "The Data Box," Handbook of Multivariate Experimental Psychology, R. B. Cattell, ed. (Chicago: Rand McNally, 1966), pp. 67-128.

[51]Paul Horst, Factor Analysis of Data Matrices. (New York: Holt, Rinehart and Winston, 1965), pp. 11-13.

[52]Stephenson, The Study of Behavior, op. cit., p. 58.

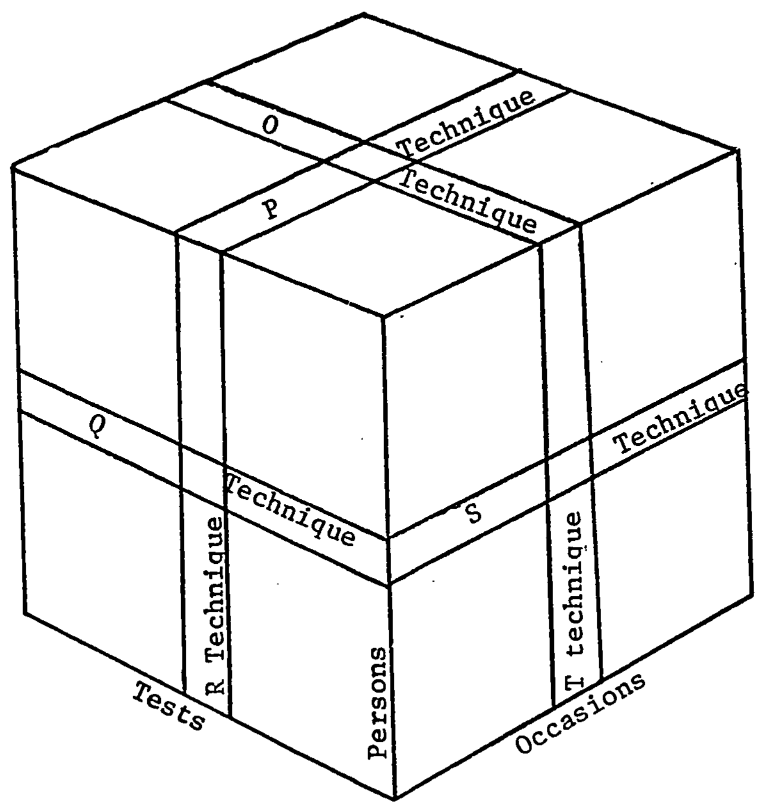

Figure 2

The Cattell Covariation Chart

confusion is perhaps that, under certain circumstances, these matrices may look the same. Thus, for example, the matrix of persons by items obtained from the application of a Q-sort to a group of persons can fit into the covariation chart only in the sense of persons by tests. Depending, however, on what is under investigation, the entities may be considered as items and the attributes as persons.

Briefly, Stephenson proposes that Q-technique is concerned with *intra*-individual differences rather than with differences between individuals. The individual is investigated with respect to certain theoretical formulations, from which are derived certain behaviors which might be observable in the individual.[53] A second important distinction, in Stephenson's view, is that between dependency and interdependency analysis. In interdependency analysis one deals with relationships among variables without regarding some as independent and others as dependent. Factor analysis thus would normally be considered as a form of interdependency analysis. Stephenson has proposed that, in Q-technique, factor analysis may be used in a dependency sense by attempting to rotate factors to match an hypothesized pattern.[54] A third distinction lies in the structure of samples. In Stephenson's sense, the sampling problem does not involve selection of persons but selection, for example, of items to be included in a Q-sort from a universe of possible items related to the effects under study.[55]

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[53] *Ibid.*, p. 19

[54] *Ibid.*, pp. 30-46.

[55] *Ibid.*, pp. 62-66.

Stephenson has also enumerated further distinctions of lesser importance for the present application.[56]

The Q-Sort

Since most of the applications of Q-sorts have been made in such areas as personality development and psychotherapy, no attempt is made here to discuss specific applications. Examples of applications have been given by Block[57] and Mowrer.[58] There are, however, certain general points related to construction of sorts which require some examination.

Cronbach[59] has discussed the advantages of the forced choice procedure over the usual questionnaire method of obtaining individual judgments. This procedure requires every person to place himself on the measuring scale in the same manner. The usual practice of placing more items in the center of the scale relieves the subject from having to make many difficult discriminations. Moreover, such discriminations are of minor importance when correlating persons because it is the extreme values which exert greatest influence on the correlation coefficient. Schill and Arnold list further advantages, in particular

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[56] Ibid., p. 58.

[57] J. Block, The Q-Sort Method in Personality Development and Psychiatric Research. (Springfield, Illinois: Charles C. Thomas, 1961), pp. 12-17.

[58] Mowrer, "Q-Technique," op. cit., pp. 317-326.

[59] Lee J. Cronbach, "Correlation Between Persons as a Research Tool," Psychotherapy: Theory and Research, O. H. Mowrer, ed. (New York: Ronald Press, 1953), p. 378.

the fact that the individual can make relative judgments without finally committing himself to a judgment until all items have been effectively compared with all others.[60]

In the Stephenson system the construction of sorts is intimately connected with the question of sampling. Generally speaking, the items in a Q-sort are regarded as a sample drawn from a universe of all conceivable items in the field under study. Stephenson presents a detailed discussion of the structuring of item samples, in which the inclusion of more than one item referring to the same aspect of the underlying theory is regarded as legitimate, these items being regarded as replications.[61] This implies that correlated items may be included in a single sort. Sundland, however, is highly critical of Q-sorts on the grounds that the use of correlated items spuriously increases the correlation between persons and the number of degrees of freedom.[62] Cronbach vacillates on this question. At one point he states that, "in obtaining data for correlating persons, it is essential that items have some logical similarity, but correlation is generally undesirable."[63] In the same article he also states, "there is some merit,

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[60]Schill and Arnold, <u>Curricula Content for Six Technologies</u>. <u>op</u>. <u>cit</u>., p. 21.

[61]Stephenson, <u>The Study of Behavior</u>, <u>op</u>. <u>cit</u>., pp. 62-66.

[62]Donald M. Sundland, "The Construction of Q-Sorts: A Criticism," <u>Psychological Review</u>, 69: 62-64, 1962.

[63]Cronbach, "Correlations Between Persons," <u>op</u>. <u>cit</u>., p. 380.

for correlating persons, in the lumpy test composed of groups of correlated items, a sort of cluster-sampling principle which permits important variables to take on substantial weight."[64]

Aside from its effect on person correlations, it appears essential, if a sort is to be structured so as to permit testing of different effects on the same individual, that groups of items be included which are highly correlated among themselves while being essentially uncorrelated with other groups. In such a situation we have, essentially, replication of effects which are important in a particular application. Such effects become meaningful with respect to the individual if he places all items in a given cluster at approximately the same point on the scale.

A minor point in the construction of sorts concerns the form of the distribution of the forced sort. Stephenson suggests a distribution which is symmetrical but somewhat flattened from the normal distribution.[65] Nahinsky, however, in developing a model for the analysis of variance of Q-sort data, uses normality of the distribution as one of the underlying assumptions.[66] To further complicate the issue, Cronbach argues that, for most applications,

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[64] Ibid.

[65] Stephenson, The Study of Behavior, op. cit., p. 59.

[66] I. D. Nahinsky, "The Analysis of Variance of Q-Sort Data," Journal of Experimental Education, 34: 66-72, 1965.

the unforced sort may be a superior procedure.[67] Cronbach bases this argument on the loss of information concerning individual differences in mean and variance of the sort as a whole. There appears to be no consensus on this point. Nevertheless, it appears safe to say that when individual differences in the sort as a whole will add nothing to the application, the simpler forced sort is most appropriate.

Analysis of Data Based on Q-Sorts

The ipsative[68] nature of Q-sort data raises questions concerning the legitimacy of using such data to compare individuals or groups. Basically the problem involves whether ipsative data can be treated normatively. Horst argues that it is erroneous to compare persons with one another with respect to ipsative measures since, "some arbitrary constant has been added or subtracted from all scores of each subject measured. Since this is not in general the same constant for all subjects, the resulting measures are not comparable from one subject to another."[69] Cattell, however, regards the treatment of ipsative scores as normative as legitimate since, as he points out, either may be rescaled at will.[70] Block has presented some empirical

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[67] Cronbach, "Correlations Between Persons," op. cit., p. 380.

[68] R. B. Cattell, "Psychological Measurements: Normative, Ipsative, Interactive," Psychological Review, 51: 292-303, 1944.

[69] Paul Horst, Factor Analysis of Data Matrices, op. cit., p. 294.

[70] Cattell, "Psychological Measurements," op. cit.

evidence that such transformations are justified.[71]

The use of the forced choice method means that, not only are the data ipsative in nature, but also that the values assigned to items are not independent. Cronbach and Gleser argue against the use of the F statistic with Q-sort data on the grounds that nonindependence violates one of the assumptions upon which the F statistic is based.[72] No evidence exists concerning the specific effect on the F statistic of violating this assumption. Block, however, indicates that for a Q-sort containing a large number of items, the bias introduced by this effect is insignificant.[73] This problem is obviated of course if it can be assumed that the forced distribution closely approximates the distribution which would occur in the absence of forcing.

Although individual differences in the conventional sense cannot be determined from Q-sort data, in one important sense it is possible to analyze this type of data in terms of differences among groups of persons. This involves the examination of whether a given group is more homogeneous than the population as a whole. Cronbach points out that this involves comparison of the similarity measures for pairs of

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[71] J. Block, "A Comparison Between Ipsative and Normative Ratings of Personality," Journal of Abnormal and Social Psychology, 54: 50-54, 1957.

[72] Lee J. Cronbach and G. C. Gleser, "The Study of Behavior: Q-Technique and its Methodology," Book Review, Psychometrika, 19: 327-30, 1954.

[73] J. Block, The Q-Sort Method, op. cit., p. 98.

individuals within a group with those for pairs drawn from the population as a whole.[74] Similarly, Cattell considers Q-technique as a useful device for finding subpopulations within a nonhomogeneous population.[75] The transformation of correlation coefficients to Fisher's Z provides a means of comparing two sets of correlation coefficients since the distribution of Z is approximately normal.

The use of Q-technique in factor analysis has been the subject of considerable controversy. One problem concerns whether Q and R factor analyses yield the same results. While Burt's proof that the results are identical for a double centered score matrix has been generally accepted, the problem of loss of factors associated with the centering operations persists. Detailed discussion of this point has been presented by Cattell[76] and Broverman.[77]

Assuming that the first factors referred to in the above citations are not of concern, and that the desire is to proceed in the conventional way by factoring correlation matrices, the choice

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[74] Cronbach, "Correlation Between Persons," op. cit. p. 377.

[75] Cattell, "The Three Basic Factor-Analytic Research Designs," op. cit.

[76] R. B. Cattell, "The Meaning and Strategic Use of Factor Analysis," Handbook of Multivariate Experimental Psychology, R. B. Cattell, ed. (Chicago: Rand McNally, 1966), pp. 228-9.

[77] Donald M. Broverman, "Effects of Score Transformations in Q and R Factor Analysis Techniques," Psychological Review, 68: 66-80, 1961.

between using person correlations or test (or item) correlations can be based on practical considerations. Horst[78] and Cattell[79] point out that the choice could depend on whether one has more persons than tests or vice versa. Cattell indicates that R-technique is generally to be preferred because it avoids the problem of applying the simple structure concept to persons.[80] In the present study the choice of using item rather than person correlations was based on further considerations. In the first place, simple structure was defined in terms of items, with the expected factor patterns being essentially predefined in terms of hypothesized item clusters. Furthermore, subsequent phases of the analysis required the evaluation of whether the hypothesized item clusters were indeed meaningful.

The use of factor analysis in hypothesis testing, as well as being essential to the system presented by Stephenson, has also been discussed by Cattell[81] and Horst.[82] In general, it is observed that dependency factor analysis is not necessarily unique to Q-technique as defined by Stephenson, and its use does not depend on the acceptance of Stephenson's postulates. The Procrustes program of Hurley

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[78]Horst, Factor Analysis of Data Matrices. op. cit., p. 325.

[79]Cattell, "The Meaning and Strategic Use of Factor Analysis," op. cit., p. 229.

[80]Ibid.

[81]Ibid., p. 191.

[82]Horst, Factor Analysis of Data Matrices. op. cit., pp. 386-7.

and Cattell is an example of an analytical procedure for matching an unrotated factor matrix to an hypothesized pattern. The possibilities of abuse of this technique have been discussed by the authors.[83] This possibility stems from the fact that the procedure will almost always produce a factor pattern which appears to give the desired match, but sometimes only at the expense of making the factors so highly correlated as to be meaningless.

III SUMMARY

The value of detailed and systematic job analysis in technical curriculum planning is well established. Techniques for carrying out this type of analysis, however, have suffered from certain drawbacks. The use of questionnaires, rating scales, and opinion surveys in general permit only descriptive data to be obtained. This is particularly true when items concerning curriculum are included as part of broader surveys.

Few attempts have been made to carry out the type of detailed study of a specific area of technology which is required. In particular, no study has been concerned with possible areas of specialization within a field as broad as electronics technology. Studies which have dealt with the problem of a common core of knowledge and areas of specialization have done so across a group

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[83]John R. Hurley and R. B. Cattell, "The Procrustes Program," Behavioral Science, 7: 258-62, 1962.

of technical occupations.

A promising methodology for the analysis of technical occupations has developed from the adaptation of the Q-sort to this problem. Techniques of analysis used with this method have, however, fallen somewhat short of realizing the full potential of the data. In this chapter the question of analysis of this type of data was considered in relation to a broad view of the nature of Q-methodology. Research is needed which deals with both the methodology itself and its application to job analysis in specific areas of technology.

CHAPTER III

DESIGN OF THE STUDY

I DEFINITIONS

Related to Identification of Technicians

Some evidence exists that company job descriptions vary considerably and therefore do not form an appropriate basis for the identification of technicians.[1] The following two definitions were designed to facilitate this identification. The definition of electronics technician was used in the resumé of the study included in the initial letter to employers. The definition of electronics was used when it was necessary to distinguish individuals working with electronics equipment from those working with electrical or electromechanical equipment.

Electronics. In general, electronics may be defined as that branch of physical science dealing with the behavior of electrons in metals, semiconductors, a vacuum, or in gaseous media, under various physical conditions. Since electronics technology is concerned with the applied rather than the theoretical aspects of the science, a more specific definition was used for the present study:

> Electronics is that branch of technology concerned with the development and application of practical devices, and equipment

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[1] William J. Schill and Joseph P. Arnold, Curricular Content for Six Technologies. (Urbana: University of Illinois, 1965), pp. 16-17.

based on these devices, which have resulted from the study of the behavior of electrons in various media under various physical conditions. In particular, electronics is concerned with the control of electron flow for practical purposes. Excluded, however, are devices which permit solely mechanical control (i.e. switches, relays, etc.), as well as those which may be analyzed solely in terms of gross electrical properties (currents, voltages, etc.) as distinct from the analysis of electron behavior.

Electronics technician. The definition of electronics technician used in the study was as follows:

An electronics technician is a person engaged in the design or development, operation or control, installation, maintenance, or sales of electronic equipment, subject, however, to the following exclusions:

1. Excluded are persons holding a university degree in science or engineering.

2. Excluded are persons whose primary function is routine operation or sales, requiring no knowledge of the internal workings of the equipment.

3. Excluded are persons engaged solely in the servicing of domestic appliances including radio and television receivers.

Related to Classification of Technicians

Of the several variables which were regarded as being of possible relevance to technicians' responses to the instruments, four were judged to be sufficiently unique to the present study to require definition. The remaining variables, age, salary, years of formal education, years of technical education, and source of training were self-explanatory.

Type of work. Technicians were given a choice of nine categories with which to characterize their predominant type of activity. These categories were as follows:

1. Research and development (including design and testing of prototypes)
2. Production
3. Maintenance
4. Installation
5. Calibration and standardization
6. Operation
7. Sales
8. Supervision
9. Others

Technicians who used category 9 were asked to describe briefly the type of activity in which they were engaged. The intention was to expand the list for analysis if a sufficient number of individuals could be found having similar descriptions.

Type of equipment. Technicians were similarly given a choice of nine categories to describe the type of equipment with which they primarily worked:

1. General electronics (including audio equipment, basic amplifiers, etc.)
2. Broadcast (radio and television)
3. Communications (VHF and UHF equipment etc., not included in 2)
4. Telephone switching
5. Microwave
6. Navigational aids (including radar)

7. Computers, data processing equipment

8. Automatic control systems and industrial electronics

9. Others

Again individuals using category 9 were asked to describe their jobs.

Range of experience. Two factors, the number of different jobs held by the individual, and the number of years worked, were relevant to this variable. Range of experience, expressed in units of job-years, was defined as the total number of jobs held multiplied by the number of years worked in the field. Only experience related to electronics was included. Jobs were determined, not in terms of different employers, but on the basis of whether different type of work or type of equipment descriptions applied.

Tenure of employment. Tenure of employment was defined as the number of years spent by the respondent in his current job. As such, this variable may be considered as a sort of reverse index of worker mobility. The connection is not direct, however, since inexperienced individuals who have had no opportunity to become mobile, are mixed with highly experienced individuals who happen to have recently changed jobs. The aim here was not to make fine distinctions but to assess a possible effect which could not be determined from the range of experience variable. This effect was the possible narrowing of views resulting from long exposure to the same job.

Degree of Generality

Generality of items was defined in terms of a sorting of items by the two panels of experts, consisting of graduate students in physics and electrical engineering, who were involved in the validation phase of the study. These individuals were requested to sort the items on a seven point scale according to their views of how fundamental a given item was to the discipline concerned. On this type of scale, theoretical constructs would, for example, normally be regarded as more general than would specific applications. The mean scale value was computed for each item over the four validators plus a sort by the investigator, which resulted in a compression of the scale to five points. The degree of generality of an item was this mean, rounded to the nearest whole number.

II HYPOTHESES

One major objective of the study was to determine the relative importance for electronics technicians of various elements of subject matter within each of the subjects under investigation. Since each Q-sort contained a relatively large number of items, a comparison of responses to individual items would clearly present problems of interpretation. It therefore appeared realistic to develop clusters of items within each instrument and to conduct the analysis in terms of these clusters. Since each of the subject areas represented a well established discipline with reasonably well defined topics existing within each subject, a logical clustering of items based on such topics could be developed without difficulty. This was particularly true since one aspect of the validation of the instruments consisted of having the validators sort cards into categories representing a topical outline of the field, with the aim of achieving a balanced representation of the major topics.

The foregoing considerations led to the question of whether in fact these logical clusters of items were significant factors in the technicians' sorts or whether, perhaps, some recombination of topics might present a more meaningful pattern of responses. It was proposed that factor analysis be used to investigate this point. Hypotheses 1.0 to 1.2 related to this question. The specific details of how factor analysis was used in this context are presented in the section on statistical design.

Hypothesis 1.0 On the basis of technicians' responses to the physics instrument, it will be possible to identify clusters of items which correspond to the following topics:

1. Mechanics
2. Wave properties, harmonic motion
3. Atomic physics, quantum theory
4. Kinetic molecular theory
5. Optics
6. Heat and thermodynamics
7. Nuclear physics
8. Relativity

Hypothesis 1.1 On the basis of technicians' responses to the electricity instrument, it will be possible to identify clusters of items corresponding to the following topics:

1. A.C. circuits
2. Properties of capacitors
3. Magnetic effects of charges
4. Inductors, induced EMF
5. Network analysis
6. Electromagnetic waves
7. The electric field
8. Maxwell's equations
9. Instrumentation principles
10. Resonance
11. Ferromagnetism

Hypothesis 1.2 On the basis of technicians' responses to the electronics instrument, it will be possible to identify clusters of items corresponding to the following topics:

1. Physical electronics
2. Transistor principles and applications
3. Vacuum tube principles and applications
4. RF circuits
5. Broadcast systems
6. Logic circuits
7. Feedback
8. Microwave
9. Large signal properties of devices
10. Instrumentation

It is emphasized that these topics were outlined to serve as a point of reference for the interpretation of factors. The topics correspond essentially to those commonly used in texts and to areas regarded as areas of specialization. In interpreting factors the intention was to accept as meaningful to the respondents certain combinations or even certain subtopics if these appeared in the factors obtained. Thus, for example, RF circuits and broadcast systems bear an obvious relationship to each other. Similarly, the electricity topics could essentially be subsumed under the two major areas of circuits and fields. Aside from the possibility of recombination of topics, it was intended that the topics outlined be used as the basis for a dependency factor analysis.

The second important objective of the study involved the possible existence of areas of specialization within electronics technology, and the differences in subject matter requirements which might occur across job classifications. Significant differences in response to the instruments by individuals in different job categories would imply that an overall ordering of importance of topics would be less meaningful than a separate ordering for each type of job. Job classification was conceived as having two components, type of work and type of equipment, as defined in the preceding section. The primary hypotheses for the study were based on these considerations. These are stated here in null form.

Hypothesis 2.0 There will be no signficant differences in overall subject matter requirements in the three subject areas, as determined by the responses to the Q-sorts, among groups formed on the basis of type of work.

2.1 There will be no significant differences among these groups in mean ratings assigned to specific topics within each subject area.

2.2 There will be no significant differences in mean ratings assigned to the various topics by each of these groups taken separately.

Hypothesis 3.0 There will be no significant differences in overall subject matter requirements among groups formed on the basis of type of equipment.

3.1 There will be no significant differences among type of equipment groups in mean ratings assigned to specific topics within each subject area.

3.2 There will be no significant differences in mean ratings assigned to the various topics by each of the type of equipment groups taken separately.

In each case the second and third hypotheses follow logically from the first. 2.0 and 3.0 are concerned with overall effects, while the remaining sections are concerned with the specific effects of groups and topics respectively. If the null hypothesis is accepted for 2.0 and 3.0 there is no advantage in pursuing the analysis for the remaining hypotheses.

It was anticipated that differences in response on the basis of job classification would be more apparent for the electronics sort than for the physics and electricity sorts, particularly for the type of equipment component of job classification. Since physics and electricity were regarded essentially as prerequisites to electronics, rather than as directly applicable to specific jobs, there was less reason to believe that areas of specialization would be determined by responses to these instruments. It was anticipated, however, that overall item or topic effects would be of some significance for the sample of technicians as a whole.

Although respondents were instructed to conduct the sorts with reference to their current jobs, it was conceivable that other variables could exert an effect on responses. In particular, the effects of amount and source of training, and range of experience could not be ignored. In the nature of nonexperimental research these variables could not be controlled. The following hypotheses were designed to explore the possible effects of these secondary variables.

Hypothesis 4.0 There will be no significant differences in overall responses to the Q-sorts among groups formed on the basis of years of formal education.

Hypothesis 5.0 There will be no significant differences among groups formed on the basis of years of technical education.

Hypothesis 6.0 There will be no significant differences among groups formed on the basis of source of training.

Hypothesis 7.0 There will be no significant differences among groups formed on the basis of range of experience.

Hypothesis 8.0 There will be no significant differences among groups formed on the basis of tenure of employment.

Hypothesis 9.0 There will be no significant differences in responses when technicians are grouped by age.

Hypothesis 10.0 There will be no significant differences among groups formed on the basis of salary range.

Certain further effects were deemed to be of significance for the study. One of these concerned the degree to which the responses of technicians agreed with emphasis in existing training programs. To this end, responses to the Q-sorts were obtained from a sample of electronics instructors at both institutes of technology in Alberta. It was postulated that these instructors would form a relatively homogeneous group and that their responses would reflect current emphasis in the training programs. A comparison of technician and instructor responses would therefore serve as an indicator of the degree to which the particular training programs represented by the instructors actually corresponded to requirements as expressed by working technicians.

Hypothesis 11.0 There will be no significant differences between the degree of agreement among instructors as a group and the degree of agreement between instructors and technicains.

11.1 There will be no significant differences between instructors and technicians in the mean rating assigned to each topic within each subject area.

11.2 There will be no significant differences in mean ratings assigned by instructors to the various topics within each subject area.

During the planning stages of the study, discussion with electronics instructors and other individuals revealed that the question of the degree of generality of subject matter was of some concern. More specifically, this issue concerned the relative merits of emphasizing subject matter which was regarded as having broad application as opposed to the emphasis of more specific points. On a purely exploratory level, therefore, it was proposed that possible differences between technicians and instructors be investigated relative to a classification of items in the card decks on the basis of degree of generality.

In order to obtain a measure of generality of items, the individuals involved in the validation phase of the study were requested to sort items on a seven point scale from highly specific to highly general. The following hypotheses were formulated relative to the generality scale.

Hypothesis 12.0 There will be no significant differences between instructors and technicians in mean ratings assigned to items within each category of the generality scale.

12.1 There will be no significant differences among generality scale categories on the basis of mean ratings assigned by technicians to the different categories.

12.2 There will be no significant differences among generality scale categories on the basis of mean ratings assigned by instructors to the different categories.

None of the foregoing hypotheses involves reference to the possibility of individual differences in perception of the measuring scale as a whole. In fact, the use of the forced sort implies the assumption that such differences are not of interest or, more specifically, that such differences represent idiosyncracies of the individuals rather than systematic effects. Hypothesis 13.0 was designed to test this assumption for the groups of technicians formed on the basis of the different classification variables. The hypothesis was tested with respect to an initial three category unforced sort originally designed to simplify the sorting process.

Hypothesis 13.0 There will be no significant differences among groups of respondents, based on the different classification variables, in the number of cards placed in the "most useful" category of the initial sort, for each of the three instruments.

III STATISTICAL DESIGN

Factor Analysis

Dimensionality of the Q-sort instruments as it related to technician responses to these instruments was investigated by means of factor analysis of item correlations. The factor analysis had a dependency orientation because it was possible to develop clusters of items within each card deck on the basis of considerations external to the present study.

In spite of the existence of well established relationships among items, the possibility of other relationships, more meaningful in the present context, could not be ignored. Thus a two stage procedure was established with respect to the factor analysis. First a principal axes solution extracting all factors with eigenvalues greater than unity was obtained. This was followed by varimax and promax rotations. The varimax and promax solutions were examined for meaningful relationships among items. Where such relationships were not apparent, the second stage was pursued. In this stage an oblique rotation designed to match the unrotated principal axes factors with the hypothesized pattern was conducted, using the Procrustes method.[2] Characteristics of an hypothesized pattern matrix are discussed by Horst.[3]

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[2] John R. Hurley and R. B. Cattell, "The Procrustes Program," Behavioral Science, 7: 258-62, 1962.

[3] Paul Horst, Factor Analysis of Data Matrices. (New York: Holt, Rinehart, and Winston, 1965), p. 387.

Correlations Between Persons

Several hypotheses were concerned with the identification of well defined groups on the basis of responses to the instruments. Such groups would be identifiable by the homogeneity of responses of group members as compared to responses in the population as a whole. A correlational approach was thus appropriate for such an analysis. Several alternative techniques were available, but that which led to the most direct test of significance involved the computation of product-moment correlation coefficients for all pairs of respondents. Samples of these correlations were then drawn at random, first from the submatrix of correlations between group members, and second from the submatrix of correlations involving one group member and one non-member.

Correlation coefficients, being index numbers, are not additive so that the computation of mean correlations is not meaningful. To facilitate the comparison of groups, therefore, correlations were converted to Fisher's Z by the transformation

$$Z = \tfrac{1}{2}\log_e(1 + r) - \tfrac{1}{2}\log_e(1 - r).$$

A conventional t test was then applied to test the significance of the difference between mean values of Z for the two samples concerned.

Analysis of Variance

Following the isolation of these groups which could be considered as well defined, the next step in the analysis was to compare these groups with respect to their responses to clusters of items and to compare item clusters across groups. On the surface it appeared that a two way analysis of variance design would be appropriate for this purpose. The nature of the forced sort, however, implied that overall group effects could not be determined, since the mean and variance for each individual and group was the same.

These considerations led to the use of a series of one way analyses of variance aimed at determining the relative importance of item clusters for each group separately and at comparing all groups based on a single classification variable for each item cluster separately. For the physics and electricity instruments, no well defined groups were isolated nor did a meaningful factor pattern emerge. It was therefore necessary to pursue the analysis of these instruments by comparing item clusters over the total technician sample.

One way analysis of variance was also used in the analysis of initial sorts (hypothesis 13.0).

Computing Considerations

All analysis was carried out using the IBM 360/67 computer at the University of Alberta. Standard programs for most aspects of the analysis were available from the Division of Educational Research Services, University of Alberta. Minor modifications to these programs were made by the investigator at various stages. Programs were written by the investigator for the computation of person correlations and values of Fisher's Z and for the various grouping and classification procedures.

CHAPTER IV

METHODOLOGY

I THE POPULATION AND SAMPLE

The Population

The technician population was defined as all electronics technicians employed in Alberta at the time of commencement of data collection. A list of organizations employing electronics technicians in Alberta was compiled for the study by the Edmonton Branch of the Canada Department of Manpower, and supplemented by the Student Placement Office at the Southern Alberta Institute of Technology and by reference to the Edmonton and Calgary telephone directories. Discussion with company officials and Electronics Department officials at the two technical institutes gave reason to believe that this list represented all but an insignificant number of employers of electronics technicains in the province. Preliminary investigation gave an estimate of the population size as approximately eight hundred technicians.

Sampling Procedures

It was apparent from the outset that many conditions might mitigate against the attainment of the objective of obtaining a random sample. In particular, it was not possible to first conduct a survey to determine precisely the number of technicians employed by each organization and the degree of cooperation which might be expected. Certain guidelines had therefore to be established in order to achieve a sample which approximated as closely as possible a random sample and which, in addition, had certain other desirable characteristics such as being representative of the different areas of work and being sufficiently large to permit meaningful analysis. These guidelines were as follows:

1. Letters requesting participation would be sent to all companies on the list, rather than carrying out a sampling by company.
2. A sample size of approximately 100 would ensure that the number of persons exceeded the number of items in any of the card decks.
3. The following approximate scale would represent the maximum number of technicians to be chosen from companies employing various numbers of technicians:

Total Technicians Employed	Number Chosen
5 or less	1 or 2
6-10	3
11-25	5
26-50	8
51-100	12
more than 100	15

This scale was designed to permit some flexibility in case considerable variation existed in the number of technicians that different companies were willing to make available. The maximum of fifteen from any organization was established in order to avoid making inordinate demands on large organizations and to prevent too great an imbalance in the sample caused by having many individuals with the same job description.

4. Each company would be requested to supply a list of all technicians in its employ in order to permit random sampling within companies.

5. As the sampling progressed, any follow-up efforts necessary would be directed towards maintaining a balance in the sample with respect to areas of work.

Application of these guidelines enabled the investigator to exert a reasonable degree of control over the sampling. In some instances, companies found it necessary to limit the number of participating technicians to fewer than that suggested. Only in very few cases, however, did companies choose to select particular individuals without permitting sampling by the investigator.

Since the sample was not strictly random, and since it was found to possess certain characteristics which raised questions about the nature of the population as compared to populations in similar studies in the past, a detailed description of the sample is presented in Chapter V. Generalizations from the data can only be made with reference to the characteristics described.

<u>The Instructor Sample</u>

The instructor sample consisted of fourteen electronics technology instructors selected at random from the population of all electronics instructors employed at the Northern and Southern Alberta Institutes of Technology. To facilitate the comparison of instructors and technicians, certain salient characteristics of the instructor sample are also presented in Chapter V.

II PILOT STUDIES

An analysis conducted by the investigator of the data from a survey carried out by the Department of Electronics, Southern Alberta Institute of Technology, may be considered as forming a pilot study. The instrument used in this survey required technicians to rate a list of fifty-four courses on a four point scale ranging from "must know" to "not needed". A rank ordering of these courses was developed and the ranks compared across four job classifications, using the coefficient of concordance as an index. Agreement at the .05 level of significance was found among the four job classifications. Submission of the item correlations to factor analysis resulted in identifiable factors in such areas as mathematics, non-technical related subjects, telecommunications, television, and computers.

In spite of the significant overall agreement among groups of technicians, the existence of factors such as telecommunications and computers indicated the possibility of the existence of areas of specialization. The nature of the data, however, precluded further analysis of this question. In particular, the small number of discriminations offered by a four point scale and the wide differences in scope of different items did not permit as penetrating an analysis as was desirable.

A second pilot study was designed to test a preliminary draft of the Q-sorts and to check the effectiveness of the operational procedures. This pilot study was conducted using as respondents five technicians from a single organization. Details of instrumentation changes resulting from this pilot study are presented in the following section.

On the basis of the pilot study, total interview time was established at from two to two and one-half hours. A maximum of five persons per session was also established, although the pilot study indicated that two or three would be a more desirable number. It was also found that instructions for the sorts had to be very explicit, with the result that an instruction form was drawn up for the main study.

III INSTRUMENTATION

Construction of Q-Sorts

As a starting point in the construction of the instruments, course descriptions were abstracted from the calendars of ten technical institutes in Canada. These course descriptions were placed on index cards and the cards combined to remove overlapping areas. A preliminary version of two instruments, for physics and electronics, was prepared by expanding course descriptions into units and by consulting standard texts for subject headings. In the case of physics, texts in general physics were consulted to ensure some uniformity in depth of coverage of various topics. In the case of electronics, it was necessary to consult a much wider variety of sources in order to cover all specialized areas as well as basic electronics.

The preliminary physics deck consisted of ninety-one cards, including items on electricity. The preliminary electronics deck consisted of forty-five cards. Statements on each card were in the form of subject headings, essentially equivalent to the subdivisions of chapters within a text. An example of typical card content was, "energy as capacity to do work, potential and kinetic energy, energy transformations, conservation of energy."

Several changes in the instruments were made as a result of discussions with individuals familiar with the subject matter and as a result of the pilot study. First it became apparent that items related to electricity were placed at the extreme high end of the physics scale by all respondents in the pilot study. This led to the conclusion that a discontinuity existed which precluded the placing of electricity items on the same scale as the remainder of physics. Furthermore, it appeared desirable to include greater depth of coverage in electricity than for the other areas of physics. Electricity was therefore separated from the physics deck and a third instrument developed.

A second major change resulting partly from the pilot study was in the card format. The inclusion of several subject headings on a single card led to confusion concerning which specific heading should be used as the basis for sorting. Furthermore, such headings tended to be catch phrases, suitable for summarizing content but revealing little about the nature of the content. Thus, for example, the reaction of a respondent to the words "Ohm's law" might be somewhat different from his reaction to the statement "under ordinary conditions the current in a conductor is directly proportional to the applied voltage." In the latter case it might reasonably be expected that the respondent would give more serious thought to the subject than he would in the former case. In the second drafting of the instruments, card content was changed from statements of the former type to those of the latter type. This change also gave more credence to the assumption that the items were samples from a body of subject matter.

A second draft of the instruments, incorporating these and other more minor changes, was submitted for validation to a panel of graduate students in each of physics and electrical engineering. Details of the validation process are described in the section on validity and reliability. Changes resulting from the validation process led to a final draft consisting of sixty-two cards for physics, thirty-eight for electricity, and seventy-one for electronics.

Sorting Distributions

The use of the forced sorts was predicated on the assumption that wide differences might exist in individuals' perceptions of the measuring scale. In such a situation an unforced sort would permit measurement of these differences but would not permit comparison of individual items across persons since a given point on the scale could mean different things to different persons. The existence of such differences was borne out by the pilot study in which respondents were required to sort the items initially into three categories with no restrictions on the number in each category. For the electronics sort, for example, the number placed in the "most often used" category ranged from two to twenty-three out of a total of forty-five cards, over a group of five respondents having similar job descriptions.

For both sorts, the number of cards placed in each category of the initial sort was approximately the same when averaged over the five respondents, thus indicating that a rectangular distribution would be appropriate. Nevertheless, it was decided that there was sufficient advantage in forcing finer discriminations at the extremes of the scale while allowing sufficient space near the middle to avoid making difficult discriminations, that the Stephenson suggestion of using a symmetrical distribution, somewhat flattened from the normal, was adopted.[1] Somewhat arbitrarily, a nine point scale was adopted, with a distribution such that approximately half the cards would be assigned to the middle three scale values while one-quarter of the cards would be assigned to the three scale values at either extreme. The exact distributions are shown in Figure 3. It was

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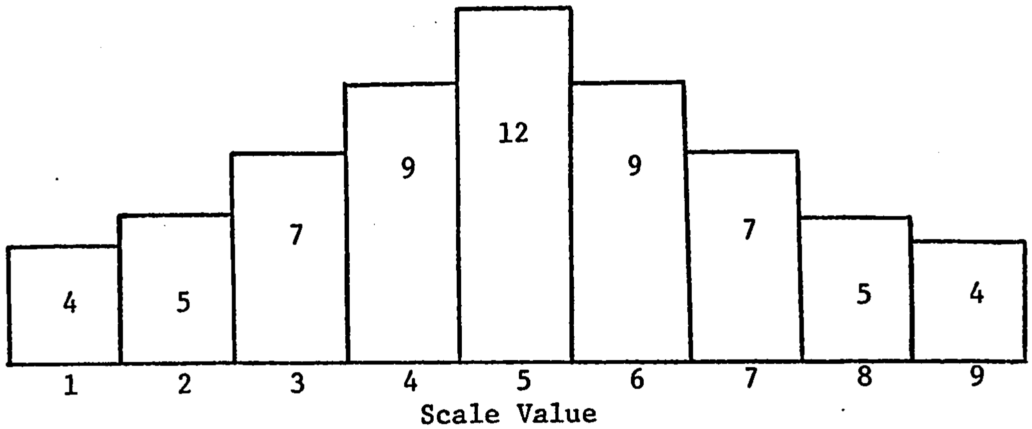
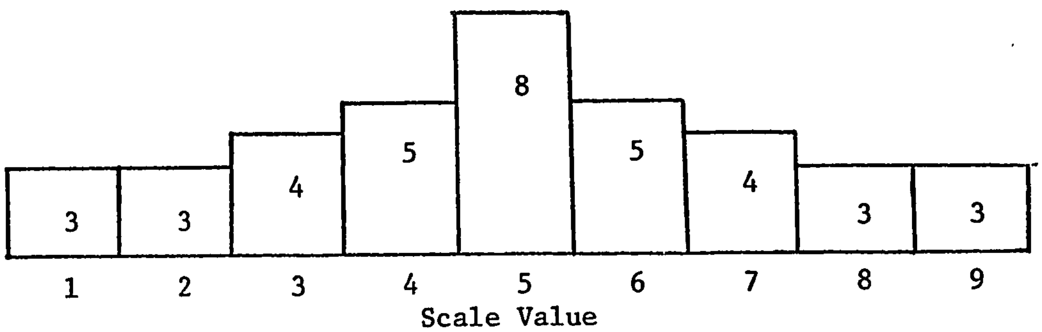
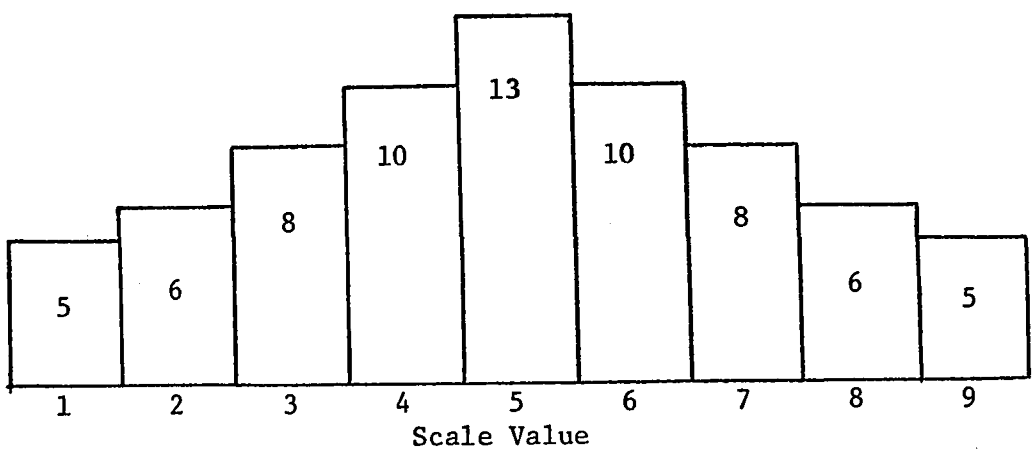
[1]William Stephenson, The Study of Behavior. (Chicago: University of Chicago Press, 1953), p. 59.



(a) Physics



(b) Electricity



(c) Electronics

Figure 3

Q-Sort Card Distributions

decided to retain the initial unforced sorts in order to check the possibility of the existence of systematic variations in the number of items regarded as "most useful" and to make the task of comparing items somewhat simpler.

Validity and Reliability

The major concern in construction of the instruments was with content validity. A panel of four graduate students in each of physics and electrical engineering was asked to examine the second draft of the instruments. Panel members were given specific instructions concerning procedures to be followed in validation. The first stage involved the examination of individual items in order to spot such problems as errors in statements, the use of obscure terminology, or poor wording. These points were important since the use of the Q-sort assumes that all items are meaningful to the subjects.

In the second stage the validators were required to prepare outlines of the subjects concerned, with specific instructions being given to ensure some degree of uniformity in the outlines. Cards were then to be sorted into the categories of the outline and cards added or deleted in order to achieve something approaching a balanced representation of all major topics within the area. In nearly all cases, detailed notes were received from the validators outlining their general views of the instruments in addition to supplying specific cards in areas where changes were required. This information was collated and used in the preparation of the final draft of the instruments.

For the main study, an estimate of the reliability of technician sorts was obtained by selecting at random four subjects who were required to repeat the sorts after an interval of approximately eight weeks. Sort-resort correlations for these individuals appear in Table I.

Preliminary Information Form

Preliminary information used in describing the sample and in developing the various bases for classification was obtained by means of a questionnaire completed by subjects in the first stage of the interviews. This form was designed so that all information could be supplied in numerical form to facilitate coding.

Present and past jobs held by technicians were described by means of codes for type of work and type of equipment. While this procedure gave more information about past jobs than was actually required, it permitted detailed examination of whether jobs listed were indeed different in the sense required. The only exception to the numerical procedure occurred if the code for "other" was used in describing jobs. In this case verbal descriptions were required.

IV OPERATIONAL PROCEDURES

Contacting Employers

Since most organizations on the list of employers were based at either Edmonton or Calgary, the task of making initial contacts was not a difficult one. The first stage usually involved a

TABLE I

SORT-RESORT CORRELATIONS FOR FOUR INDIVIDUALS

Person	Physics	Electricity	Electronics
1	.501	.589	.563
2	.487	.714	.787
3	.258	.307	.696
4	.469	.234	.738

telephone call to determine the name and title of the appropriate officer to whom to make a formal request for participation. Letters containing a resumé of the project were then sent to these individuals. In some instances it was necessary to send letters addressed either to "manager" or "personnel officer" depending on the investigator's judgment of the size of the organization. In a few cases the initial telephone call resulted in direct contact with the proper official.

Procedures following these initial steps varied somewhat depending on the response from particular employers. In some cases immediate approval was forthcoming, together with a list of technician numbers or names. In many cases it was necessary to visit the company to discuss the project. Most organizations were indifferent concerning precisely which technicians were chosen, thus making the sampling task somewhat simpler. Particularly near the end of the sampling, one or more follow-up efforts were sometimes necessary before participation could be ensured. No replies were received from a few employers, no doubt partly because follow-up efforts were not pursued to sufficient lengths. The actual amount of follow-up effort depended on whether, in the judgement of the investigator, the technicians from a given company would aid in balancing the sample. Only one organization, unfortunately a rather large one, declined to participate.

Selection and Scheduling

Once approval to conduct the study had been obtained, the selection of the participants was typically carried out through discussion between the investigator and the company official designated to coordinate the study. Typically a fairly formalized procedure was followed, whereby either the investigator or this official selected participants from a list of technicians and immediate supervisors. In some instances participation was permitted only on a voluntary basis. In all cases interviews were conducted in company time and, with a few exceptions, on company premises. In these few exceptions the companies preferred that technicians report to the investigator. These situations normally occurred when the technicians were engaged in field work within the city of Edmonton.

Interview times were established by mutual agreement, with the restriction that not more than five individuals be scheduled for one session. More typically only two or three participants were scheduled for one time so that interference with company operations would be at a minimum. Interviews were arranged with the understanding that work would be interrupted for approximately one-half day.

Interview Procedures

At the designated time, participants were required to report to the investigator in an office or conference room set aside for the duration of the interview. Technicians were first briefed on the purpose of the project and advised that all information supplied would be treated as confidential, with the company receiving no report which would permit the identification of individuals. To ensure anonymity, all participants were assigned identification numbers. Individuals were supplied with card decks, instruction and reporting forms, and preliminary information and coding forms.

Before commencing the sorting procedure, the preliminary information questionnaire was completed. This typically required attention to individuals to ensure proper coding, particularly in connection with job history. Following this process, instructions for the card sorts were given and the actual sorting commenced. Participants were advised that the investigator was prepared to clarify the meaning of card items but not to give any suggestion of their relative importance. No time restriction was placed on the sorting procedure. Total interview time ranged from two hours to upwards of four hours. It is estimated that actual card sorting time ranged from about seventy-five minutes to three hours, averaging about two hours.

The Card Sort Task

The precise question to which technicians were required to respond was slightly different for each Q-sort. These differences were designed to reflect the anticipated status of each subject area with respect to technicians' jobs. For the physics instrument the instructions were to sort the cards according to the degree to which the respondent considered each item to be required as background to the electronics knowledge used on his job. For the electricity instrument respondents were instructed to sort the cards on the basis of the degree to which each item was required either as background or directly in the job. Electronics items were sorted in response to the question "how often is the knowledge expressed in the card items used in your job?"

The nature of these instructions imposed certain restrictions on the information obtained from the Q-sorts. For example, the stipulation that the physics sort be conducted in terms of prerequisites to electronics precluded the possibility of obtaining information concerning physics knowledge which might be of direct use in, say, elements of the job connected with mechanics. This assumes, of course, that respondents actually conducted the sorts precisely according to instructions. In any event, in the absence of information concerning how closely the instructions were followed, it is not possible to make any generalizations regarding the value of subject matter beyond its value in relation to the questions posed.

The permitting of alternative interpretations of an item in the case of the electricity sort may appear to result in some ambiguity. Justification for the use of these alternatives lay in the structure of the electricity sort. A clear division appeared to exist between theoretical and applied items or, more specifically, between electromagnetic field thoery and circuit applications. It was reasoned that items involving circuit applications would be of more direct use on the job, while field theory items would be of value as prerequisite to electronics. In the analysis of the electricity sort it was not possible to separate items on the basis of which alternative was used in deciding on the scale value for a particular item. However, this did not distract from the main purpose of the analysis which was to determine the relative importance of items or, more specifically, of item clusters. Since, in fact, some of these clusters could be regarded as theoretical and others as applied, it was possible to shed some light on the weight assigned by technicians to each of the alternatives.

CHAPTER V

PRELIMINARY RESULTS AND DESCRIPTIVE ANALYSIS

Because considerable variation existed in the enthusiasm of employers' responses to the initial contacts and in the relative difficulty of scheduling, it was not possible to strictly apply random sampling principles in the selection of subjects. Furthermore, even assuming random sampling, certain characteristics of the sample and population must be taken into account in any attempt to generalize from the findings. For these reasons, the preliminary phase of the analysis was designed to provide a relatively complete description of the sample in terms of various categorical variables judged relevant to responses to the instruments. Also explored were certain possible relationships among these variables. This preliminary analysis also serves to define various groups used in the treatment of the Q-sort data.

Responses of Employers

Table II presents a breakdown of the results of initial attempts to contact employers. A note concerning the meaning of the term employer is perhaps relevant at this point. It was clear at the outset that some large organizations might maintain essentially independent branches in local areas. There were, for example, several instances of organizations having both Edmonton and Calgary branches. In some cases these offices were independent from the standpoint that separate contacts were necessary. In other

TABLE II

RESULTS OF INITIAL CONTACTS

	Number of Employers
Initial list	52
Number contacted	46
No technicians as defined employed	6
No reply	5
Declined participation	1
Willing to Participate	34
Not used	8
Participating organizations	26

cases one office could be considered as a regional headquarters and all arrangements could be made through this office. The term employer was thus defined as a unit which was capable of approving the study and making arrangements, without appeal to higher authority.

For organizations which were known to have more than one location but which employed only a few (five or less) technicians at some locations, it was judged that separate trips to smaller locations would not be warranted. In these cases the total sample was chosen from the largest location. Among those organizations not contacted or contacted but not used, are included those for which a sample had already been chosen from another location.

A classification of participating organizations by number of electronics technicians employed appears in Table III. The significance of this table is that it indicates that relatively few companies employ a large proportion of the technicians. In fact, the two largest employers, constituting only eight percent of the total participating employers, account for nearly forty percent of the total number of technicians available for the study. With respect to the original list, assuming that no large employers were omitted from this list, it is clear that even if the list was relatively incomplete, the number of technicians missing would be insignificant.

An important limitation in the sample resulted from the decision of one organization not to participate. It is estimated that this organization is one of the largest employers of electronics

TABLE III

CLASSIFICATION OF EMPLOYERS

BY NUMBER OF TECHNICIANS EMPLOYED

Technicians Employed	Number of Companies	Total Technicians
More than 80	2	203
41-80	3	150
21-40	1	37
11-20	8	99
6-10	6	37
5 or less	6	13
Total participating companies	26	539

technicians in the province. The inability to use technicians from this organization is reflected in the shortage of subjects in the two areas of microwave and telephone switching. Although these areas were established on an a priori basis as possible areas of specialization, the sample did not contain sufficient individuals in these categories to permit a meaningful analysis. In the case of telephone switching this is perhaps not a serious limitation since it was found that one large telephone company, which was otherwise willing to participate, in fact employed no electronics technicians as defined, since all equipment was electromechanical rather than electronic in nature. The absence of sufficient technicians in microwave, however, must be considered a serious limitation.

Sample Description

Description of the sample was conducted in terms of those categorical variables which were defined at the outset as of possible relevance to Q-sort responses. For most of these variables, categories were developed with the aim of achieving an approximate balance in the number of individuals in each category. With respect to the two primary variables, type of work and type of equipment, the categories were essentially predefined. The only change made was the necessity to combine under the "others" label these categories which contained an insufficient number of individuals to permit a meaningful analysis.

Job classification. The categories used for type of work and type of equipment appear in Table IV. The most striking feature of this table is clearly the large number of technicians in the maintenance category. In fact, if supervisors of maintenance technicians are included, it is found that close to eighty percent of the respondents were involved in maintenance activities. This feature is indicative of the strong orientation towards service as the prime reason for the existence of electronics technology as a field of work in Alberta. This is certainly to be expected in an area in which manufacturing is not the primary source of employment overall.

It is noted in passing that, although maintenance and installation were considered as separate categories in the original job classification scheme, it was found that a large number of individuals giving maintenance as their primary activity were also engaged in installation. The reasons for this will become apparent upon consideration of the nature of the work engaged in by the employers of technicians.

The nature of electronics activities in Alberta may be further clarified by an examination of the type of activities performed by participating companies. Of the twenty-six employers, seven were local branches of large international organizations whose primary type of business is the manufacture and sale of electronic equipment. Technicians employed by local branches, however, were solely engaged in the installation and servicing of company products. Five organizations were government agencies or public utilities whose primary activities necessarily involved the use of electronic equipement

TABLE IV

IDENTIFICATION OF GROUPS FOR JOB CLASSIFICATION VARIABLES

Group	Type of Work Name	Type of Work Number	Type of Equipment Name	Type of Equipment Number
1	Research and Development	9	General Electronics	9
2	Maintenance	65	Broadcast	6
3	Supervision	15	Communications	7
4	Others	11	Navigational Aids	15
5			Computers	25
6			Industrial Electronics	20
7			Others	18

(i.e. in communications or navigational aids). Again, however, this equipment was, with a few exceptions, not designed or constructed in Alberta. Such organizations required technicians only in a service capacity. Similarly, those organizations concerned with broadcasting had demands only for service technicians and, in some cases, for operators.

Five other organizations were non-electronics in terms of their primary business, electronic equipment being used only in support of other activities (i.e. for making physical measurements). Although such organizations could be considered as customers for the electronics firms mentioned, for various reasons they employed their own service personnel rather than relying on equipment manufacturers to supply service. A further five organizations could be considered as using electronics as part of research or teaching activities. In some instances for these organizations design and development work was required because the nature of the activities demanded the development of highly specialized equipment. Only two organizations could be considered as having the design and manufacture of electronic equipment as their major activity. These were both relatively small local companies catering to demands for various types of custom equipment.

The above considerations strongly indicate that the findings should be generalized to areas which are similar to Alberta in that they are not primary areas for research and development and manufacture of electronic equipment. Such areas are primarily markets for electronic equipment which is manufactured elsewhere but which requires servicing at its point of use.

A significant point concerning the type of equipment classification is the relatively small number of individuals in the broadcast category. There is evidence that this area is underrepresented with respect to the population, since the two largest broadcast organizations contacted, while expressing their willingness to cooperate, were reluctant to make time commitments. This can be partly attributed to the shift schedule under which technicians worked and to the fact that technicians were required to work on an extremely rigid schedule because of programming requirements. It was not until near the end of the data collection that it was possible to schedule interviews with several technicians to ensure that the broadcast area was not completely omitted from the sample. Even at this stage it was necessary in one case to simply give the technicians instructions in the interview session and to leave the card sort material to be completed at a convenient time. This tactic was entirely unsuccessful since neither of the two technicians involved returned the material, in spite of several follow-up telephone calls.

From the point of view of analysis of the Q-sort data, underrepresentation in a particular area is not as serious as it might appear. In no instance did the analysis involve a weighting of responses in terms of the number of technicians in a particular group as might, for example, be done in a rank order analysis. As long as it can be assumed that individuals sampled are representative of their particular job classification, it is possible to make generalizations about that job classification. The major limitation is, of course, the fact that very small samples result in statistics being rather unreliable as estimates of population parameters, so that only gross differences between groups can be detected.

Other Categorical Variables. Table V summarizes the seven secondary variables considered relevant to the main analysis. In those cases where categories are based on ranges of the underlying variable, the ranges were selected with the aim of achieving a balance in the number of individuals in each category. Median values of these variables serve to provide a description of the typical technician used in the sample.

Relationships Among Categorical Variables

Since the provision of a descriptive analysis of the sample was not the primary aim of the study, all possible relationships among the various ways of classification were not explored. It was nevertheless recognized that these categorical variables were not necessarily independent. In particular, such pairs as total education and technical education, age and range of experience, and salary and range of experience could be expected to be related. It was intended that if any two of these secondary variables yielded significant effects in the main analysis, then these would be tested for independence.

TABLE V

CLASSIFICATION OF TECHNICIANS ON THE BASIS OF SECONDARY VARIABLES

Group	Age (years)		Salary		Total Education (years)		Technical Education (years)		Source of Training		Range of Experience (job-years)		Tenure of Employment (years)	
	Range	N	Range	N	Range	N	Range	N	Source	N	Range	N	Range	N
1	25	18	$6000	8	13	11	1	21	Technical Institute	54	10	27	1	23
2	25-29	22	6000-6999	41	13	20	2	45	Armed Forces	29	10-29	31	2	29
3	30-34	25	7000-7999	27	14	40	3	23	Other	17	30-59	21	3-5	26
4	35-39	16	8000-8999	13	15	18	4	11			60	21	6	22
5	40	19	9000	11	16	11								
Total		100		100		100		100		100		100		100
Median	32		$7000		14		2				25		2	
Range	19-54		$4000+ to 11,000+		9-17		1-5				1-245		0-30	

Since job classification, particularly as represented by the type of equipment variable, was of primary importance to the study, there appeared to be some advantage in pursuing the possible relationships between this and the secondary variables. As well as furthering the description of the sample, this analysis would also be of value in making interpretations based on the main results. In order to simplify the analysis and to give sufficiently large numbers to permit meaningful X^2 tests, all secondary variables except source of training were dichotomized at the median, with those individuals falling exactly at the median being included in the below median category.

Table VI gives the observed and expected frequencies and the values of X^2 associated with the seven type of equipment groups when classified into two categories of the basis of each of the remaining categorical variables. Only in the case of years of technical education is the value of X^2 sufficiently large to justify rejection of the hypothesis of independence. Thus, from the point of view of analysis of the Q-sort data, these results indicate that the interpretation of differences among groups for the type of equipment variable will be relatively uncomplicated by systematic relationships between this and the other variables.

Once exception to the general picture presented by Table VI is worthy of note. Early in the sampling a tendency was noted with respect to the nature of changes in jobs. In the reports of job history it was observed that a relatively large number of changes

TABLE VI

RELATIONSHIP BETWEEN TYPE OF EQUIPMENT GROUPS AND

DICHOTOMIZED CATEGORIES FOR REMAINING VARIABLES

Variable	Category	General		Broadcast		Communi-cation		Nav. Aids		Computers		Industrial Electronics		Others	
		0	(E)	0	(E)	0	(E)	0	(E)	0	(E)	0	(E)	0	(E)
Age (years)	> 32	6	(4.0)	3	(2.6)	4	(3.1)	6	(6.6)	7	(11.0)	12	(8.8)	6	(7.9)
	≤ 32	3	(5.0)	3	(3.4)	3	(3.9)	9	(8.4)	18	(14.0)	8	(11.2)	12	(10.1)
							X^2 = 7.97		n.s.						
Salary	≥ $7000	4	(4.6)	2	(3.1)	3	(3.6)	7	(7.6)	19	(12.7)	7	(10.2)	9	(9.2)
	< 7000	5	(4.4)	4	(2.9)	4	(3.4)	8	(7.4)	6	(12.3)	13	(9.8)	9	(8.8)
							X^2 = 9.66		n.s.						
Total Education (years)	> 14	1	(2.8)	3	(1.9)	4	(2.2)	3	(4.6)	9	(7.7)	7	(6.2)	4	(5.6)
	≤ 14	8	(6.2)	3	(4.1)	3	(4.8)	12	(10.4)	16	(17.3)	13	(13.8)	14	(12.4)
							X^2 = 6.69		n.s.						
Technical Education (years)	> 2	1	(3.1)	3	(2.0)	4	(2.4)	2	(5.1)	13	(8.5)	8	(6.8)	3	(6.1)
	≤ 2	8	(5.9)	3	(4.0)	3	(4.6)	13	(9.9)	12	(16.5)	12	(13.2)	15	(11.9)
							X^2 = 13.72		$P < .05$						
Source of Training	Tech. Institute	4	(4.9)	4	(3.2)	3	(3.8)	5	(8.1)	12	(13.5)	13	(10.8)	13	(9.7)
	Others	5	(4.1)	2	(2.8)	4	(3.2)	10	(6.9)	13	(11.5)	7	(9.2)	5	(8.3)
							X^2 = 7.51		n.s.						
Range of Experience (job years)	> 25	5	(4.4)	2	(2.9)	5	(3.4)	9	(7.4)	11	(12.3)	11	(9.8)	6	(8.8)
	≤ 25	4	(4.6)	4	(3.1)	2	(3.6)	6	(7.6)	14	(12.7)	9	(10.2)	12	(9.2)
							X^2 = 5.15		n.s.						
Tenure of Employment (years)	> 2	6	(4.3)	3	(2.9)	3	(3.4)	6	(7.2)	8	(12.0)	13	(9.6)	9	(8.6)
	≤ 2	3	(4.7)	3	(3.1)	4	(3.6)	9	(7.8)	17	(13.0)	7	(10.4)	9	(9.3)
							X^2 = 6.70		n.s.						
Type of Work	Maint.	5	(5.9)	5	(3.9)	4	(4.5)	9	(9.7)	17	(16.2)	12	(13.0)	13	(11.7)
	Other	4	(3.1)	1	(2.1)	3	(2.5)	6	(5.3)	8	(8.8)	8	(7.0)	5	(6.3)
							X^2 = 2.32		n.s.						

occurred from other areas of electronics into the computer area. In the total sample, eighteen of the twenty-five computer technicians had transferred from other areas, while only three individuals could be found who reported a job change from computers into other areas. This indicated that certain differences might exist between the computer area and other areas, either because of certain attractions in the computer field itself (i.e. higher salary) or resulting from the transfer of a particular type of individual into the field.

The relevance of this point to the information presented in Table VI is that, for certain of the dichotomized variables, the major contribution to the total X^2 comes from the computer area. This suggests that a closer examination of the distinction between computer technicians and those in other areas is warranted. In order to permit this examination, the figures of Table VI were consolidated for those variables for which the computer field appeared distinctly different from the other areas.

Table VII presents a comparison of computers with other areas with respect to four of these variables, again dichotomized at the median. In two instances, for salary and years of technical education, the difference between computers and other areas is significant beyond the .05 level. These results indicate a strong tendency towards above median salaries in the computer field and also that computer technicians tend to have an above median amount of technical training.

This comparison can be pursued in somewhat more depth by an

TABLE VII

OBSERVED AND EXPECTED FREQUENCIES AND X^2 TESTS,

COMPUTER TECHNICIANS VERSUS OTHERS, FOUR VARIABLES

Variable	Range	Computers 0	Computers (E)	Others 0	Others (E)	X^2	P
Salary	⩾ $7000	19	(12.7)	32	(38.2)	8.21	< .01
	< 7000	6	(12.3)	43	(36.8)		
Technical Education (years)	> 2	13	(8.5)	21	(25.5)	4.83	< .05
	⩽ 2	12	(16.5)	54	(49.5)		
Tenure (years)	> 2	8	(12.0)	40	(36.0)	3.41	n.s.
	⩽ 2	17	(13.0)	35	(39.0)		
Age	> 32	7	(11.0)	37	(33.0)	3.46	n.s.
	⩽ 32	18	(14.0)	38	(42.0)		

examination of certain aspects of training requirements. Although the source of training variable as defined refers only to the predominant source, most technicians reported more than one source. Table VIII shows the number of technicians in the computer and other areas who have received training from various sources. It is apparent that computer technicians are much more likely to have received company training, while no distinctions exist with respect to other sources. Thus the general result that computer technicians are more highly trained than others may be attributed to company programs. This point is further borne out by Table IX in which the amount of company training is presented. Thus, not only do proportionately more computer technicians receive company training, but also the amount of such training is significantly greater.

The Instructor Sample

Although the preliminary information collected from instructors was not as detailed as for technicains, it was possible to make certain comparisons between instructor and technician samples. Table X provides a description of the instructor sample in terms of four variables, and also gives a comparison of instructors and technicians for these variables.

Significant differences between technicians and instructors occur only in amount of technical education. A closer examination of source of training indicated that some of this difference could be attributed to the fact that eight of the fourteen instructors reported some university training, while only three technicians

TABLE VIII

OBSERVED AND EXPECTED FREQUENCIES AND X^2 TESTS,

COMPUTER TECHNICIANS VERSUS OTHERS, FOUR SOURCES OF TRAINING

Source	Computers O	Computers (E)	Others O	Others (E)	X^2	P
Company Training	18	(12.2)	31	(36.8)	7.17	<.01
No Company Training	7	(12.8)	44	(38.2)		
Technical School	15	(16.7)	52	(49.3)	.79	n.s.
No Technical School	10	(8.3)	23	(24.7)		
Armed Forces	10	(8.7)	25	(26.3)	.40	n.s.
No Armed Forces	15	(16.3)	50	(48.7)		
Individual Study	6	(8.2)	27	(24.8)	1.18	n.s.
No Individual Study	19	(16.8)	48	(50.2)		

TABLE IX

MONTHS OF COMPANY TRAINING, COMPUTER TECHNICIANS VERSUS OTHERS, OBSERVED AND EXPECTED FREQUENCIES AND X^2 TESTS

Months of Training	Computers O	Computers E	Others O	Others E
1-3	2	(6.2)	15	(10.8)
4-6	6	(4.4)	6	(7.6)
7-9	3	(3.3)	6	(5.7)
9	7	(4.0)	4	(7.0)
$X^2 = 8.98$		$P < .05$		

TABLE X

INSTRUCTOR-TECHNICIAN COMPARISONS FOR FOUR VARIABLES

Variable	Range	Technicians		Instructors		X^2	P
		0	(E)	0	(E)		
Technical Education	1-2 years	66	(60.5)	3	(8.5)		
	3 years	23	(21.9)	2	(3.1)	23.8	<.001
	3 years	11	(17.5)	9	(2.5)		
Source of Training	Tech. Inst.	54	(53.5)	7	(7.5)		
	Armed Forces	29	(27.2)	2	(3.8)	3.3	n.s.
	Others	17	(19.3)	5	(2.7)		
Range of Experience (job years)	0-9	27	(26.3)	3	(3.7)		
	10-29	31	(28.9)	2	(4.1)	2.8	n.s.
	30-59	21	(22.8)	5	(3.2)		
	60	21	(21.9)	4	(3.1)		
Tenure of Employment	1 year	23	(22.8)	3	(3.2)		
	2 years	29	(29.0)	4	(4.0)	.05	n.s.
	3-5 years	26	(26.4)	4	(3.6)		
	5 years	22	(21.9)	3	(3.1)		

listed such training. As the results for source of training indicate, the technical institute was the primary source of training for instructors as well as for technicians. University courses, where reported, tended to be in addition to technical institute training. Only three instructors reported university training to the degree level.

Summary

Results presented in this chapter emphasize certain characteristics of the technician sample. The most obvious of these is the large number of technicians engaged in maintenance activities. This indicates that the existence of electronics technology as a field of work in Alberta is mainly a result of demands for the servicing of equipment. The manufacture of electronics equipment takes place on an extremely small scale, while research and development activity exists on only a slightly larger scale mainly supportive to other research and to teaching.

With respect to job classification, particularly as defined by the type of equipment variable, generalizations can be made only for these areas for which the technician sample contained a reasonable number of members. Moreover, even with this restriction, and with the added assumption of random sampling at least within the areas submitted to analysis, it is necessary, before applying the results to other populations, to consider the characteristics of the population from which this sample was drawn.

Some attention was devoted in this chapter to evidence which indicated that computer technicians differ from others with respect to certain variables of interest. It was found that a tendency existed for computer technicians to possess a greater amount of technical education, a tendency which was attributed to formal training given by employers.

In a comparison of instructors and technicians with respect to four categorical variables, it was found that instructors possessed significantly more technical training than technicians. No other significant differences were detected.

CHAPTER VI

ANALYSIS OF Q-SORT DATA

The main analysis may be regarded as following a three step sequence. The first problem involved the identification of the dimensionality of each instrument as determined by technician response patterns. It was hypothesized that this dimensionality would bear some relationship to a set of dimensions which were developed on logical grounds external to the responses of technicians. A dependency oriented factor analysis was used as the primary analysis technique for this stage.

The second stage of analysis was concerned with the identification of groups, based on certain relevant categorical variables, which could be regarded as being well defined in terms of responses of group members to the instruments. Of primary interest were variations in response patterns on the basis of job classification. This analysis was carried out by developing a matrix of intercorrelations among all pairs of respondents and comparing the correlations among group members with those involving one member and one non-member for each group of interest.

For these groups which could be considered as being relatively homogeneous in their responses, the analysis was further developed by comparing, for each group, responses to specific clusters of items. Also compared were different groups on the basis of responses to each item cluster separately. These comparisons were made by means of a series of one way analysis of variance designs. This phase of the analysis formed the third step in the main sequence.

Isolated from this sequence were the analysis of instructor responses, the comparison of technicians and instructors, and the analysis of the initial sorts. Instructor-technician comparisons were made using the same correlational procedure as for stage two of the main sequence, followed by a series of *t* tests on responses to specific clusters. Analysis of variance was used to determine the relative ratings of item clusters by instructors. Besides the use of item clusters as defined from subject matter relationships, the responses of instructors and technicians were analyzed with respect to degree of generality of the items, again using analysis of variance. Analysis of variance was also used to test the hypothesis of no differences among groups on the initial sorts.

A nonparametric analysis had originally been planned for purposes of comparison of groups and items. An examination of previous studies[1,2] which had used nonparametric methods, however, indicated that such methods, rank order techniques in particular, did not properly lend themselves to the basic questions under investigation in the present study. Thus, in spite of certain

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[1]William J. Schill and Joseph P. Arnold, *Curricula Content for Six Technologies*. (Urbana: University of Illinois, 1965).

[2]Christy A. Murphy, *Technician Need Study: Vermillion County Illinois*. (Urbana: University of Illinois, 1964).

questions pertaining to the tenability of assumptions underlying some parametric tests, a full parametric analysis was carried out.

I DIMENSIONALITY OF SORTS

The general approach to this phase of the analysis involved factor analysis of the correlations among items in the three Q-sort instruments. The basic aim was to determine the extent to which factor patterns based on technician responses to the instruments could be identified with topics based on conventional divisions within the subject areas under consideration.

Because of the large number of variables involved and the space required to present, even in abbreviated form, a listing of card content, actual factor patterns are not presented in the discussion of results to follow. Rather, each factor is discussed in terms of items having high loadings on that factor. The pattern matrices themselves are presented in Appendix C.

In all cases, attempts were made to replicate results by dividing the total technician sample into two subsamples, designated as samples A and B, by choosing odd and even identification numbers. Factor matching procedures were carried out to determine the extent to which results were consistent across different samples. It is pointed out, however, that because of the relatively small number of persons in each subsample and the large number of variables, anomalies might be expected to occur due to sampling errors. Results must be interpreted with this point in mind.

One further point in connection with the interpretation of factors is worthy of note. The tendency of some factors to be strongly bipolar was not anticipated in formulating the hypotheses, since the question of which topics might appear to technicians as opposites could not be resolved by reference to the structure of the subjects alone. In the normal situation, variables appearing at opposite poles of a factor would be regarded as representing opposite ends of a continuum. The factor could thus be labelled in terms of the continuum. From the standpoint of the logic of the subject, however, no such continuum is apparent. For practical purposes this is not a serious matter since opposite poles of a factor can be interpreted separately and treated as distinct areas, the fact that they appear as opposites being regarded as of minor interest.

The bipolar nature of factors does, however, lead to a problem in connection with replication, since any factors being compared will agree highly only if both poles are in agreement. Thus, any index of agreement between factors for two samples may be depressed, even though high agreement may exist on a single pole. Moreover, in this particular situation, failure to anticipate which factors might be bipolar led in one instance to the rotation of more factors than were necessary to account for all hypothesized topics. A further aspect of the same problem involves the structure of hypothesized factor pattern matrices. While it is possible to construct such matrices in bipolar form, lack of knowledge of which items to place at opposite poles no doubt contributed to the ineffectiveness of this method in the present application.

Hypothesis 1.0

This hypothesis was concerned with the identification of subject topics within the field of physics, on the basis of patterns of responses to the physics sort. More specifically, topics were proposed which corresponded to those conventionally included in general physics, and it was hypothesized that response patterns would be identifiable with these topics. The hypothesized topics are repeated here for convenience:

1. Mechanics
2. Wave properties, harmonic motion
3. Quantum theory, atomic physics
4. Kinetic molecular theory
5. Optics
6. Heat and thermodynamics
7. Nuclear physics
8. Relativity

The first step in examining this hypothesis involved a principal axes factoring of the matrix of correlations among items, extracting all factors with eigenvalues greater than unity. This was followed by varimax and promax rotations of the twenty-one factors obtained. Inspection of the varimax and promax patterns revealed that these were too complex to yield a straightforward interpretation in terms of the hypothesized topics or any realistic combination of these.

Pursuing the concept of using a dependency type analysis, the physics card items were sorted into eight groups corresponding to the postulated topics. An hypothesized factor pattern was developed by considering each topic as a factor and by assigning loadings of unity to items belonging to a particular factor and loadings of zero to all other items on this factor. Each item was considered as loading on only one factor. A few items were omitted from the analysis either because they were highly specific isolated items or because they were so general as to apply equally to several factors. An attempt was then made, using the Procrustes procedure, to rotate the first eight factors of the principal axes solution to achieve a match with the hypothesized matrix. This effort proved entirely fruitless since a factor pattern with the desired characteristics could be produced only at the expense of having the factors so highly intercorrelated that the solution had to be discarded.

Returning to the original solution, a plot of eigenvalues was conducted, as suggested by Cattell,[3] in order to obtain a further estimate of the number of factors which might be interpretable. This plot, shown in Figure 4, indicated that a rotation of the first six factors might be meaningful. These six factors, accounting for thirty-eight percent of the total variance of the sort, were then rotated by the varimax and promax methods.

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[3]R. B. Cattell, "The Meaning and Strategic Use of Factor Analysis," Handbook of Multivariate Experimental Psychology, R. B. Cattell, ed. (Chicago: Rand McNally, 1966), p. 206.

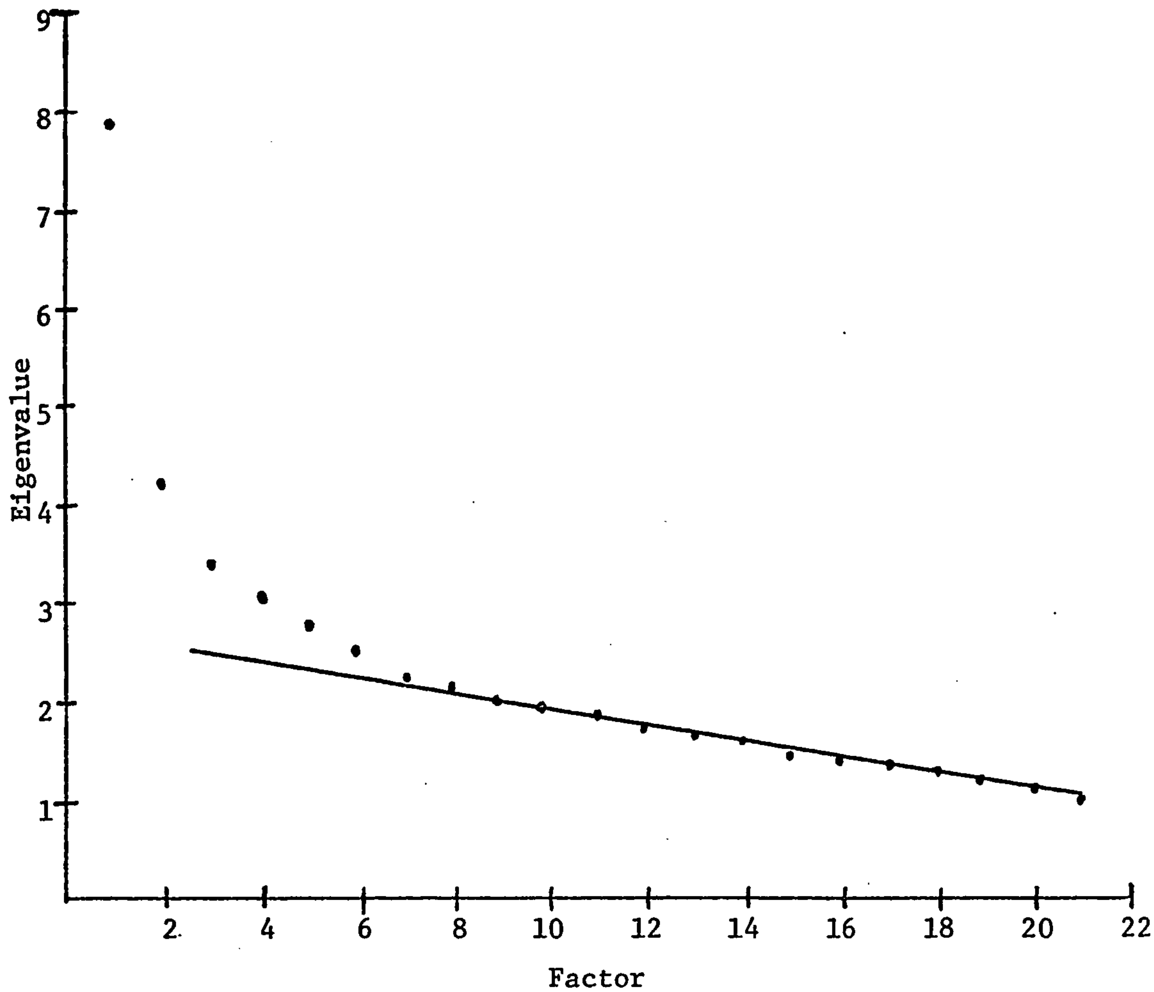

Figure 4

Plot of Eigenvalues: Principal Axes Factor Analysis of Physics Sort

Table XI shows, for each of the six factors, the card items exhibiting loadings greater than .3 or less than -.3. Again the solution was far from simple in the sense of conformity to the hypothesized pattern. Certain identifiable clusters of items did, however, appear although each factor cannot be identified with a single cluster.

The most striking feature of Table XI is the appearance of an extremely strong factor for harmonic motion. Similarly a strong optics factor appears in factor II. Mechanics items tend to be split, with items which may be defined as basic mechanics appearing in factor IV, while some of the more advanced mechanics items appear in factor I, as well as being scattered among other factors. Items in the general area of nuclear physics are split between factors II and VI.

The appearance of more than one cluster of items in a single factor and scattering of clusters among more than one factor indicate the possibility that six factors were still too many to permit the achievement of simple structure. A further possibility, considering that the factors were derived from oblique rotation, is the existence of a hierarchical structure to the factors. Since these six factors accounted for only some thirty percent of the total variance of the sort, and since further losses would result from continuation of the analysis, it was judged that further analysis along either of these lines would not yield useful results.

The factors identified as optics, harmonic motion, and basic mechanics were somewhat more clearly defined than were any of the other

TABLE XI

INTERPRETATION OF FACTORS FOR PHYSICS SORT,

SIX FACTOR OBLIQUE SOLUTION

Positive Pole			Negative Pole		
Item	Loading	Abbreviated Card Content	Item	Loading	Abbreviated Card Content
		Factor I			
108	.63	Fluid flow in tube	110	-.64	Bohr model of atom
107	.59	Stress and strain; elastic body	114	-.60	Structure of nucleus
106	.56	Liquid; external pressure	131	-.52	Velocity limit of energy prop.
129	.52	Torque	153	-.39	Elementary particles
141	.47	Gas pressure; molecular theory	156	-.38	Doppler effect
143	.46	Ideal gas law			
130	.44	Moment of inertia			
160	.36	Angular momentum; conservation			
120	.34	Conservation of momentum			
117	.32	Concept of inertia			
		Factor II			
134	.71	Light as a wave	150	-.50	Transmutation of elements
137	.71	Light as part of E/M spectrum	151	-.47	Nuclear chain reaction
133	.69	Fermat's principle	114	-.38	Structure of nucleus
138	.63	Colorimetry	142	-.36	Temperature: molecular motion
159	.49	Refraction; velocity dependence	102	-.35	Heat conduction
136	.45	Polarization of light			
155	.43	Sound waves			
135	.39	Superposition of waves			
147	.38	Entropy of universe			
		Factor III			
132	.45	Brownian motion	139	-.93	Damped harmonic oscillator
128	.35	Mass-energy relation	140	-.91	Forced harmonic oscillator
			123	-.80	Simple harmonic oscillator
		Factor IV			
119	.68	Newton's second law	149	-.49	Molecular binding force
115	.63	Velocity; definition	141	-.41	Gas pressure; molecular theory
116	.61	Acceleration; definition	151	-.36	Nuclear chain reaction
128	.41	Mass-energy relation	157	-.34	Crystal structure
118	.36	Newton's third law	161	-.33	Atomic spectra
104	.32	Source of X-rays			
		Factor V			
112	.64	Uncertainty principle	145	-.52	First law of thermodynamics
113	.48	Interpretation of wave function	146	-.48	Second law of thermodynamics
158	.42	Frames of reference	126	-.36	Potential and kinetic energy
120	.35	Conservation of momentum	156	-.31	Doppler effect
160	.34	Angular momentum; conservation			
153	.34	Elementary particles			
		Factor VI			
124	.49	Conservative force field	150	-.61	Transmutation of elements
127	.49	Conservation of energy	104	-.65	Source of X-rays
122	.48	Planetary motion	152	-.53	Radioactive decay law
121	.32	Projectile motion	101	-.38	Electromagnetic waves
162	.31	Centripetal force	105	-.37	Waves: $V = f\lambda$

factors. The replication process was therefore carried out in this case mainly to determine whether these factors were indeed stable. Samples A and B were factored, again rotating six factors. The three promax oblique patterns were then compared, using the Ahmavaara matching procedure.[4] Table XII summarizes the identification of factors for the three analyses, while Table XIII shows the comparison matrices for the Ahmavaara match. In all interpretations based on these comparisons it must be kept in mind that the indices of agreement may be interpreted geometrically as cosines of angles between two factors.

Factor I in the total sample is strongly bipolar and agrees reasonably well with factor I in sample B. For sample A, however, the topics identified with the two poles are split. Some items in the positive pole appear in factor V of sample A as indicated by the index of .82 between Factor I, total sample, and Factor V sample A. Similarly, the modern physics pole appears in factor II of sample A, although the index of .60 does not indicate strong agreement. This is no doubt because strong agreement for a bipolar factor can be obtained only if both poles agree across the two samples.

Factor II in the total sample is again bipolar, although the positive pole, identified as optics, is considerably stronger than the negative pole, nuclear physics. This factor agrees well with

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[4]Benjamin Fruchter and Earl Jennings, "Factor Analysis," Computer Applications in the Behavioral Sciences, Harold Borko, ed. (Englewood Cliffs, N.J.: Prentice-Hall, 1962), pp. 256-258.

TABLE XII

IDENTIFICATION OF FACTORS FOR PHYSICS SORT, SAMPLES A, B, AND TOTAL GROUP,

SIX FACTOR OBLIQUE SOLUTION

Factor	Total Group		Sample A		Sample B	
	+ Pole	-Pole	+ Pole	- Pole	+ Pole	- Pole
I	Mechanics, Hydrodynamics, Gas laws	Modern physics	Mechanics	Waves	Modern physics	Gas laws Hydrodynamics
II	Optics	Nuclear Physics	Basic Mechanics	Modern physics	Optics	
III		Harmonic Motion		Harmonic Motion		Harmonic Motion, waves
IV	Basic Mechanics			Optics	Nuclear physics	Optics
V	Quantum theory	Thermo-dynamics	Gas laws			Inertia, Momentum
VI		Waves, Nuclear physics				

TABLE XIII

COMPARISON MATRICES AHMAVAARA MATCH,

SIX FACTOR OBLIQUE PATTERN, PHYSICS SORT

Sample	Factor	I	II	III	IV	V	VI
		Total Group					
Sample A	I	.29	-.14	-.05	-.08	.45	.82
	II	.60	.01	-.12	.74	-.28	-.09
	III	.10	.05	.94	.17	.20	-.16
	IV	.01	-.94	.08	.16	-.28	-.10
	V	.82	.07	.08	-.19	-.44	.29
	VI	.53	.07	-.03	.17	.71	-.43
		Total Group					
Sample B	I	-.86	-.00	-.07	.03	.40	-.29
	II	.35	.54	.04	-.32	.51	-.47
	III	-.07	-.03	.95	.21	-.09	-.22
	IV	.14	-.83	-.06	-.40	.21	-.30
	V	-.42	.21	-.06	-.41	-.69	-.36
	VI	.08	-.29	.07	.85	.19	-.38
		Sample B					
Sample A	I	-.38	-.14	-.16	.13	-.88	-.14
	II	-.74	.02	.01	-.33	-.33	.49
	III	-.17	.15	.92	-.05	-.32	.08
	IV	-.12	-.68	.23	.67	.02	.15
	V	-.98	.12	.13	-.01	.04	-.08
	VI	-.15	.59	-.41	-.08	-.56	.39

factor IV in sample A, indicating the strength of the optics pole, since only optics items could be identified with this factor in sample A. For sample B, optics items are split between two factors, each of which agrees only moderately with the optics factor in the other two samples.

Very strong agreement exists on factor III, harmonic motion, across the three samples. This is in fact the most striking feature of the comparisons. It is suspected, however, that the wording of the items rather than the content may have exerted an influence in this case. The three items dealing with harmonic motion were similarly worded and each contained the term "harmonic oscillator." It is possible that respondents, grasping for some logical similarity among items, seized upon this wording and placed these items together in the sort.

The factor identified as basic mechanics for the total group appears as factor II in sample A. Again, however, the index of .74 is only moderate, no doubt again due to the appearance of a strong negative pole in sample A which is absent in the total group. Although factor IV, total group, shows an index of agreement of .85 with factor VI, sample B, this latter factor could not be identified as basic mechanics in terms of the criterion of loadings above .3.

No factors could be found in samples A and B which could be identified with factor V in the total group. Factor VI in the total group, however, showed an index of agreement of .82 with factor I in sample A. Items relating to wave theory appeared in the harmonic motion factor in sample B, the existence of the harmonic motion items precluding the possibility of agreement between this and the wave theory factors for the other samples.

In general, it must be concluded that hypothesis 1.0 is not supported. Although it is possible to relate obtained factors in certain cases to logical clusterings of items, these clusters are neither sufficiently well defined nor sufficiently consistent to warrant acceptance of the hypothesis.

Hypothesis 1.1

In this hypothesis, the following eleven topics were postulated as forming a basis for a structuring of the electricity sort:

1. AC circuits
2. Properties of capacitors
3. Magnetic effects of charges
4. Inductors, induced EMF
5. Network analysis
6. Electromagnetic waves
7. The electric field
8. Maxwell's equations
9. Instrumentation principles
10. Resonance
11. Ferromagnetism

The procedure followed in the analysis related to this hypothesis was identical to that for hypothesis 1.0. The original factor analysis yielded fifteen factors accounting for seventy-two percent of the total variance of the sort. Again resorting to the Procrustes matching procedure, an hypothesized pattern matrix was constructed after assigning cards in the electricity deck to the postulated topics. As for the physics sort, this procedure proved fruitless since the computed factors were highly intercorrelated. The procedure was of value only to the extent of indicating how poorly the observed factor pattern fitted the hypothesized pattern.

In this case the plot of eigenvalues, as shown in Figure 5, indicated that a rotation of eight factors would be appropriate. Table XIV presents the results of the promax oblique rotation in terms of items with loadings greater than .3 or less than -.3. The labelling of these factors for the total group and the two subsamples appears in Table XV.

In terms of these labels it appears that, at least for sample A and the total group, the factors represent a fairly close approximation to those hypothesized. The results for sample B, while somewhat less intelligible, nevertheless yield factors which seem consistent with some of those for the other two samples. Examination of the comparison matrices for the Ahmavaara match, as given in Table XVI, shows, however, that the picture is somewhat more complex than the labelled factors indicate.

Factor I for the total group, identified as RLC circuits and resonance, appears in all three samples. In samples A and B the factor contains a strong negative pole which is different for the two

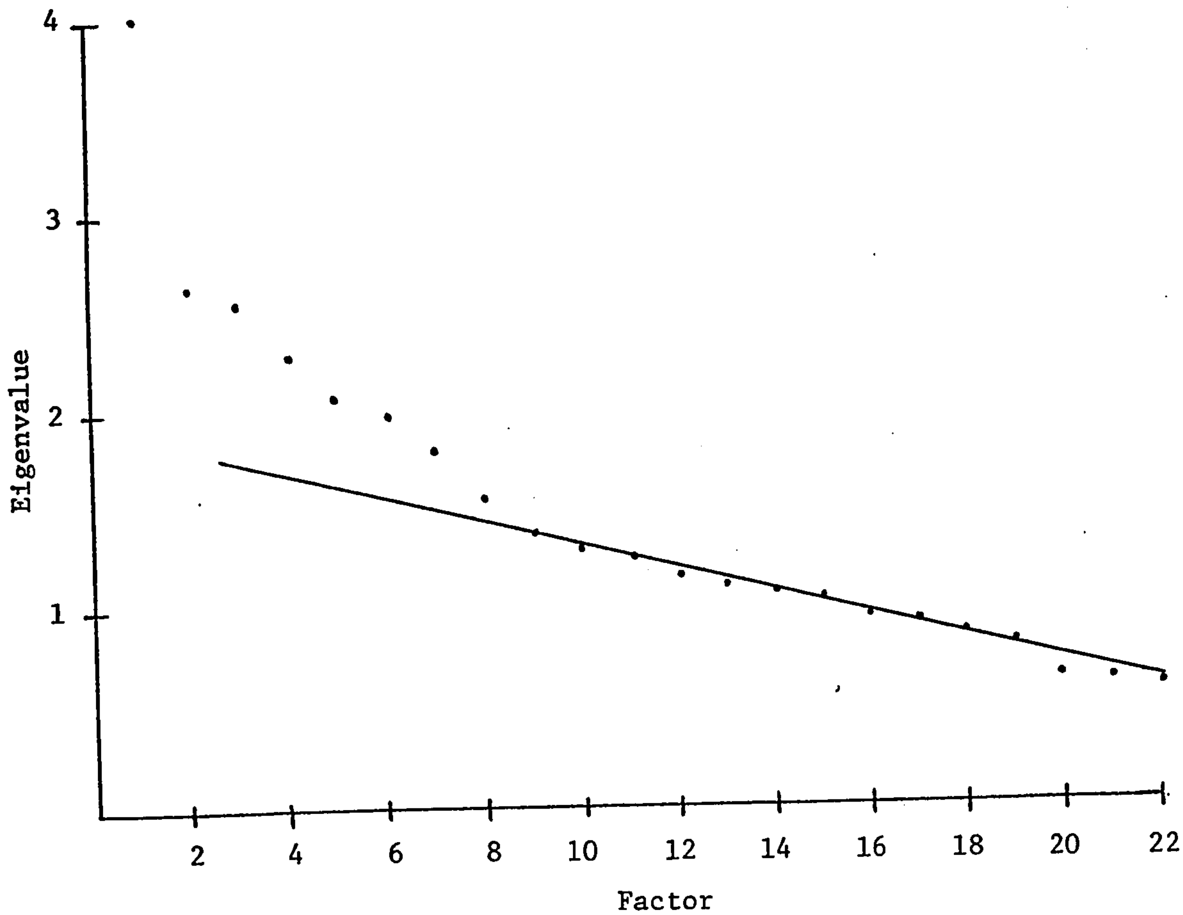

Figure 5

Plot of Eigenvalues: Principal Axes Factor Analysis of

Electricity Sort

TABLE XIV

INTERPRETATION OF FACTORS FOR ELECTRICITY SORT,

EIGHT FACTOR OBLIQUE SOLUTION

Positive Pole			Negative Pole		
Item	Loading	Abbreviated Card Content	Item	Loading	Abbreviated Card Content
		Factor I			
237	.55	Lenz's law	208	-.68	RLC circuit: power dissipation
201	.48	Ohm's law	211	-.65	RLC circuit; resonance condition
226	.40	Induced EMF	215	-.57	Filter design
202	.40	Kirchhoff's second law	207	-.54	Current-voltage phase; RC circuit
216	.38	Frictional electricity	210	-.37	AC circuits; vector solution
205	.32	Transformer			
		Factor II			
229	.77	Ferromagnetic materials	209	-.45	Current-voltage phase: inductor
230	.71	Hysteresis loop	220	-.45	Potential difference definition
225	.48	Torque on current loop	212	-.36	Impedance matching
227	.45	Moving charge; mag. flux density			
238	.43	Magnetic flux lines; closed surface			
226	.34	Induced EMF			
		Factor III			
221	.46	Capacitor; effect of dielectric	232	-.78	EM radiation: oscillating charges
210	.34	AC circuits; vector solution	234	-.66	EM waves; reflection & refraction
222	.34	Parallel capacitors	233	-.59	Waveguide
		Factor IV			
231	.76	Force on charge in EM field	214	-.60	Bridge principle
218	.56	Electric field intensity	212	-.47	Impedance matching
227	.44	Moving charge; mag. flux density			
217	.42	Coulomb's law			
		Factor V			
223	.74	Energy of charged capacitor	237	-.31	Lenz's law
203	.69	Definition of capacitance			
221	.64	Capacitor; effect of dielectric			
219	.39	Gauss's law			
		Factor VI			
222	.69	Parallel capacitors	235	-.70	Maxwell's equations
236	.55	Capacitor discharge	238	-.51	Mag. flux lines: closed surface
216	.37	Frictional electricity	220	-.31	Potential difference
		Factor VII			
228	.81	Eddy currents: energy losses	202	-.45	Kirchhoff's second law
205	.71	Transformer	206	-.44	Thevinin's theorem
212	.38	Impedance matching			
		Factor VIII			
213	.63	Galvanometer principle	204	-.77	Current-voltage relation: inductor
214	.44	Bridge principle	209	-.34	Current-voltage phase: inductor
224	.40	Hall effect			

TABLE XV

IDENTIFICATION OF FACTORS FOR ELECTRICITY SORT: SAMPLES A, B, AND TOTAL GROUPS,

EIGHT FACTOR OBLIQUE SOLUTION

Factor	Total Group		Sample A		Sample B	
	+ Pole	- Pole	+ Pole	- Pole	+ Pole	- Pole
I		RLC circuits, resonance	Magnetic field, ferromagnetism	Current-voltage phase		AC circuits
II	Magnetic field, ferromagnetism		Capacitance	Maxwell's eqns. transformer	RLC circuits, resonance	Transformer
III		EM waves	RLC circuits, resonance	Induced EMF		
IV	Charges in EM field		Transformer	EM waves	Magnetic field, ferromagnetism	
V	Capacitance			Network analysis		Instrument principles
VI	Capacitance	Maxwell's equations				
VII	Transformer	Network analysis	Capacitance		Capacitance	EM waves
VIII	Instrument principles	Inductance		Instrument principles	Charges in EM field	

TABLE XVI

COMPARISON MATRICES AHMAVAARA MATCH,

EIGHT FACTOR OBLIQUE PATTERN, ELECTRICITY SORT

Sample	Factor	I	II	III	IV	V	VI	VII	VIII
		Total Group							
Sample A	I	.13	.87	.04	.20	.23	-.20	-.16	.27
	II	-.12	-.08	.31	.27	.05	.78	-.40	-.19
	III	-.95	-.05	-.16	-.09	.16	-.07	-.11	-.14
	IV	-.04	.18	.84	-.08	-.25	.11	.38	-.20
	V	-.05	.09	-.17	.22	-.07	.33	.77	.45
	VI	.35	-.46	-.02	.48	.36	-.30	-.30	.34
	VII	.11	-.12	.15	-.00	.95	-.05	.08	-.20
	VIII	-.18	.10	.12	.77	-.16	-.19	-.05	-.54
		Total Group							
Sample B	I	.42	.48	-.18	-.10	.44	.05	-.14	.58
	II	-.78	-.08	-.25	-.07	.22	.08	-.47	.21
	III	.22	.09	.47	.67	-.00	-.08	-.46	.24
	IV	-.15	.59	.08	.10	-.05	.48	.61	-.07
	V	.50	.09	-.33	.34	.26	.16	-.23	-.60
	VI	.25	-.53	.03	-.12	-.09	.77	.06	.19
	VII	-.14	.21	.74	-.13	.50	.14	.17	-.28
	VIII	-.11	-.30	-.16	.80	.24	-.10	.40	.03
		Sample B							
Sample A	I	.87	-.09	.14	.16	-.04	-.43	.03	.03
	II	-.21	.15	.47	.17	.13	.74	.34	.05
	III	-.40	.76	-.39	.06	-.23	-.21	.08	-.06
	IV	-.53	-.30	.26	.28	-.19	.14	.65	-.06
	V	.26	-.06	-.07	.84	-.12	.28	.01	.35
	VI	.26	-.22	.70	-.55	.10	.06	-.09	.28
	VII	.43	.00	.05	-.13	.19	.02	.82	.30
	VIII	-.66	-.14	.44	.01	.33	-.22	.10	.42

samples. The index of agreement for this factor between samples A and B is thus reduced to .76, representing in geometric terms an angle of some forty degrees between the two factors.

Factor II, the magnetic field and ferromagnetism, also can be identified in the two subsamples. Comparisons involving sample B show poor agreement. Similarly for the factor labelled electromagnetic waves. In sample B the factor has a strong positive pole identified as capacitance. This results in stronger agreement of this factor with the capacitance factors in the other samples than with the electromagnetic waves factors.

Factor IV for the total sample appears, in a somewhat less well defined manner, as factor VIII in sample B, with an index of agreement of .80. Although factor VIII, sample A, is labelled differently, the index of .77 for this factor with factor IV in the total group can be attributed to the appearance of some items common to the two factors.

For sample A and the total sample, items dealing with capacitance are split between two factors. Although both poles of factor VI, total sample, have been labelled the same as those of factor II, sample A, the index of .78 is somewhat less than the index of .95 for factor V, total sample, and factor VII, sample A. This would indicate that these are the stronger capacitance factors. This is also borne out by the index of .82 between factor VII for both samples A and B.

In the case of factors VII and VIII for the total sample, no reasonable agreement exists with any factors in the remaining two samples, in spite of the presence of factors in these two samples which bear the same labels. Aside from the bipolarity problem, the identification of these factors was rather tenuous since the names were based in each instance on only two items. In these circumstances little agreement could be expected.

Even taking into account the reduction in agreement which might have resulted from the bipolar nature of some factors, it is concluded that only three areas may be considered as well defined. These are RLC circuits and resonance, electromagnetic waves, and capacitance. Identifying RLC circuits and resonance with the AC circuits topic hypothesized, the hypothesis is thus considered supported to the extent of three of the eleven topics appearing as factors.

In terms of actual clusters of items having significant loadings on factors, but not in terms of consistency across samples, several other areas are identifiable. These areas cannot be considered as directly supporting the hypothesis but are of value in determining the clusters of items to be used in further phases of the analysis.

Hypothesis 1.2

This hypothesis was identical in general form to the two preceeding, with ten topics being identified as follows:

1. Physical electronics

2. Transistor principles and applications

3. Vacuum tube principles and applications

4. RF circuits

5. Broadcast systems

6. Logic circuits

7. Feedback

8. Microwave

9. Large signal properties of devices

10. Instrumentation

The initial stage of this analysis involved the same procedure as before. In this case, however, both the varimax and promax rotations of the twenty factors with eigenvalues greater than unity yielded somewhat more intelligible results. It was therefore decided to forgo the development of an idealized pattern matrix and to proceed directly to the rotation of ten factors, since this was the number of hypothesized topics. The varimax and promax procedures were therefore repeated for the first ten factors, accounting for fifty-seven percent of the total variance of the sort.

Card items with loadings greater than .3 or less than -.3 on each factor of the promax solution are given in Table XVII. It is immediately apparent that the pattern is much more clearly defined for this case than for either of the previous cases. Factors can be identified which correspond closely to the hypothesized topics, with

TABLE XVII

INTERPRETATION OF FACTORS FOR ELECTRONICS SORT,

TEN FACTOR OBLIQUE SOLUTION

Positive Pole			Negative Pole		
Item	Loading	Abbreviated Card Content	Item	Loading	Abbreviated Card Content
			Factor I		
350	.40	Magnetic cores; binary storage	367	-.83	Waveguide
301	.36	Triode linear equiv. circuit	353	-.82	Microwave; circuit limitation
356	.36	Complex switching circuits	352	-.78	Klystron tube
346	.34	Transducer; definition	359	-.75	Radar principle
364	.31	High fidelity audio circuits	354	-.71	Resonant cavity
			362	-.52	Doppler effect; EM waves
			360	-.42	Maser Principle
			334	.-35	RF amplifier
			340	-.32	Directional antennas
			Factor II		
311	.76	Amplification in triode	349	-.56	Flip-flop; binary operations
318	.65	Pentode characteristics	350	-.52	Magnetic cores; binary storage
322	.65	Coupling of amplifier stages	341	-.48	Flip-flop; use as switch
323	.54	Class B amplifier	361	-.47	AND logic circuit
335	.53	Superheterodyne receiver	360	-.45	Maser principle
334	.42	RF amplifier	357	-.43	Integrated circuits
312	.34	Load line; triode characteristic			
324	.34	Tubes and transistors; large signal			
313	.31	Triode biasing techniques			
328	.31	Push-pull driver stage			
			Factor III		
348	.72	Tolerences in SSB circuits	369	-.74	Servo systems; synchro motor
370	.63	AM carrier and sidebands	355	-.70	Control system principle
338	.53	Advantage of FM broadcast	346	-.51	Transducer; definition
339	.42	Reflection of EM waves	324	-.34	Tubes and transistors; large signal
336	.40	AM broadcast principle	302	-.32	Cathode Ray Tube deflection
337	.37	FM broadcast principle			
307	.35	Detection of AM signal			
			Factor IV		
362	.34	Doppler effect; EM waves	351	-.89	Color TV broadcast
			343	-.87	Composite TV signal; structure
			344	-.78	TV picture tube
			342	-.71	Image orthicon tube
			345	-.45	FM multiplexing
			364	-.49	High fidelity audio circuits
			Factor V		
317	.81	Biasing of transistor amp.	355	-.39	Control system principle
315	.69	Transistor as amplifier	319	-.37	Conduction in gas tubes
316	.68	Transistor; thermal runaway	340	-.32	Directional antennas
368	.64	Reverse breakdown; PN junction	363	-.32	Magnetic amplifier
314	.55	Emitter follower amplifier			
309	.33	PN junction; potential barrier			
			Factor VI		
313	.72	Triode; biasing techniques	371	-.44	Schmitt trigger
306	.66	Vacuum diode action	340	-.36	Directional antennas
333	.62	Property of ripple filters	337	-.35	FM broadcast principle
319	.51	Conduction in gas tubes			
310	.37	Photoelectric effect			
318	.36	Pentode characteristics			
311	.33	Amplification in triode			
			Factor VII		
331	.62	Feedback amplifier; oscillation	303	-.67	Free electrons in metal
329	.51	Effect of negative feedback	304	-.66	Thermionic emission
330	.35	Operational amplifier	302	-.56	Cathode ray tube deflection
328	.34	Push-pull driver stage	305	-.54	Impurities in semiconductor
			324	-.34	Tubes and transistors; large signal
			Factor VIII		
337	.64	FM broadcast principle	349	-.45	Flip-flop; binary operations
326	.62	Impedance matching	358	-.45	Analog computer
338	.44	Advantage of FM broadcast	361	-.43	AND logic circuit
336	.35	AM broadcast principle	301	-.40	Triode linear equiv. circuit
345	.35	FM multiplexing	357	-.37	Integrated circuits
307	.34	Detection of AM signal	341	-.35	Flip-flop; use as switch
			350	-.35	Magnetic cores
			330	-.32	Operational amplifier
			371	-.31	Schmitt Trigger
			Factor IX		
366	.66	Oscilloscope operation	312	-.62	Load line; triode characteristic
320	.54	VTVM; high input impedance	347	-.37	Telemetry principle
327	.47	Push-pull; distortion reduction	360	-.35	Maser principle
332	.36	Crystal; use in tuned circuit	308	-.34	Transistor hybrid parameters
			Factor X		
325	.75	Waveform analysis	311	-.41	Amplification in triode
321	.52	Filter design	306	-.31	Vacuum diode action
365	.57	Stability of feedback amplifier			
364	.40	High fidelity audio circuits			

only minor departures being evident. For example, the broadcast systems topic appears as separate factors for radio and television. Also, no factors appear which can be identified with RF circuits in general or with large signal properties.

Again proceeding with the replication process, samples A and B were factored and ten factors rotated. The identification of factors for the three analyses appears in Table XVIII, while Table XIX gives the comparison matrices for the Ahmavaara match.

Considering the factors in turn, in the order in which they are identified for the total group, it is apparent that, with certain exceptions, due no doubt at least partly to the bipolarity and the splitting of factors, good overall agreement exists across samples. Exceptions to the overall picture occur mainly in the last three factors where little agreement exists. This is an indication that more factors were rotated than were strictly necessary. A further indication of the same problem is the splitting of factors. Little is lost in the interpretation if, for the total group, factors above factor VII are disregarded. Both poles of factor VIII are repeats of factors previously identified, although the negative pole of this factor may be more broadly interpreted as logic and computer circuits than can the negative pole of factor II. The factor labelled instrument, although appearing in sample B, is not clearly defined, no doubt because only two items directly related to instrumentation appeared in the sort.

TABLE XVIII

IDENTIFICATION OF FACTORS FOR ELECTRONICS SORT, SAMPLES A, B, AND TOTAL GROUP,

TEN FACTOR OBLIQUE SOLUTION

Factor	Total Group + Pole	Total Group - Pole	Sample A + Pole	Sample A - Pole	Sample B + Pole	Sample B - Pole
I		Microwave	Radio Broadcast	Feedback		Microwave
II	Vacuum tube	Logic circuits		Television		Logic circuits
III	Radio broadcast	Control systems	Feedback, large signal		Feedback	Physical electronics
IV		Television		Logic circuits	Transistor	
V	Transistor		Transistor		AM broadcast	Control systems
VI	Vacuum tube		Microwave			Television
VII	Feedback	Physical electronics	Vacuum tube			Radio broadcast
VIII	Radio broadcast	Logic circuits	Physical electronics		Vacuum tube	
IX	Instrument				Vacuum tube	
X				Radar	Instrument	

TABLE XIX

COMPARISON MATRICES AHMAVAARA MATCH,

TEN FACTOR OBLIQUE PATTERN, ELECTRONICS SORT

Sample	Factor	I	II	III	IV	V	VI	VII	VIII	IX	X
		Total Group									
Sample A	I	-.10	.02	.85	.06	.11	-.10	-.19	.35	.21	-.20
	II	-.03	.10	.08	.95	.01	.01	.08	-.24	-.03	.10
	III	-.02	.34	-.02	.13	-.11	.18	.53	.47	.56	-.05
	IV	.02	.81	.05	-.01	-.08	.10	-.25	.19	-.11	.46
	V	.00	.11	-.00	.01	.98	-.04	.01	.15	.11	-.00
	VI	-.89	-.12	.25	.01	.03	.20	.21	.09	-.20	-.02
	VII	-.04	.27	.04	-.12	-.06	.86	-.03	-.37	-.02	.18
	VIII	.07	-.27	-.20	.11	.12	.37	-.69	.29	.08	-.38
	IX	-.01	.59	-.15	-.01	-.02	.20	.09	-.03	-.27	-.71
	X	.55	-.36	.57	-.07	.14	.40	.07	-.15	.06	-.18
		Total Group									
Sample B	I	.89	-.06	-.32	-.00	.03	.13	.09	.02	.01	.29
	II	-.09	.80	-.09	-.08	.10	.13	.08	.50	-.06	.23
	III	-.01	.14	.09	.07	.15	-.08	.96	.08	.02	-.14
	IV	.08	-.06	.07	-.10	.93	.07	-.09	-.19	-.23	-.10
	V	.27	.54	.76	.09	.12	.03	.01	.09	.14	.01
	VI	-.09	.05	.17	.90	-.10	.09	.06	-.11	-.08	.33
	VII	.03	.55	-.61	.18	.18	.22	.04	-.43	.12	-.09
	VIII	-.14	-.10	.11	-.08	-.29	.85	-.15	-.05	.10	-.32
	IX	-.09	.44	.24	.13	.28	.35	.06	-.18	-.69	-.12
	X	.34	.17	.21	-.11	.27	.20	-.40	-.09	.61	.39
		Sample B									
Sample A	I	-.54	.02	.02	-.00	.69	-.06	-.43	.10	-.17	.10
	II	-.10	-.26	.18	-.02	.01	.87	.31	-.14	.11	.02
	III	-.19	.51	.49	-.63	.13	-.06	-.08	.00	-.08	.12
	IV	.00	.89	-.25	.03	.18	.15	.10	.02	.02	.30
	V	-.03	.30	.05	.89	.14	-.05	.12	-.25	-.00	.10
	VI	-.90	.19	.13	-.04	-.20	.05	-.10	.07	.25	-.12
	VII	.33	.13	-.12	.11	.21	.11	.31	.75	.33	.18
	VIII	.06	-.04	-.81	.04	-.25	-.25	.10	.45	.05	-.05
	IX	-.46	.22	.19	-.10	-.08	-.23	.41	.39	.48	-.29
	X	.57	-.53	.05	.20	.41	-.18	-.21	.27	.14	.05

Only in two cases is it necessary to go beyond factor VII for either sample. Physical electronics appears as factor VIII for sample A. This factor is not as well defined for this sample as for the remaining samples as indicated by the indices of -.69 and -.81 with factor VII, total sample, and factor III, sample B, respectively. This is compared with .96 for the latter two factors themselves. Part of the problem here is no doubt the appearance of feedback at the opposite pole of both factor VII, total sample, and factor III of sample B, while feedback appears as a separate factor for sample A. The second instance is the appearance of vacuum tubes in factors VIII and IX of sample B. In the case of factor VIII, indices of agreement of .75 and .85 exist with the appropriate factor of sample A and the total sample respectively.

To summarize, it is apparent that hypothesis 1.2 is well supported. In terms of factors identified for the total sample, seven of the ten hypothesized topics appear as factors. Topics four and five appear in modified form, with broadcast systems showing a clear division between television and radio. Items relating to the RF circuits topic d not appear as a separate factor but are scattered among other factors relating to broadcast and communications. The instrumentation factor is not well defined, this being attributed to the presence of only two instrumentation items in the sort. A control systems factor which had not been anticipated appeared for the total sample and for sample B. This factor also was not well defined, no doubt for the same reason as for the instrumentation factor.

Summary

In order to reduce the complexity inherent in the analysis of individual items in a Q-sort, some structuring of items into logical clusters is desirable. Factor analysis of item correlations for the three Q-sort instruments was conducted to determine the extent to which a clustering of items on the basis of topics conventionally used in structuring the subjects concerned was, in fact, compatible with any clustering imposed by technicians in the sorting process.

For the physics instrument, results did not permit either support or outright rejection of the hypothesized structure. On the one hand, while factors could be labelled in a general manner compatible with the hypothesized topics, these factors were neither sufficiently well defined nor consistent to justify support of the hypothesis. On the other hand, no clearly defined alternative to the hypothesized structure emerged, although the analysis technique was capable of yielding such an alternative if it existed in responses. The possibility that an element of randomness in the sorts tended to override systematic effects could not be ignored, particularly in view of the relative unreliability of the physics sort.[5]

The electricity sort yielded only three factors which could be considered supportive of the hypothesized topics. The same general

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[5]Cf. Table I, p. 76.

result as for physics applied. The hypothesis was neither supported nor did a credible alternative emerge.

The electronics instrument yielded a factor pattern which was generally consistent with the hypothesized topics. While the results were slightly complicated by some splitting of factors and by bipolar combinations which were not anticipated in formulating the hypothesis, this hypothesis was considered supported.

Results of the factor analysis permitted minor modifications to be made for purposes of the more detailed analysis of topics to be presented in a succeeding section. In the case of physics and electricity, for reasons which will become apparent, it did not appear inconsistent to use the hypothesized topics as a basis for further analysis. Their status with respect to the factor analysis should, however, be taken into account.

II IDENTIFICATION OF GROUPS

The purpose of this phase of the analysis was to determine which of the categorical variables considered relevant to the responses to the Q-sorts could, in fact, be regarded as having a significant influence on these responses. For this purpose a matrix of intercorrelations among all respondents was developed for each of the three instruments. These correlation coefficients were converted to Fisher's Z to facilitate comparison of means within groups and between groups. The basic question to be answered was: "Are pairs of technicians from the same group more highly correlated than pairs of technicians belonging to different groups?"

For each categorical variable, the Z matrix was partitioned to form groups based on the categories defined in Chapter V. Because of the large number of correlations involved (a 100 x 100 matrix), a sampling procedure was developed whereby random samples, generally of thirty Z scores each, were chosen from within each group and from those scores involving one group member and one non member. These are hereafter referred to as the within-group and between-group samples respectively. For each sample a t test was used to compare within-group and between-group mean values of Z. The level of significance accepted was .05. For each group the analysis was replicated by choosing two sets of samples, designated as A and B. An added criterion for the identification of a well defined group was that a group would be considered as well defined only if the results were significant for both samples A and B. All tests were one tailed since the only groups of interest were those for which the agreement among members, as measured by Z, was greater than that between members and non members, and also since the hypothesis of less within-group than between-group agreement was essentially meaningless.

It is necessary to draw attention to certain aspects of the sampling of Z scores. Initially, with the aim of avoiding the actual computation of a 100 x 100 matrix and the punching of individual Z scores on cards, nine individuals were selected without replacement for each sample from among group members and non members, and only these individuals were correlated. It was soon discovered that this procedure led to sampling errors which were much larger than those accounted for in the statistical tests.

The basic problem appeared to be that the number of degrees of freedom used in computing probabilities for _t_ was based on the number of actual Z scores in each sample, assuming random sampling from a large population of such scores. In fact, however, the sampling procedure placed constraints on the selection of Z scores since prior sampling of individuals meant that only correlations among the selected individuals could be used in a given sample. Many possible combinations were thus eliminated. Furthermore, the selection of a particular individual for, say, sample A, implied that many correlations involving this individual appeared in this sample while sample B contained no correlations for this individaul. Thus the effect of one possibly idiosyncratic individual in a particular group weighed inordinately on one sample, leading to the possibility of highly inconsistent results for the two samples. The number of degrees of freedom used in the _t_ test was too large to account for such gross errors. This whole problem was corrected by generating the complete matrix and applying random sampling principles to the Z scores themselves.

This correction could not eliminate all inconsistencies since the large number of tests involved in the comparison of groups raised the problem of the possible occurrence of a few significant differences due to chance. The criterion for the identification of a well defined group was that both samples yield a significant effect. This reduced considerably the chance that the acceptance of a result might be due to a Type I error.

A further aspect of this analysis was the nonindependence of Z scores. In many instances the same individual could have been involved in both a within-group and a between-group score. Two such scores would not be independent. Furthermore, the relatively small number of individuals in some groups virtually assured that the same individual would be involved more than once, even within a single sample. The first type of dependency would imply that the use of _t_ tests between correlated samples would have been appropriate. Short of choosing extremely small samples, there appeared to be no way of avoiding the within-sample dependency. The lack of a criterion for deciding upon which Z scores should be paired prevented the construction of correlated samples. It was therefore necessary to proceed by using _t_ tests for independent samples. Assuming positive correlation between the samples, an assumption which appears justified since the same individuals would be involved in both samples, the effect of this procedure is to give a more stringent test.

Hypothesis 2.0

The null hypothesis in this case postulated no differences among groups based on the type of work variable. For this variable four groups were identified as follows:

1. Research and development
2. Maintenance
3. Supervision
4. Others

The "others" category summarized several of the categories included in the initial classification scheme because none of these contained a sufficient number of persons to permit a meaningful analysis.

Means, standard deviations, and *t* tests for within-group and between group Z scores appear in Table XX. No groups can be considered as well defined on the basis of responses to the physics and electricity instruments. For the electronics instrument the research and development group is strongly defined. With this exception, the null hypothesis is accepted for all comparisons related to the type of work variable.

Aside from the isolation of this one group, it is possible to examine the data for general tendencies. Thus, in the case of the physics sort, two of the eight values of *t* are negative. A sign test was used to determine whether this represented a significant trend in the direction of within-group responses being higher than those between groups. This test showed that the tendency was not significant at the .05 level. A similar result applies to the remaining two tables.

Hypothesis 3.0

This hypothesis was concerned with the identification of

TABLE XX

COMPARISON OF WITHIN GROUP AND BETWEEN GROUP MEAN VALUES

OF FISHER Z, TYPE OF WORK VARIABLE

Group	Sample	Within Group Mean	Within Group S.D.	Between Group Mean	Between Group S.D.	t	P* (one tail)
			Physics				
Research and Development	A	.37	.24	.32	.26	.85	n.s.
	B	.39	.23	.32	.19	1.17	n.s.
Maintenance	A	.30	.15	.32	.21	-.37	n.s.
	B	.33	.26	.38	.19	-.81	n.s.
Supervision	A	.44	.18	.37	.25	1.18	n.s.
	B	.46	.15	.37	.28	1.51	n.s.
Others	A	.42	.29	.34	.25	1.14	n.s.
	B	.36	.30	.34	.30	.25	n.s.
			Electricity				
Research and Development	A	.37	.20	.38	.19	-.12	n.s.
	B	.41	.21	.35	.18	1.04	n.s.
Maintenance	A	.42	.20	.32	.27	1.67	<.05
	B	.38	.25	.36	.25	.24	n.s.
Supervision	A	.33	.22	.33	.25	-.08	n.s.
	B	.32	.25	.42	.26	-1.51	n.s.
Others	A	.32	.23	.33	.22	-.12	n.s.
	B	.29	.25	.36	.26	-1.08	n.s.
			Electronics				
Research and Development	A	.64	.20	.40	.23	4.23	<.001
	B	.62	.19	.36	.30	3.85	<.001
Maintenance	A	.29	.31	.20	.25	1.19	n.s.
	B	.32	.30	.37	.26	-.67	n.s.
Supervision	A	.27	.21	.28	.17	-.02	n.s.
	B	.34	.13	.33	.19	.28	n.s.
Others	A	.16	.26	.19	.27	-.52	n.s.
	B	.14	.22	.25	.31	-1.57	n.s.

*Degrees of Freedom = 58

groups on the basis of the type of equipment variable. The following seven groups were compared:

1. General electronics
2. Broadcast
3. Communications
4. Navigational aids
5. Computers
6. Industrial electronics
7. Others

Table XXI gives means, standard deviations, and t tests for the above groups for the three sorts. For the physics sort the null hypothesis is accepted for all groups. For the electricity sort only the broadcast group is well defined. In the case of the electronics sort four well defined groups emerge. These are broadcast, communications, navigational aids, and computers. A rather interesting phenomenon occurs in the case of the communications group. The within-group mean of .27 is considerably smaller than for any of the other groups, indicating that members of the communications group did not agree highly among themselves. Nevertheless, the essentially zero between group means show that communications technicians were sufficiently different from others to give a significant value of t and to justify the identification of communications as a distinct area with respect to the electronics instrument.

Again examining overall tendencies for this variable, the five negative and nine positive values of t for the physics sort does not

TABLE XXI

COMPARISON OF MEAN WITHIN-GROUP AND BETWEEN-GROUP VALUES

OF FISHER Z, TYPE OF EQUIPMENT VARIABLE

Group	Sample	Within Group Mean	Within Group S.D.	Between Group Mean	Between Group S.D.	d.f.	t	P (one tail)
				Physics				
General	A	.39	.22	.39	.21	58	-.06	n.s.
	B	.38	.20	.33	.19	58	1.05	n.s.
Broadcast	A	.44	.18	.29	.19	43	2.38	< .01
	B	.44	.18	.40	.24	43	.57	n.s.
Communications	A	.42	.19	.38	.19	49	.75	n.s.
	B	.42	.19	.38	.25	49	.62	n.s.
Nav. Aids	A	.49	.18	.43	.27	58	.90	n.s.
	B	.50	.21	.46	.23	58	.77	n.s.
Computers	A	.32	.24	.36	.18	58	-.70	n.s.
	B	.24	.18	.38	.22	58	-2.60	n.s.
Industrial Electronics	A	.18	.22	.21	.21	58	-.44	n.s.
	B	.23	.19	.28	.24	58	-.81	n.s.
Others	A	.40	.17	.35	.20	58	1.03	n.s.
	B	.40	.15	.36	.21	58	.88	n.s.
				Electricity				
General	A	.40	.22	.40	.20	58	-.09	n.s.
	B	.41	.21	.36	.30	58	.71	n.s.
Broadcast	A	.52	.19	.39	.23	43	1.77	< .05
	B	.52	.19	.38	.23	43	1.94	< .05
Communications	A	.45	.21	.39	.18	49	1.06	n.s.
	B	.45	.21	.37	.18	49	1.48	n.s.
Nav. Aids	A	.52	.15	.43	.20	58	1.91	< .05
	B	.54	.17	.48	.20	58	1.30	n.s.
Computers	A	.37	.20	.32	.22	58	.99	n.s.
	B	.32	.19	.29	.22	58	.61	n.s.
Industrial Electronics	A	.39	.30	.46	.22	58	-.97	n.s.
	B	.43	.24	.39	.21	58	.55	n.s.
Others	A	.44	.19	.42	.20	58	.34	n.s.
	B	.40	.18	.35	.24	58	.76	n.s.
				Electronics				
General	A	.37	.23	.31	.24	58	.97	n.s.
	B	.40	.17	.30	.24	58	1.88	< .05
Broadcast	A	.44	.16	.14	.17	43	5.49	< .001
	B	.44	.16	.20	.13	43	5.32	< .001
Communications	A	.27	.22	.09	.25	49	2.60	< .01
	B	.27	.22	.07	.26	49	2.97	< .01
Nav. Aids	A	.49	.16	.18	.13	58	8.30	< .001
	B	.41	.18	.20	.17	58	4.58	< .001
Computers	A	.66	.27	.24	.31	58	5.40	< .001
	B	.69	.20	.28	.28	58	6.38	< .001
Industrial Electronics	A	.40	.22	.32	.26	58	1.18	n.s.
	B	.41	.26	.28	.19	58	2.25	< .01
Others	A	.28	.20	.21	.18	58	1.34	n.s.
	B	.37	.21	.30	.23	58	1.19	n.s.

indicate a significant tendency according to the sign test. For the electricity sort, however, the tendency towards within-group agreement is significant beyond the .01 level. In the case of the electronics sort the tendency is obvious.

Hypotheses 4.0 to 10.0

These seven hypotheses related to the effects on responses of the following seven secondary variables:

1. Years of formal education
2. Years of technical education
3. Source of training
4. Range of experience
5. Tenure of employment
6. Age
7. Salary range

Table XXII presents, in slightly condensed form, results analogous to those given in the analysis of the two preceeding hypotheses. Results may be summarized very simply. For the physics and electronics instruments no clearly defined groups were isolated. For the electricity sort the following groups showed significant effects:

1. Total education 13 years
2. Technical education 1 year
3. Salary range less than $6000
4. Salary range $6000-6999

TABLE XXII

T TESTS FOR DIFFERENCES BETWEEN

WITHIN-GROUP AND BETWEEN-GROUP MEAN VALUES OF FISHER Z,

SECONDARY CLASSIFICATION VARIABLES

Group	Sample	Physics Mean Within	Physics Mean Between	Physics t	Physics P*	Electricity Mean Within	Electricity Mean Between	Electricity t	Electricity P*	Electronics Mean Within	Electronics Mean Between	Electronics t	Electronics P*
Total Education													
Less than 13 years	A	.37	.32	.79	n.s.	.43	.42	.14	n.s.	.27	.23	.51	n.s.
	B	.38	.31	1.23	n.s.	.43	.42	.11	n.s.	.30	.29	.09	n.s.
13 years	A	.37	.35	.31	n.s.	.51	.39	1.99	<.05	.31	.32	-.05	n.s.
	B	.41	.38	.72	n.s.	.50	.42	1.67	<.05	.31	.26	.95	n.s.
14 years	A	.22	.33	-1.70	n.s.	.29	.33	-.78	n.s.	.29	.28	.18	n.s.
	B	.29	.30	-.22	n.s.	.28	.39	-1.87	n.s.	.29	.25	.69	n.s.
15 years	A	.35	.31	.79	n.s.	.37	.37	.01	n.s.	.16	.18	-.27	n.s.
	B	.36	.33	.57	n.s.	.43	.35	1.52	n.s.	.26	.22	.55	n.s.
16 years or more	A	.33	.40	-1.36	n.s.	.22	.37	-2.14	n.s.	.32	.28	.59	n.s.
	B	.35	.31	.63	n.s.	.20	.38	-2.44	n.s.	.32	.34	-.25	n.s.
Technical Education													
1 year	A	.42	.36	.97	n.s.	.51	.34	3.07	<.001	.36	.36	-.09	n.s.
	B	.45	.35	1.75	< .05	.49	.36	2.07	<.05	.27	.31	-.52	n.s.
2 years	A	.30	.35	-.86	n.s.	.41	.41	-.06	n.s.	.38	.29	1.49	n.s.
	B	.26	.33	-1.44	n.s.	.38	.44	-1.07	n.s.	.28	.24	.58	n.s.
3 years	A	.29	.34	-.96	n.s.	.33	.43	-1.92	n.s.	.20	.29	-1.05	n.s.
	B	.41	.33	1.70	<.05	.39	.41	-.32	n.s.	.22	.25	-.29	n.s.
4 years or more	A	.30	.31	-.13	n.s.	.21	.26	-.81	n.s.	.33	.28	.79	n.s.
	B	.33	.38	-1.02	n.s.	.21	.28	-1.00	n.s.	.33	.31	.43	n.s.
Source of Training													
Technical Institute	A	.40	.33	1.21	n.s.	.33	.33	.15	n.s.	.21	.19	.29	n.s.
	B	.35	.26	1.48	n.s.	.34	.36	-.40	n.s.	.27	.27	.03	n.s.
Armed Forces	A	.38	.30	1.57	n.s.	.37	.35	.24	n.s.	.31	.33	-.20	n.s.
	B	.30	.30	.11	n.s.	.40	.41	-.28	n.s.	.35	.35	-.10	n.s.
Other	A	.40	.34	1.04	n.s.	.32	.36	-.78	n.s.	.35	.25	1.43	n.s.
	B	.32	.33	-.13	n.s.	.29	.31	-.32	n.s.	.35	.36	-.21	n.s.
Range of Experience													
Less than 10 job years	A	.23	.36	-2.39	n.s.	.45	.30	2.51	<.01	.40	.23	2.56	<.01
	B	.25	.33	-1.21	n.s.	.39	.41	-.22	n.s.	.27	.35	-.98	n.s.
10-29 job years	A	.38	.34	.78	n.s.	.41	.39	.33	n.s.	.22	.22	.01	n.s.
	B	.44	.35	1.56	n.s.	.36	.41	-.94	n.s.	.34	.27	1.06	n.s.
30-59 job years	A	.35	.28	1.44	n.s.	.28	.36	-1.23	n.s.	.21	.30	-1.26	n.s.
	B	.30	.33	-.63	n.s.	.28	.35	-.96	n.s.	.26	.27	-.08	n.s.
60+ job years	A	.32	.26	1.17	n.s.	.38	.37	.33	n.s.	.28	.26	.43	n.s.
	B	.25	.38	-2.17	n.s.	.41	.33	1.36	n.s.	.28	.28	.01	n.s.

*One tailed test

TABLE XXII (continued)

Group	Sample	Physics Mean Within	Physics Mean Between	Physics t	Physics p*	Electricity Mean Within	Electricity Mean Between	Electricity t	Electricity p*	Electronics Mean Within	Electronics Mean Between	Electronics t	Electronics p*
Tenure of Employment													
1 year	A	.33	.28	.71	n.s.	.39	.39	-.03	n.s.	.21	.22	-.19	n.s.
	B	.37	.33	.64	n.s.	.52	.38	2.19	< .05	.22	.24	-.37	n.s.
2 years	A	.34	.35	-.09	n.s.	.27	.36	-1.47	n.s.	.29	.20	1.25	n.s.
	B	.33	.31	.41	n.s.	.30	.40	-1.70	n.s.	.32	.27	.82	n.s.
3-5 years	A	.28	.29	-.23	n.s.	.47	.38	1.56	n.s.	.40	.27	2.02	<.05
	B	.22	.33	-1.57	n.s.	.36	.39	-.57	n.s.	.34	.36	-.33	n.s.
More than 5 years	A	.40	.38	.22	n.s.	.30	.38	-1.42	n.s.	.32	.32	.01	n.s.
	B	.33	.26	1.71	< .05	.32	.34	-.33	n.s.	.18	.25	-.88	n.s.
Age													
Less than 25	A	.38	.42	-.81	n.s.	.42	.45	-.38	n.s.	.32	.32	-.09	n.s.
	B	.43	.36	1.42	n.s.	.48	.38	1.58	n.s.	.37	.36	.09	n.s.
25-29	A	.28	.25	.58	n.s.	.39	.37	.43	n.s.	.33	.30	.44	n.s.
	B	.32	.36	-.71	n.s.	.45	.42	.75	n.s.	.34	.32	.22	n.s.
30-34	A	.37	.36	.29	n.s.	.38	.34	.90	n.s.	.28	.25	.53	n.s.
	B	.32	.27	.78	n.s.	.40	.33	1.05	n.s.	.21	.16	.86	n.s.
35-39	A	.37	.39	-.46	n.s.	.37	.35	.54	n.s.	.35	.25	1.72	<.05
	B	.32	.35	-.53	n.s.	.42	.41	.10	n.s.	.34	.37	-.56	n.s.
40 or more	A	.37	.32	.82	n.s.	.38	.36	.21	n.s.	.23	.30	-.96	n.s.
	B	.32	.39	-1.70	n.s.	.35	.36	-.18	n.s.	.25	.19	.85	n.s.
Salary**													
Less than $6000	A	.32	.28	.66	n.s.	.57	.45	2.11	<.05	.24	.25	-.29	n.s.
	B	.32	.33	-.23	n.s.	.56	.46	1.65	<.05	.21	.31	-1.51	n.s.
$6000-6999	A	.29	.33	-.67	n.s.	.48	.35	2.18	<.05	.22	.25	-.45	n.s.
	B	.25	.31	-1.02	n.s.	.41	.31	1.65	<.05	.20	.25	-.68	n.s.
$7000-7999	A	.39	.39	-.16	n.s.	.25	.32	-1.15	n.s.	.30	.20	1.82	<.05
	B	.39	.28	2.01	<.05	.29	.37	-1.23	n.s.	.30	.38	-1.08	n.s.
$8000-8999	A	.44	.45	-.04	n.s.	.30	.34	-.67	n.s.	.22	.25	-.35	n.s.
	B	44	.37	1.33	n.s.	.33	.41	-1.55	n.s.	.16	.23	-.81	n.s.
$9000 or more	A	.38	.36	.60	n.s.	.24	.38	-2.29	n.s.	.44	.40	.58	n.s.
	B	.35	.25	2.26	<.01	.24	.28	-.83	n.s.	.45	.29	3.12	<.01

*One tailed test

**Degrees of freedom for under $6000 group = 56; all other degrees of freedom = 58

The existence of these effects, all occurring in the lower ranges of the variables concerned, indicated the possibility that these variables were not independent. In order to test this possibility, the sample was divided for the three variables concerned into two groups representing those showing significant effects and those showing no such effects. In this form the variables were tested for independence using X^2. Results of these tests are presented in Table XXIII.

It is seen that technical education and total education are highly dependent. This result might be expected since most technicians would have completed secondary education to grade twelve. One year of technical education added to this gives a total of thirteen years of formal education. It may thus be concluded that the significant effects for these two variables are manifestations of the same phenomenon. Since salary is independent of the other two variables, it must be concluded that technicians in the lower salary ranges form distinct groups with respect to electricity requirements.

Summary

Hypotheses under consideration in this section concerned the classification of technicians into groups which could be considered comparatively homogeneous in response to the Q-sort instruments. Again a reduction in complexity was the objective, since a detailed analysis of the large number of variables of possible relevance to responses would be prohibitive.

TABLE XXIII

OBSERVED AND EXPECTED FREQUENCIES AND X^2 TESTS

FOR COMPARISON OF THREE VARIABLES

YIELDING WELL DEFINED GROUPS FOR ELECTRICITY INSTRUMENT

Variable	Group	Total Education 13 years 0	 (E)	 Others 0	 (E)	X^2	P
Technical Education	1 year	15	(4.2)	6	(16.8)	43.94	< .001
	Others	5	(15.8)	74	(63.2)		
		Total Education 13 years		Others			
Salary	Less than $7000	9	(9.8)	40	(39.2)	.16	n.s.
	$7000 or more	11	(10.2)	40	(40.8)		
		Salary Less than $7000		$7000 or more			
Technical Education	1 year	10	(10.3)	11	(10.7)	.02	n.s.
	Others	39	(38.7)	40	(40.3)		

The analysis proceeded by classifying technicians on the basis of the different variables and comparing within-group and between-group responses. The basis for the comparison was the matrix of intercorrelations among all persons. Correlation coefficients were converted to values of Fisher Z to permit comparison of within-group and between-group means.

For the type of work classification, it was found that research and development technicians were significantly different from others in responses to the electronics instrument. Classification by type of equipment revealed four such groups for electronics, in the areas of broadcast, communications, navigational aids, and computers. For electricity the broadcast group was well defined. The remaining classification variables showed few systematic effects. Those significant were the lower two salary ranges and one group each for the total education and technical education classifications, all for the electricity instrument.

III DETAILED ANALYSIS OF GROUPS AND TOPICS

The present section is concerned with the third and final phase of the main sequence. Having isolated certain groups of technicians which could be considered distinct in terms of homogeneity of response to one or more of the instruments, the next step was to determine as specifically as possible the manner in which such groups differed from each other, and to compare the various subject matter topics in terms of the requirements within the groups identified.

In order that the anlysis be related, as far as possible, to actual dimensions of the sorts as perceived by respondents, results of the investigation of dimensionality of the sorts were used to make a posteriori modifications in the hypothesized topics. Thus, for example, the discovery that radio and television formed distinct factors in the electronics sort was taken into account in developing a revised list of topics to be used in the present stage of analysis.

The basic analysis technique used in investigating the hypotheses under consideration in the present section was a series of one way analysis of variance designs, developed from the basic two way classification of data by groups and topics. Each group was analyzed with respect to all topics. Similarly, each topic was investigated over all groups. In the case of physics and electricity, topic effects were analyzed for the total sample.

Since each topic contained several items, it was necessary to develop a composite measure of the value of each topic for every individual. Because topics, in general, contained different numbers of items, a straightforward computation of the mean over all items in a topic was not appropriate. Instead, a sampling of items was carried out within each topic with the aim of basing the computed topic mean on the same number of items for every topic. This procedure of course resulted in the discarding of some items for each sort. It was, however, deemed to be a more desirable procedure than the use of means based on different numbers of items since the latter would lead to violation of homogeneity of within-cell variance for the analysis of variance.

Items were sorted into topics in the same manner as in the development of hypothesized factor patterns, except for the slight modifications in topics made on the basis of the factor analysis results. Items were then randomly sampled within topics where such sampling was necessary. The revised topics and the items used to represent these in the analysis to follow appear in Table XXIV.

Hypothesis 2.1

As was pointed out in connection with the statement of this and the remaining hypotheses under consideration in the present section, these hypotheses have meaning only in the context of positive results for hypotheses 2.0 and 3.0. For the type of work variable, only the research and development group could be considered well defined and this only with respect to the electronics instrument. Hypothesis 2.1 was therefore concerned only with the comparison of research and development technicians with all others taken as a group, in terms of responses to the various electronics topics.

Because the research and development group contained only nine members, it was again necessary to resort to sampling procedures in order to avoid the problem of comparing two groups containing widely different numbers. Two samples, each of ten members, were drawn from the ninety-one technicians in areas of work other than research and development. The t statistic was used to compare these two samples

TABLE XXIV

SUMMARY OF TOPICS AND ITEMS

USED IN THE COMPARISON OF TOPICS AND GROUPS

Topic Number	Name	Items
	Physics	
I	Advanced Mechanics	107, 121, 124, 160, 162
II	Basic Mechanics	115, 116, 117, 119, 120
III	Atomic and Quantum Physics	104, 109, 110, 111, 161
IV	Gases, Kinetic Molecular Theory	132, 141, 143, 144, 149
V	Optics	134, 136, 137, 138, 159
VI	Heat and Thermodynamics	102, 103, 145, 146, 148
VII	Waves	101, 105, 135, 155, 156
VIII	Nuclear Physics	114, 150, 151, 152, 153
IX	Relativity	128, 131, 154, 158
	Electricity	
I	AC Circuits and Resonance	208, 210, 215
II	Capacitance	203, 222, 236
III	EM Waves	232, 233, 234
IV	Magnetic Field, Ferromagnetism	225, 227, 229
V	Inductors, Induced EMF	204, 205, 237
VI	Electric Field	217, 218, 220
VII	Maxwell's Equations	219, 235, 238
VIII	Network Analysis	202, 206
IX	Instrument Principles	213, 214
	Electronics	
I	Microwave	352, 353, 354, 362, 367
II	Vacuum Tube	301, 306, 311, 318, 319
III	Logic and Computer Circuits	341, 349, 350, 358, 361
IV	Radio Broadcast	307, 337, 338, 339, 370
V	Television	342, 343, 344, 351
VI	Transistor, Semiconductor	308, 315, 316, 317, 368
VII	Feedback	329, 330, 331, 365
VIII	Physical Electronics	303, 304, 305, 309, 310

with research and development technicians for each electronics topic. Results of these tests appear in Table XXV.

Because the samples used in these comparisons were drawn from a much more heterogeneous group than the research and development group itself, the assumption of homogeneity of variance was systematically violated. This violation is apparent from an examination of the standard deviations which, with one exception, are larger for the "others" samples than for the research and development group. Although the differences are in some cases insignificant, the Welch approximation to *t* is reported in all cases.

Results of these tests may be interpreted in a straightforward manner. Research and development technicians have significantly stronger requirements in the areas of logic circuits, transistors, and feedback than do technicians in other fields of work. In the opposite direction, requirements for knowledge of vacuum tubes are significantly less for research and development technicians than for others. Radio broadcast, television, physical electronics, and microwaves show no significant effects in these comparisons.

Hypothesis 2.2

Hypothesis 2.2 postulated no significant differences among topics for any groups isolated with respect to type of work. As for hypothesis 2.1, it is meaningful to test the present hypothesis only for the research and development group.

TABLE XXV

COMPARISON OF RESEARCH AND DEVELOPMENT TECHNICIANS

WITH ALL OTHERS FOR ELECTRONICS TOPICS

Topic	Sample	R and D Mean	R and D S.D.	Others Mean	Others S.D.	df*	t	P (two tail)
Microwave	A	2.71	.53	4.84	1.60	11.10	3.97	< .01
	B	2.71	.53	3.62	1.26	12.32	2.09	n.s.
Vacuum Tube	A	4.44	.48	5.16	.67	16.19	2.69	< .05
	B	4.44	.48	5.28	1.03	13.01	2.31	< .05
Logic Circuit	A	7.09	1.11	5.34	2.16	13.73	2.26	< .05
	B	7.09	1.11	4.70	1.91	14.67	3.37	< .05
Radio Broadcast	A	4.07	1.14	4.42	1.34	16.96	.62	n.s.
	B	4.07	1.14	4.62	1.61	16.18	.87	n.s.
Television	A	2.22	.64	3.10	1.67	11.82	1.54	n.s.
	B	2.22	.64	3.52	1.82	11.40	2.12	n.s.
Transistor	A	6.58	.48	5.34	1.17	12.17	3.08	< .01
	B	6.58	.48	5.60	1.19	12.05	2.39	< .05
Feedback	A	6.69	1.14	5.45	.97	15.81	2.55	< .05
	B	6.69	1.14	5.42	1.43	16.78	2.15	< .05
Physical Electronics	A	5.00	1.36	4.64	1.35	16.78	.58	n.s.
	B	5.00	1.36	5.02	1.67	16.85	.03	n.s.

*Adjusted for nonhomogeniety of variance by Welch method

Because all topics were analyzed with respect to the same group of individuals, topic effects were not necessarily independent. The analysis of variance was thus of the repeated measures type. Results of this analysis are presented in Table XXVI. It is clear that the null hypothesis must be rejected in view of the probability associated with the F ratio.

In order to develop a more detailed view of electronics requirements for research and development technicians, a posteriori tests were conducted on all pairs of topic means for this group. Table XXVII gives the means, differences between means, and the level of significance associated with these differences, as determined by the Newman-Keuls procedure.

It is apparent from Table XXVII that the topics may generally be grouped into three clusters with significant differences across clusters but no such differences among topics within clusters. At the high end of the scale are the topics of transistors, feedback, and logic circuits, which do not differ among themselves but which differ beyond the .01 level of significance from all other topics. Similarly, the radio broadcast, vacuum tube, and physical electronics topics may be considered as forming a cluster, each of these topics in fact having a mean which is close to the mean of the sort as a whole. At the opposite extreme are the television and microwave topics. These do not differ from each other but both have significantly lower means than all other topics.

TABLE XXVI

SUMMARY OF ANALYSIS OF VARIANCE FOR ELECTRONICS TOPICS, RESEARCH AND DEVELOPMENT GROUP

Source of Variation	SS	df	MS	F	P
Between People	1.46	8	.18		
Within People	273.02	63	4.33		
Topics	213.12	7	30.44	28.47	< .001
Residual	59.89	56	1.07		
Total	274.49	71			

TABLE XXVII

NEWMAN-KEULS COMPARISONS BETWEEN ORDERED MEANS,

ELECTRONICS TOPICS, RESEARCH AND DEVELOPMENT GROUP

Group		Tele-vision	Micro-wave	Radio Broadcast	Vacuum Tube	Physical Elect.	Trans-istor	Feedback	Logic Circuits
	Means	2.22	2.71	4.07	4.44	5.00	6.58	6.69	7.09
Television	2.22		.49	1.85**	2.22**	2.78**	4.36**	4.47**	4.87**
Microwave	2.71			1.36*	1.73**	2.29**	3.87**	3.98**	4.38**
Radio	4.07				.37	.93	2.51**	2.62**	3.02**
Vacuum Tube	4.44					.56	2.14**	2.25**	2.65**
Physical Elect.	5.00						1.58**	1.69**	2.09**
Transistor	6.58							.11	.51
Feedback	6.69								.40
Logic Circuits	7.09								

*Significant at .05 level

**Significant at .01 level

<u>Hypothesis 3.1</u>

In the examination of hypothesis 3.0, the following groups were isolated on the basis of the classification of respondents by type of equipment:

Electricity Sort

Broadcast technicians

Electronics Sort

Broadcast technicians

Communications technicians

Navigational aids technicians

Computer technicians

For each instrument, respondents not falling into any of the above well defined groups were classified under an "others" category. Although these individuals did not form a homogeneous group in the sense of the correlational analysis, it was necessary to include these in the present more specific analysis since the subject matter requirements of these technicians must be taken into account in curriculum planning. The only difficulty in including the others category in the analysis involves the possible violation of the homogeneity of variance assumptions underlying the various statistical tests. Because sampling was conducted to give an approximately equal number of persons in each group under comparison, this violation is not a serious matter.

Hypothesis 3.1 was concerned with the comparison of the above groups for each separate topic. For the electricity instrument the analysis involved simply the comparison of broadcast technicians with all others taken as a group. For the electronics sort five groups, including the "others" category, were involved in the analysis.

Electricity sort. Since the broadcast category contained only six individuals, a test of differences between means based on this number and on the remaining ninety-four individuals was not realistic. Following the practice already established, two samples, each of ten members, were drawn at random from the "others" group. Table XXVIII gives means, standard deviations, and t tests for the required comparisions. Again the values of t and the number of degrees of freedom are adjusted for nonhomogeneity of variance. The null hypothesis can be rejected only for the instrument principles topic, with broadcast technicians rating this topic significantly lower than others.

Electronics sort. Table XXIX gives the mean values for each electronics topic for each of the five type of equipment groups relevant to the electronics sort. It would appear that a complete analysis of differences between these means would involve a two way analysis of variance design, testing both group and topic effects as well as the possibility of interaction. The nature of the forced sort, however, implies that the means of columns of Table XXIX should all be equal to 5.0, the only departure from this value being due to the sampling of items in defining the topics. Thus no overall group effect could be observed. The analysis thus reduced to a series of one way analysis of variance designs. Hypothesis 3.1 was examined by an analysis of variance for each topic over all groups; that is,

TABLE XXVIII

COMPARISON OF BROADCAST TECHNICIANS

WITH ALL OTHERS, ELECTRICITY TOPICS

Topic	Sample	Broadcast Mean	Broadcast S.D.	Others Mean	Others S.D.	df*	t	P Two Tail
AC Circuits Resonance	A	6.22	.46	5.30	1.24	12.38	2.12	n.s.
	B	6.22	.46	5.13	1.32	12.08	2.38	<.05
Capacitance	A	6.17	.74	7.10	1.27	14.00	1.85	n.s.
	B	6.17	.74	6.57	1.01	13.26	.91	n.s.
EM Waves	A	4.05	1.41	3.73	1.22	9.44	.46	n.s.
	B	4.05	1.41	4.07	1.65	12.09	.02	n.s.
Magnetic Field	A	3.28	.83	3.80	.67	8.94	1.31	n.s.
	B	3.28	.83	2.87	.75	9.79	1.00	n.s.
Inductors	A	6.55	.37	6.33	.76	13.67	.78	n.s.
	B	6.55	.37	6.53	.97	12.57	.07	n.s.
Electric Field	A	3.28	.59	3.53	.70	12.20	.78	n.s.
	B	3.28	.59	4.10	.87	13.64	2.25	n.s.
Maxwell's Equations	A	3.28	.97	2.53	1.17	12.28	1.38	n.s.
	B	3.28	.97	3.47	1.13	11.99	.35	n.s.
Network Analysis	A	4.92	1.13	6.25	1.81	13.91	1.81	n.s.
	B	4.92	1.13	5.70	1.29	11.81	1.27	n.s.
Instrument Principles	A	4.67	.85	6.35	1.21	13.46	3.27	<.01
	B	4.67	.85	6.20	1.29	13.76	2.87	<.05

*Adjusted for nonhomogeniety of variance by Welch method

TABLE XXIX

ELECTRONICS TOPIC MEANS FOR EACH TYPE OF EQUIPMENT GROUP

Topic	Broadcast	Communi-cations	Group Nav. Aids	Computers	Others
Microwave	3.10	5.29	5.60	2.79	3.43
Vacuum Tube	4.90	5.31	5.32	5.06	5.03
Logic and Computer Circuits	4.13	3.26	4.32	8.00	5.99
Radio Broadcast	5.70	6.14	4.83	3.48	4.23
Television	7.41	3.96	2.18	2.92	3.06
Transistor	5.47	4.74	5.19	6.33	6.34
Feedback	4.88	5.32	5.25	5.35	6.18
Physical Electronics	4.03	4.71	4.24	5.92	4.84

a separate analysis for each row of Table XXIX.

Once again, because of wide disparities in the size of groups, it was necessary to invoke the sampling process. In this case the aim was to reduce all sample sizes to a number reasonably close to the number of persons in the broadcast and communications groups. Samples of ten members each were thus drawn from each of the other groups. In the case of the computers and others groups, the total group size was sufficiently large to permit replication. Two samples were therefore chosen for each of these groups, giving a total of seven groups to be compared.

Results of the analysis of variance are presented in Table XXX. The hypothesis of no significant differences among groups must be rejected for all except the vacuum tube topic.

In view of the significant overall group differences, it is evident that a more detailed examination of these differences is warranted. Table XXXI therefore presents the differences between all pairs of means for each topic and the level of significance associated with these differences, according to the Newman-Keuls method. A brief discussion of the salient features of these comparisons follows.

For the microwave topic the interpretation is straightforward. The communications and navigational aids groups are distinct from all others, most comparisons being significant beyond the .01 level.

Results for logic circuits are slightly more complicated, with three distinct sets of differences occurring. Communications,

TABLE XXX

SUMMARY OF ANALYSIS OF VARIANCE

FOR ELECTRONICS TOPICS OVER TYPE OF EQUIPMENT GROUPS

Topic	Source of Variation	SS	df	MS	F	P
Microwave	Groups	102.87	6	17.15	9.90	<.001
	Error	97.00	56	1.73		
Vacuum Tube	Groups	1.30	6	.22	.16	n.s.
	Error	73.66	56	1.32		
Logic Circuits	Groups	180.86	6	30.14	20.02	<.001
	Error	84.33	56	1.51		
Radio Broadcast	Groups	55.58	6	9.26	7.68	<.001
	Error	67.56	56	1.21		
Television	Groups	136.33	6	22.72	15.96	<.001
	Error	79.70	56	1.42		
Transistor	Groups	28.47	6	4.74	3.87	<.01
	Error	68.74	56	1.23		
Feedback	Groups	22.96	6	3.83	3.14	<.01
	Error	68.33	56	1.22		
Physical Electronics	Groups	25.99	6	4.33	3.94	<.01
	Error	61.57	56	1.10		

TABLE XXXI

NEWMAN-KEULS COMPARISONS BETWEEN ORDERED MEANS OF GROUPS

FOR SEVEN ELECTRONICS TOPICS

Microwave

Groups	Means	Computers B	Others B	Computers A	Broadcast	Others A	Communi-cations	Nav. Aids
		2.64	2.82	3.06	3.10	3.64	5.28	6.16
Computers B	2.64		.18	.42	.46	1.00	2.64**	3.52**
Others B	2.82			.24	.28	.82	2.46**	3.34**
Computers A	3.06				.04	.58	2.22**	3.10**
Broadcast	3.10					.54	2.18**	3.06**
Others A	3.64						1.64*	2.52**
Communications	5.28							.88
Nav. Aids	6.16							

Logic Circuits

Groups	Means	Communi-cations	Broadcast	Nav. Aids	Others A	Others B	Computers B	Computers A
		3.26	4.13	4.40	5.94	6.58	7.78	8.16
Communications	3.26		.87	1.14	2.68**	3.32**	4.52**	4.90**
Broadcast	4.13			.27	1.81**	2.45**	3.65**	4.03**
Nav. Aids	4.40				1.54*	2.18**	3.38**	3.76**
Others A	5.94					.64	1.84**	2.22**
Others B	6.58						1.20*	1.58*
Computers B	7.78							.38
Computers A	8.16							

Radio Broadcast

Groups	Means	Computers B	Others B	Computers A	Others A	Nav. Aids	Broadcast	Communi-cations
		3.14	3.68	3.84	4.32	4.56	5.70	6.14
Computers B	3.14		.54	.70	1.18	1.42	2.56**	3.00**
Others B	3.68			.16	.64	.88	2.02**	2.46**
Computers A	3.84				.48	.72	1.86**	2.30**
Others A	4.32					.24	1.38*	1.82**
Nav. Aids	4.56						1.14*	1.58**
Broadcast	5.70							.44
Communications	6.14							

Television

Groups	Means	Nav. Aids	Others B	Computers A	Computers B	Others A	Communi-cations	Broadcast
		2.05	2.08	3.10	3.13	3.15	3.96	7.42
Nav. Aids	2.05		.03	1.05	1.08	1.10	1.91*	5.37**
Others B	2.08			1.02	1.05	1.07	1.88*	5.34**
Computers A	3.10				.03	.05	.86	4.32**
Computers B	3.12					.03	.84	4.30**
Others A	3.15						.81	4.27**
Communications	3.96							3.45**
Broadcast	7.42							

Transistor

Groups	Means	Communi-cations	Nav. Aids	Broadcast	Computers B	Others A	Computers A	Others B
		4.74	5.30	5.47	6.14	6.50	6.54	6.72
Communications	4.74		.56	.72	1.40	1.76*	1.80*	1.98*
Nav. Aids	5.30			.17	.84	1.20	1.24	1.42
Broadcast	5.47				.67	1.03	1.07	1.25
Computers B	6.14					.36	.40	.58
Others A	6.50						.04	.22
Computers A	6.54							.18
Others B	6.72							

Feedback

Groups	Means	Broadcast	Computers A	Nav. Aids	Communi-cations	Computers B	Others A	Others B
		4.88	5.08	5.25	5.32	5.68	5.75	6.83
Broadcast	4.88		.20	.38	.44	.80	.87	1.95*
Computers A	5.08			.17	.24	.60	.67	1.75*
Nav. Aids	5.25				.07	.43	.50	1.58*
Communications	5.32					.35	.43	1.50*
Computers B	5.68						.07	1.15
Others A	5.75							1.08
Others B	6.83							

Physical Electronics

Groups	Means	Broadcast	Nav. Aids	Communi-cations	Others B	Others A	Computers A	Computers B
		4.03	4.42	4.71	5.04	5.38	5.58	6.12
Broadcast	4.03		.39	.68	1.01	1.35	1.55*	2.09**
Nav. Aids	4.42			.29	.62	.96	1.16	1.70*
Communications	4.71				.33	.67	.87	1.41
Others B	5.04					.34	.54	1.08
Others A	5.38						.20	.74
Computers A	5.58							.54
Computers B	6.12							

*Significant at .05 level
**Significant at .01 level

navigational aids, and broadcast appear to cluster together at the lower end of the scale. At a somewhat higher level are the others groups, while the computers groups form a third level. For computers and others, the A and B samples differ only insignificantly. Both samples are,however, different from other groups.

For the radio broadcast topic the broadcast and communications groups have significantly higher means than do any other groups. The remaining groups form a cluster in the sense that no significant differences appear between any of these groups.

In the case of the television topic, the broadcast group shows a mean that is clearly different from those for all other groups, all comparisons being significant beyond the .01 level. The communications group appears as significantly different from navigational aids and from others sample B. This latter mean of 2.08 is, however, somewhat lower than the mean of 3.06 for the total others group as shown in Table XXIX. Since the mean of 3.15 for others A is closer to the overall others mean, and since this is not significantly different from the communications mean, it is concluded that the significant result for others B was due to sampling error and may be disregarded.

For the remaining three topics the differences were not as extreme, as indicated by the size of the overall F ratios for these topics. Furthermore, the situation is made somewhat more complex by sampling errors which, for example, result in the computer A sample showing a significant effect, while no such effect exists for the computer B sample in the case of the transistor topic. Combining the two computer samples for this topic gives a computer mean of 6.29 which, according to the Scheffé test, is not significantly different from the mean of 4.74 for communications. The others A and B samples are, however, both significantly different from communications. The significant overall F ratio is therefore attributed solely to the difference between communications and the others group.

A similar situation prevails for both the feedback and physical electronics topics. In the case of feedback, the combined mean of 6.29 for the others samples was found to be not significantly different from that for broadcast. The significant overall F ratio must therefore be attributed to sampling error for the groups which were replicated. For the physical electronics topic both computer samples show significant effects so that the significance of the F ratio is a function of the difference between computers and broadcast.

In summary, it is clear that highly significant differences among the groups exist for the four specialized topics of microwave, logic circuits, radio broadcast, and television. For the transistor and physical electronics topics differences occur only between the groups at opposite extremes of the sequence of means. The feedback topic gives a significant overall F ratio but closer examination reveals that this effect must be attributed to sampling error in the replication process. Means for all groups for the vacuum tube topic are almost precisely the same. These means are approximately coincident with the mean of the sort as a whole.

Hypothesis 3.2

This hypothesis was concerned with the same group and topics as for hypothesis 3.1. In this case, however, the null hypothesis was with respect to differences between topics for each group. In terms of Table XXIX, the analysis involved a comparison of means presented in each column of that table. Again in addition to the testing of overall topic differences, a posteriori tests were conducted on all pairs of means for each group showing a significant overall effect.

Electricity sort. Table XXXII presents the summary of analysis of variance over all electricity topics for the broadcast group. In view of the highly significant F ratio, the null hypothesis is rejected. The second stage of the analysis was thus carried out, with the results appearing in Table XXXIII.

In this case a reasonably clear division into two clusters of topics is apparent. The three topics of inductors, AC circuits, and capacitance form a cluster with mean ratings significantly higher than those for the remaining six topics. The general tendency in these comparisons appears to relate to the division of electricity into field theory and circuit applications. Topics of most direct relevance to circuits received distinctly higher means than others. At the lower end of the scale are the three topics most directly related to field theory. The three intermediate topics may be regarded as forming a transition between the two major categories.

TABLE XXXII

SUMMARY OF ANALYSIS OF VARIANCE OVER ELECTRICITY TOPICS, BROADCAST TECHNICIANS

Source of Variation	SS	df	MS	F	P
Between People	1.64	5	.33		
Within People	126.08	48	2.63		
Topics	86.57	8	10.82	10.96	<.001
Residual	39.51	40	.99		
Total	127.72	53			

TABLE XXXIII

NEWMAN-KEULS COMPARISONS BETWEEN ORDERED MEANS,

ELECTRICITY TOPICS, BROADCAST TECHNICIANS

Topics	Means	Magnetic Field	Electric Field	Maxwell's Eqns.	EM Waves	Instru-ment	Network Analysis	Capac-itance	AC Circuits	Induc-tors
	Means	3.28	3.28	3.28	4.05	4.67	4.92	6.17	6.22	6.56
Magnetic Field	3.28		.00	.00	.77	1.39	1.64	2.89**	2.94**	3.28**
Electric Field	3.28			.00	.77	1.39	1.64	2.89**	2.94**	3.28**
Maxwell's Eqns.	3.28				.77	1.39	1.64	2.89**	2.94**	3.28**
EM Waves	4.05					.62	.87	2.12**	2.17**	2.51**
Instrument	4.67						.25	1.50*	1.55*	1.89*
Network Anal.	4.92							1.25*	1.30*	1.64*
Capacitance	6.17								.05	.49
AC Circuits	6.22									.44
Inductors	6.56									

*Significant at .05 level
**Significant at .01 level

In terms of the present comparisons, however, these three topics belong in the lower cluster.

Electronics sort. Table XXXIV presents the summary of analysis of variance for each group over the eight electronics topics. The null hypothesis is rejected at the .05 level for all except the communications group. The result for communications might be expected in view of the relative lack of agreement among members of this group as determined by the correlational analysis of the preceding section. This group was considered well defined on the basis of lack of between-group agreement rather than on the basis of strong within-group agreement. For the remaining groups, Newman-Keuls comparisions between ordered means appear in Table XXXV.

It is clear that for the broadcast group the television topic stands out as having a significantly higher mean than any of the remaining topics. The transistor and radio broadcast topics are significantly different only from microwave at the extreme low end of the scale.

For the navigational aids group, the television topic at the low end of the scale is significantly different from all other topics. The microwave topic has the highest mean but this mean is significantly different only from the means for the three lowest topics.

The computer group presents a somewhat more complex picture. Logic circuits appears clearly as a distinct topic, all comparisons being significant beyond the .01 level. The transistor and physical electronics topics have somewhat lower means than does logic circuits

TABLE XXXIV

SUMMARY OF ANALYSIS OF VARIANCE

FOR TYPE OF EQUIPMENT GROUPS OVER ELECTRONICS TOPICS

Group	Source of Variation	SS	df	MS	F	P
Broadcast	Between People	1.58	5	.32		
	Within People	122.35	42	2.91		
	Topics	71.11	7	10.16	6.94	<.001
	Residual	51.24	35	1.46		
	Total	123.93	47			
Communi-cations	Between People	1.43	6	.24		
	Within People	148.38	49	3.03		
	Topics	39.55	7	5.65	2.18	n.s.
	Residual	108.82	42	2.59		
	Total	149.81	55			
Nav. Aids	Between People	3.39	14	.24		
	Within People	237.07	105	2.26		
	Topics	125.75	7	17.96	15.82	<.001
	Residual	111.32	98	1.14		
	Total	240.46	119			
Computers	Between People	6.27	24	.26		
	Within People	738.22	175	4.22		
	Topics	581.16	7	83.02	88.80	<.001
	Residual	157.06	168	.93		
	Total	744.49	199			
Others	Between People	18.51	46	.40		
	Within People	1124.62	329	3.42		
	Topics	512.92	7	73.27	38.57	<.001
	Residual	611.70	322	1.90		
	Total	1143.13	375			

TABLE XXXV

NEWMAN-KEULS COMPARISONS BETWEEN ORDERED MEANS OF ELECTRONICS TOPICS

FOR FOUR TYPE OF EQUIPMENT GROUPS

Broadcast

Topics	Means	Microwave	Physical Elect.	Logic Circuits	Feedback	Vacuum Tube	Transistor	Radio Broadcast	Television
		3.10	4.03	4.13	4.88	4.90	5.47	5.70	7.41
Microwave	3.10		.93	1.03	1.78	1.80	2.37*	2.60*	4.31**
Physical	4.03			.10	.85	.87	1.44	1.67	3.38**
Logic Circuits	4.13				.75	.77	1.43	1.57	3.28**
Feedback	4.88					.02	.59	.82	2.53**
Vacuum Tube	4.90						.57	.80	2.51**
Transistor	5.47							.23	1.94*
Radio	5.70								1.71*
Television	7.41								

Nav. Aids

Topics	Means	Television	Physical Elect.	Logic Circuits	Radio Broadcast	Transistor	Feedback	Vacuum Tube	Microwave
		2.18	4.24	4.32	4.83	5.19	5.25	5.32	5.60
Television	2.18		2.06**	2.14**	2.65**	3.01**	3.07**	3.14**	3.32**
Physical	4.24			.08	.59	.95	1.01	1.08	1.36*
Logic Circuits	4.32				.51	.87	.93	1.00	1.28*
Radio	4.83					.36	.42	.49	.77
Transistor	5.19						.06	.13	.41
Feedback	5.25							.07	.35
Vacuum Tube	5.32								.28
Microwave	5.60								

Computers

Topics	Means	Microwave	Television	Radio Broadcast	Vacuum Tube	Feedback	Physical Elect.	Transistor	Logic Circuits
		2.79	2.92	3.48	5.06	5.35	5.92	6.33	8.00
Microwave	2.79		.13	.69*	2.27**	2.56**	3.13**	3.54**	5.21**
Television	2.92			.56*	2.14**	2.43**	3.00**	3.41**	5.08**
Radio	3.48				1.58**	1.87**	2.44**	2.85**	4.52**
Vacuum Tube	5.06					.29	.86**	1.27**	2.94**
Feedback	5.35						.57*	.98**	2.65**
Physical	5.92							.41	2.08**
Transistor	6.33								1.67**
Logic Circuits	8.00								

Others

Topics	Means	Television	Microwave	Radio Broadcast	Physical Elect.	Vacuum Tube	Logic Circuits	Feedback	Transistor
		3.06	3.43	4.23	4.84	5.03	5.99	6.18	6.34
Television	3.06		.37	1.17**	1.78**	1.97**	2.93**	3.12**	3.28**
Microwave	3.43			.80**	1.41**	1.60**	2.56**	2.75**	2.91**
Radio	4.23				.61*	.80*	1.76**	1.95**	2.11**
Physical	4.84					.19	1.15**	1.34**	1.50**
Vacuum Tube	5.03						.96**	1.15**	1.31**
Logic Circuits	5.99							.19	.35
Feedback	6.18								.17
Transistor	6.34								

*Significant at .05 level
**Significant at .01 level

but these means are nevertheless significantly higher than those for the remaining topics. Similarly the feedback and vacuum tube topics group together. Radio broadcast is an isolated topic having a rather low mean but one which is nevertheless significantly greater than the means for television and microwave.

For the others group, the three topics having the largest means may be regarded as forming a cluster since these means differ significantly from all others. Physical electronics and vacuum tubes may also be regarded as forming a group with mean close to the mean of the sort as a whole. Again radio broadcast is an isolated topic. Television and microwave appear at the low end of the scale, with only slightly different means both of which, however, are significantly lower than any of the remaining means.

Considering these comparisons more broadly, it is apparent that, with the exception of the others group, the topic with the largest mean is a specialized topic which would tend to be associated with the group identified. Near the lower end of the scale in each case appear the remaining specialized topics. Generally speaking, the topics which may be considered as forming basic electronics appear near the middle of the range of means. The exception is the others group for which basic electronics topics tend to show larger means than any of the specialized topics. This result might be anticipated in view of the fact that the others group was relatively heterogeneous, with no area of specialization being predominant. The appearance of the logic circuits topic among basic electronics topics for the others group is evidence of the pervasiveness of this topic throughout many areas of electronics.

Further Considerations

In the case of the physics and electricity sorts, the investigation of dimensionality did not generally lead to the identification of meaningful factors either in support or in contradiction of the hypothesized topics. The question remained, however, whether this could be attributed to a high degree of randomness in these sorts or to the existence of relatively close agreement among all respondents on the placement of items. The latter situation would imply, for example, that all items in a given topic could cluster near a particular point of the scale for all respondents, while items of another topic could form a cluster near another point. Under such conditions, items within topics need not correlate among themselves more highly than the correlations between pairs of items coming from different topics. This is in contrast to the situation in which items within topics might be placed at widely different points of the scale by different individuals or groups, while nevertheless tending to form a cluster regardless of the part of the scale to which they were assigned.

The failure to isolate significant groups for the physics and electricity sorts gave some credence to the hypothesis of approximately equal agreement over all respondents, at least in the sense that no major systematic departures form the overall degree of agreement were detected. The relative unreliability of these sorts, however, seemed to support the hypothesis of a good deal of randomness in the sorts.[4] On the basis that both the sort-resort correlations and the correlations between respondents were generally significantly greater than zero, it was concluded that an overall examination of topic effects was warranted. It is emphasized, however, that although the factor analysis results were used to make minor modifications in physics and electricity topics, these topics do not have the status of factors as was the case for the electronics sort.

Topic means over all respondents for the physics and electricity sorts appear in Table XXXVI. Table XXXVII presents the summary of analysis of variance for comparisons of these means. Results of this analysis strongly support the hypothesis of significant differences between topics. More specific comparisons of topic means are shown in Table XXXVIII.

For the physics sort the waves topic has a distinctly higher mean than does any other topic. The next five topics have means which are insignificantly different from each other but which do differ significantly from the mean for waves at the high end of the scale and from the means for the three topics at the opposite extreme. The latter three topics, advanced mechanics, kinetic theory, and

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[4]Cf. Table I, p. 77.

TABLE XXXVI

MEANS OVER ALL PERSONS FOR PHYSICS AND ELECTRICITY TOPICS

Topic Number	Physics		Electricity	
	Topic	Mean	Topic	Mean
I	Advanced Mechanics	3.87	AC Circuits and Resonance	5.43
II	Basic Mechanics	5.06	Capacitance	6.80
III	Atomic and Quantum Physics	5.26	Electromagnetic Waves	3.89
IV	Gases, Kinetic Molecular Theory	4.30	Magnetic Field, Ferromagnetism	3.91
V	Optics	5.26	Inductors, Induced EMF	6.41
VI	Heat and Thermodynamics	5.08	Electric Field	3.86
VII	Waves	6.78	Maxwell's Equations	3.07
VIII	Nuclear Physics	5.42	Network Analysis	5.20
IX	Relativity	4.63	Instrument Principles	6.21

TABLE XXXVII

SUMMARY OF ANALYSIS OF VARIANCE

PHYSICS AND ELECTRICITY TOPICS, ALL TECHNICIANS

Source of Variation	SS	df	MS	F	P
		Physics			
Between People	28.71	99	.29		
Within People	1514.09	800	1.89		
Topics	535.95	8	66.99	54.25	<.001
Residual	978.14	792	1.24		
Total	1542.81	899			
		Electricity			
Between People	46.62	99	.47		
Within People	2855.86	800	3.57		
Topics	1435.02	8	179.38	99.99	<.001
Residual	1420.84	792	1.79		
Total	2902.48	899			

TABLE XXXVIII

NEWMAN-KEULS COMPARISONS BETWEEN ORDERED MEANS, PHYSICS AND ELECTRICITY TOPICS

Topics	Means	Adv. Mech.	Kinetic Theory	Relativity	Basic Mech.	Heat	Optics	Atomic	Nuclear	Waves
		Physics								
	Means	3.87	4.30	4.63	5.06	5.08	5.26	5.26	5.42	6.78
Adv. Mechanics	3.87		.43*	.76**	1.19**	1.21**	1.39**	1.39**	1.55**	2.91**
Kinetic Theory	4.30			.33*	.76**	.87**	.96**	.96**	1.12**	2.48**
Relativity	4.63				.43*	.45*	.63**	.63**	.79**	2.15**
Basic Mechanics	5.06					.02	.20	.20	.36	1.72**
Heat	5.08						.18	.18	.34	1.70**
Optics	5.26							.00	.16	1.52**
Atomic Physics	5.26								.16	1.52**
Nuclear Physics	5.42									1.36
Waves	6.78									

Topics	Means	Maxwell's Eqns.	Electric Field	EM Waves	Magnetic Field	Network Anal.	AC Circuits	Instrument	Inductors	Capacitance
		Electricity								
	Means	3.07	3.86	3.89	3.91	5.20	5.43	6.21	6.41	6.80
Maxwell's Eqns.	3.07		.79*	.82**	.84**	2.13**	2.36**	3.14**	3.34**	3.73**
Electric Field	3.86			.03	.05	1.34**	1.57**	2.35**	2.55**	2.94**
EM Waves	3.89				.02	1.31**	1.54**	2.32**	2.52**	2.91**
Magnetic Field	3.91					1.29**	1.52**	2.30**	2.50**	2.89**
Network Anal.	5.20						.23	1.01**	1.21**	1.60**
AC Circuits	5.43							.78**	.98**	1.37**
Instrument	6.21								.20	.59**
Inductors	6.41									.39*
Capacitance	6.80									

*Significant at .05 level
**Significant at .01 level

relativity are all significantly different from each other and from all remaining topics.

In the case of electricity the differences are even more extreme. Significant differences appear between nearly all pairs of topics. The only notable cluster is formed by the three topics of electric fields, electromagnetic waves, and magnetic fields. The nonsignificant difference between AC circuits and network analysis is also worthy of note. As for the previous analysis involving broadcast technicians only, a strong tendency exists for topics involving applications to have higher means than theoretical topics. In this case, however, many significant differences exist even within the two major divisions.

An interesting comparison between the physics and electricity sorts as a whole is evident from Table XXXVIII. The waves topic, some items of which relate to electromagnetic waves, is at the extreme high end of the physics scale, while the electromagnetic waves topic of the electricity sort appears relatively low on the electricity scale. This may be interpreted as implying that the two scales are not coincident but form a continuum with perhaps some slight overlap between the upper end of the physics scale and the lower end of the electricity scale.

Summary

Detailed analysis was conducted for those groups, based on the primary classification variables, which were isolated in the preceding section. The basic two way classification by groups and topics was reduced to a series of single factor designs, comparing topics for each group and comparing groups for each separate topic. In addition to the analysis of variance for determining overall group and topic effects, specific comparison of pairs of means was made using the Newman-Keuls procedure. For the physics and electricity sorts, topic comparisons over the total sample were made because of the general lack of differences between groups for these subjects.

For electronics, the broadcast and computer groups indicated strong requirements for the television and logic circuits topics respectively. These topics bear an obvious relation to these two areas of specialization. The navigational aids group was characterized by moderate mean values for all topics except television, which had a significantly lower mean than others. The communications group showed no significant topic effects. In general it was found that specialized topics other than those directly related to particular types of equipment tended to receive relatively low means for the type of equipment concerned. Means for topics which might be considered as constituting basic electronics tended to be below the means for specialized topics related to a particular group but higher than unrelated specialized topics. Exceptions were for the research and development group in type of work and the others category in type of equipment, which tended to rate general electronics more highly than specialized topics.

For the physics and electricity sorts a large number of significant comparisons appeared. In the case of physics the most notable result was the position occupied by the waves topic, this topic having a mean which was significantly higher than the mean for any other topic. The five topics of basic mechanics, heat, optics, atomic physics, and nuclear physics formed a cluster having means near the mid point of the scale. The order in which these topics appeared indicated a tendency towards higher mean ratings for modern physics topics. As might be expected, advanced mechanics, kinetic theory, and relativity all received significantly lower mean ratings than did other topics.

The tendency in the electricity sort was towards higher means for applied topics. Significant differences, however, occurred between nearly all topics. An important exception was the apparent clustering of three topics relating to field theory, these topics receiving relatively low means.

IV FURTHER ANALYSIS

Instructor Responses

Hypothesis 11.0. The examination of this hypothesis required an overall analysis of the extent to which instructors agreed among themselves as compared to the extent of agreement between instructors and technicians. The correlational approach used in the earlier identification of groups was judged appropriate for this analysis.

intercorrelations among instructors and between instructors and technicians were therefore computed, converted to Fisher Z scores, and the resulting mean values of Z compared by means of the *t* statistic. Results of this analysis appear in Table XXXIX. The hypothesis of no overall differences between instructors and technicians is rejected with respect to the electricity and electronics sorts. For the physics sort the null hypothesis is accepted.

Hypothesis 11.1. The null hypothesis in this case postulated no differences between instructors and technicians on the basis of specific topics within each sort. Results for hypothesis 11.0 indicate that instructors form a well defined group with respect to the electricity and electronics instruments. Topic comparisons were thus conducted only for these sorts. Means, standard deviations, and *t* tests for instructors and two technician samples for these two sorts appear in Table XL.

It is apparent from Table XL that overall differences between instructors and technicians for the electricity instrument may be accounted for on the basis of significant differences for three topics. The capacitance and instrument principles topics were rated significantly lower by instructors than by technicians, while the network analysis topic was considered more important by instructors. It is observed that the general tendency to rate application topics more highly than theoretical topics held true for instructors as well

TABLE XXXIX

COMPARISON OF MEAN VALUES OF FISHER Z
BASED ON INSTRUCTOR WITHIN-GROUP
AND INSTRUCTOR-TECHNICIAN BETWEEN-GROUP CORRELATIONS

Sort	Sample	Within-Group Mean	Within-Group S.D.	Between-Group Mean	Between-Group S.D.	df	t	P (one tail)
Physics	A	.43	.28	.35	.30	70	1.09	n.s.
	B	.53	.25	.35	.31	58	2.32	<.05
Electricity	A	.43	.29	.32	.26	70	1.65	.05
	B	.40	.33	.25	.33	58	1.77	<.05
Electronics	A	.37	.17	.24	.16	70	3.34	<.001
	B	.35	.21	.23	.22	58	2.14	<.05

TABLE XL

INSTRUCTOR-TECHNICIAN COMPARISONS BY TOPICS, ELECTRICITY AND ELECTRONICS

Topic	Sample	Instructors Mean	Instructors S.D.	Technicians Mean	Technicians S.D.	t	p* (two tail)
Electricity							
AC Circuits	A	5.52	1.05	5.50	1.61	.05	n.s.
	B	5.52	1.05	5.38	1.08	.34	n.s.
Capacitance	A	5.86	1.10	6.95	1.01	-2.65	< .01
	B	5.86	1.10	6.86	1.19	-2.23	< .05
EM Waves	A	3.91	1.21	4.19	1.85	-.46	n.s.
	B	3.91	1.21	3.57	1.52	.62	n.s.
Magnetic Field	A	3.74	.88	4.00	1.21	-.63	n.s.
	B	3.74	.88	3.62	1.51	.25	n.s.
Inductors	A	6.45	1.02	6.38	1.06	.18	n.s.
	B	6.45	1.02	6.64	1.05	-.47	n.s.
Electric Field	A	4.45	2.08	4.10	1.09	.55	n.s.
	B	4.45	2.08	4.60	1.26	.21	n.s.
Maxwell's Equations	A	3.09	1.30	2.69	1.21	.82	n.s.
	B	3.09	1.30	3.14	1.00	-.11	n.s.
Network Analysis	A	6.75	1.86	4.79	1.59	2.90	< .01
	B	6.75	1.86	5.32	1.41	2.21	< .05
Instrument Principles	A	4.75	1.71	6.04	1.43	-2.08	< .05
	B	4.75	1.71	6.29	1.29	-2.59	< .05
Electronics							
Microwave	A	3.89	1.30	4.54	1.82	-1.06	n.s.
	B	3.89	1.30	3.74	1.42	.27	n.s.
Vacuum Tube	A	5.97	1.11	5.26	.66	2.00	n.s.
	B	5.97	1.11	5.16	1.17	1.82	n.s.
Logic Circuits	A	4.19	.93	5.30	2.07	-1.77	n.s.
	B	4.19	.93	5.50	2.20	-1.98	n.s.
Radio Broadcast	A	4.70	.42	4.64	1.60	.12	n.s.
	B	4.70	.42	4.49	1.28	.57	n.s.
Television	A	3.29	1.60	2.62	1.15	1.20	n.s.
	B	3.29	1.60	3.04	1.62	.40	n.s.
Transistor	A	6.34	1.02	5.29	1.08	2.57	< .05
	B	6.34	1.02	6.00	1.05	.85	n.s.
Feedback	A	5.84	1.00	5.41	1.17	1.01	n.s.
	B	5.84	1.00	6.16	.97	-.83	n.s.
Physical Electronics	A	6.83	1.22	5.24	1.37	3.12	< .01
	B	6.83	1.22	5.26	.87	3.79	< .001

*Degrees of freedom = 26

as for technicians.

For the electronics sort, significant differences occur only for the physical electronics topic, with instructors assigning a much higher mean to this topic than did technicians. It must be pointed out that topic means computed over all technicians for the electronics sort have less meaning than those for the other sorts, in view of the wide differences in topic means for different type of equipment classifications. With respect to the physical electronics group, all groups identified on the basis of type of equipment rate this topic below the mean for the sort as a whole. This tends to support the view that the significant effect observed in the present comparison is a meaningful one, and that instructors do in fact consider physical electronics more important than do technicians.

Hypothesis 11.2. Instructor means for all topics in the three sorts are summarized in Table XLI. Hypothesis 11.2 postulated no significant differences between topics within each sort on the basis of instructor responses. Since instructors were not clearly distinct from technicians for the physics sort, topic comparisons were unnecessary in this case. The null hypothesis was rejected. That specific topic effects are similar for instructors and technicians for the physics sort is apparent from a comparison of instructor means for physics in Table XLI with those for technicians as given in Table XXXVI. In both cases the waves topic appears as of considerably higher value than other topics.

TABLE XLI

INSTRUCTOR MEANS FOR ALL TOPICS

Topic Number	Physics		Electricity		Electronics	
	Topic	Mean	Topic	Mean	Topic	Mean
I	Advanced Mechanics	4.09	AC Circuits	5.52	Microwave	3.89
II	Basic Mechanics	5.64	Capacitance	5.86	Vacuum Tube	5.97
III	Atomic and Quantum Physics	5.84	Electromagnetic Waves	3.91	Logic Circuits	4.19
IV	Kinetic Molecular Theory	3.73	Magnetic Field	3.74	Radio Broadcast	4.70
V	Optics	5.67	Inductors	6.45	Television	3.29
VI	Heat and Thermodynamics	4.47	Electric Field	4.45	Transistor	6.34
VII	Waves	6.74	Maxwell's Equations	3.10	Feedback	5.84
VIII	Nuclear Physics	5.20	Network Analysis	6.75	Physical Electronics	6.83
IX	Relativity	4.79	Instrument Principles	4.75		

The summary of analysis of variance over topics for the remaining two sorts appears in Table XLII. The null hypothesis is rejected in both cases. Without making detailed comparisons among all pairs of topics, the nature of the differences may be examined with reference to the instructor-technician comparisons of Table XL and to the specific technician effects of the preceding section.

Generality Scale

The value of each card item on a scale of generality was obtained during the validation phase of the study. Validators were required to sort cards on a seven point scale, essentially on the basis of the degree to which items were considered fundamental to the subject concerned. The mean scale value was computed over five sorts, including a sort by the investigator, for each item. Because of the small number of items falling in categories one and seven, these were combined with the adjacent categories to yield a final five point distribution. Again because categories contained unequal numbers of items, a sampling of items within categories was conducted in order that category means be comparable. After sampling, each category of the physics and electronics sorts contained seven items, while each category of the electricity sorts contained five items, with one or two minor deviations. The items assigned to each generality scale category appear in Table LV of Appendix C.

Hypothesis 12.0. It had been anticipated that differences between instructors and technicians might exist with respect to the

TABLE XLII

SUMMARY OF ANALYSIS OF VARIANCE

FOR INSTRUCTORS OVER ELECTRICITY AND ELECTRONICS TOPICS

Source of Variation	SS	df	MS	F	P
		Electricity			
Between People	3.19	13	.25		
Within People	430.21	112	3.84		
Topics	181.19	8	22.65	9.46	<.001
Residual	249.02	104	2.39		
Total	433.41	125			
		Electronics			
Between People	72.56	13	.56		
Within People	295.59	98	3.02		
Topics	162.31	7	23.19	15.83	<.001
Residual	133.28	91	1.46		
Total	302.84	111			

generality scale because of a possible broader view of the field which might be expected of instructors. Hypothesis 12.0 was concerned with such differences. Since a broader view on the part of instructors would be characterized by higher instructor means for high generality items and lower instructor means for low generality items, it was decided that for scale values one and five the null hypothesis would be appropriately tested with respect to a directional alternative, while tests for the remaining scale values would be nondirectional

Table XLIII gives means computed over the sampled items for each category of the generality scale for instructors and technicians. In view of the failure to isolate instructors as a well defined group for the physics sort, the null hypothesis was accepted with respect to this sort. For the electricity and electronics sorts, two technician samples, of fourteen members each, were selected and the mean for each was compared to that for the fourteen instructors. Results of this analysis appear in Table XLIV.

For the electricity instrument, only category three shows a significant difference consistent over two samples. For category one the effect is in the predicted direction but is not significant for both samples. The hypothesis of a broader view of the subject on the part of instructors is therefore not supported.

For the electronics instrument, both categories one and five give significant differences in the direction predicted. That is, instructors regarded the most general items as more important than

TABLE XLIII

INSTRUCTOR AND TECHNICIAN MEANS

FOR CATEGORIES OF GENERALITY SCALE

Scale Value	Instructors	Technicians
	Physics	
1	4.93	4.84
2	5.62	5.27
3	4.51	4.67
4	5.22	4.99
5	4.62	4.36
	Electricity	
1	5.66	6.20
2	5.40	4.89
3	5.90	4.99
4	3.36	3.41
5	3.64	3.43
	Electronics	
1	4.29	5.46
2	4.00	4.78
3	4.85	4.66
4	5.29	5.12
5	6.06	5.07

TABLE XLIV

COMPARISON OF INSTRUCTORS AND TECHNICIANS

FOR GENERALITY SCALE CATEGORIES, ELECTRICITY AND ELECTRONICS

Scale Value	Sample	Instructors Mean	Instructors S.D.	Technicians Mean	Technicians S.D.	t	P**
				Electricity			
1	A	5.66	.91	6.20	.68	-1.73	<.05*
	B	5.66	.91	6.11	.56	-1.55	n.s.*
2	A	5.40	.47	4.94	.86	1.68	n.s.
	B	5.40	.47	4.44	.68	4.16	<.001
3	A	5.90	.93	5.09	.99	2.16	<.05
	B	5.90	.93	4.90	1.02	2.61	<.05
4	A	3.36	1.23	3.37	.66	.04	n.s.
	B	3.36	1.23	3.79	.86	1.03	n.s.
5	A	3.64	1.58	3.62	1.33	.04	n.s.*
	B	3.64	1.58	3.57	1.30	.13	n.s.*
				Electronics			
1	A	4.30	.46	5.45	.73	-4.81	<.001*
	B	4.30	.46	5.48	.47	-6.48	<.001*
2	A	4.00	.44	4.68	.68	3.03	<.01
	B	4.00	.44	4.95	.49	5.16	<.001
3	A	4.85	.27	4.64	.87	.81	n.s.
	B	4.85	.27	4.91	.82	.26	n.s.
4	A	5.29	.66	5.36	.46	.32	n.s.
	B	5.29	.66	5.03	.48	1.12	n.s.
5	A	6.06	.74	5.39	.61	2.52	<.01*
	B	6.06	.74	4.86	1.16	3.16	<.01*

*One tailed test: all other tests two tailed
**Degrees of Freedom = 26

did technicians while the opposite effect occurred for the least general items. Furthermore, the result for category two is significant in the direction which might be expected, even though a two tailed test was applied to this category. The hypothesis concerning a broader view taken by instructors is thus considered supported for the electronics instrument.

Hypothesis 12.1. This hypothesis pertains to differences among the generality scale categories on the basis of technician responses. The summary of analysis of variance for the three sorts is presented in Table XLV. On the basis of this analysis it is concluded that significant differences do indeed exist between items at different levels of generality.

Hypothesis 12.2. Hypothesis 12.2 is analogous to hypothesis 12.1, using instructor rather than technician responses. Table XLVI gives the summary of analysis of variance with respect to this hypothesis. Again the null hypothesis is rejected for all sorts.

Trends in generality scale categories. Results for hypotheses 12.1 and 12.2 may be made more meaningful by examining trends in the generality scale responses of instructors and technicians. This examination assumes that the generality scale values represent equal intervals on a continuous scale. Figure 6 shows a plot of mean responses to items at each point of the generality scale for both instructors and technicians.

Inspection of Figure 6 (a) reveals that the overall significant F ratio for physics cannot be attributed to any clear tendency for

TABLE XLV

SUMMARY OF ANALYSIS OF VARIANCE

FOR TECHNICIANS OVER GENERALITY SCALE CATEGORIES

Source of Variation	SS	df	MS	F	P
		Physics			
Between People	20.94	99	.21		
Within People	242.91	400	.61		
Scale Values	46.03	4	11.51	23.14	<.001
Residual	196.89	396	.50		
Total	263.86	499			
		Electricity			
Between People	30.39	99	.31		
Within People	943.84	400	2.36		
Scale Values	559.23	4	139.81	143.95	<.001
Residual	384.61	396	.97		
Total	974.23	499			
		Electronics			
Between People	23.34	99	.24		
Within People	267.57	400	.67		
Scale Values	38.94	4	9.73	16.86	<.001
Residual	228.63	396	.58		
Total	290.90	499			

TABLE XLVI

SUMMARY OF ANALYSIS OF VARIANCE

FOR INSTRUCTORS OVER GENERALITY SCALE CATEGORIES

Source of Variation	SS	df	MS	F	P
		Physics			
Between People	6.89	13	.53		
Within People	50.16	56	.90		
Scale Values	11.56	4	2.89	3.89	<.01
Residual	38.60	52	.74		
Total	57.05	69			
		Electricity			
Between People	12.27	13	.94		
Within People	150.99	56	2.70		
Scale Values	80.16	4	20.04	14.71	<.001
Residual	70.83	52	1.36		
Total	163.27	69			
		Electronics			
Between People	1.40	13	.11		
Within People	56.47	56	1.01		
Scale Values	37.37	4	9.34	25.43	<.001
Residual	19.10	52	.37		
Total	57.88	69			

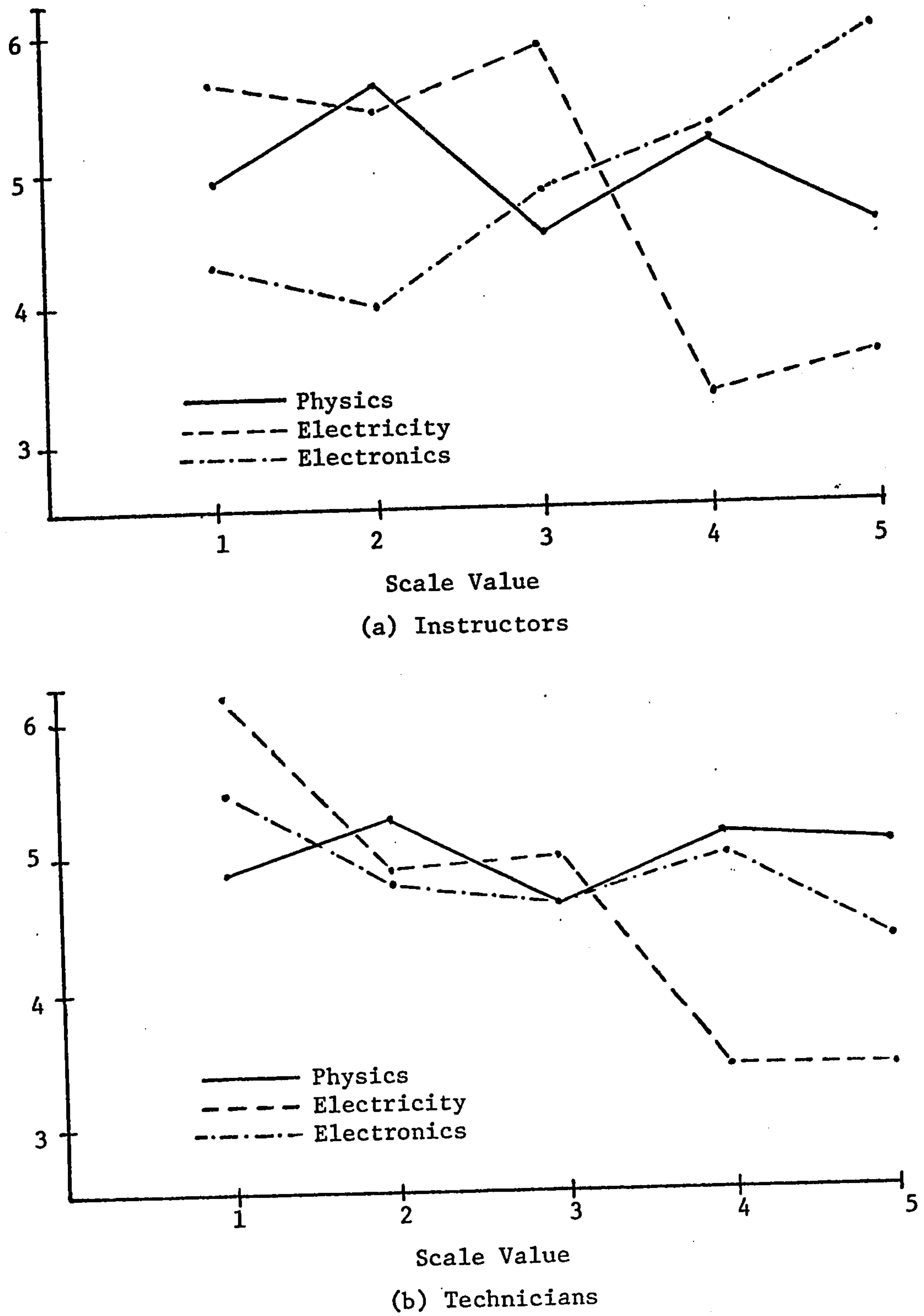

Figure 6

Trends in Generality Scale Means

instructor means to be either an increasing or a decreasing function of generality. The trend for electricity appears to be generally towards decreasing mean with increasing generality. In the case of electronics a more clearly defined trend emerges. With the exception of scale value one, means for electronics increase montonically, and approximately linearly, with increasing generality.

For technicians, as indicated by Figure 6 (b), no trend is observable for physics or electronics. As for instructors, the electricity trend is generally downward, the major distinction between this and the instructor plot being with respect to point three, that for which a significant difference between instructors and technicians was detected.

Analysis of Initial Sorts

Hypothesis 13.0. This hypothesis was designed to examine an assumption inherent throughout the analysis, namely that no systematic variations existed in technicians' perceptions of the sorting scale as a whole. That is, in the absence of the forced distribution, the number of cards assigned to a particular part of the scale would not be a function of any of the categorical variables. In order to examine this assumption, the initial three point unforced sort was used, the examination being carried out only on the "most useful" category of this sort.

Mean numbers of cards placed in the "most useful" category by groups based on each categorical variable were compared by means of a one way analysis of variance. Results for each of the three instruments appear in Table XLVII. In no case was the value of F sufficiently large to justify rejection of the null hypothesis. The assumption of no systematic variation thus appeared well founded.

Summary

The analysis of instructor responses to the instruments revealed that instructors formed a relatively homogeneous group in terms of responses to the electricity and electronics sorts. For the electricity instrument differences between instructors and technicians could be traced to the capacitance, network analysis, and instrumentation topics. For electronics the difference was in the decidedly greater importance attached to physical electronics on the part of instructors.

A measure of the degree of generality of each card item was obtained,and technician responses were analyzed for items classified on the basis of degree of generality. For the electricity sort differences between instructors and technicians were confined to items in the middle generality category. For both instructors and technicians the trend in electricity was towards greater emphasis on highly specific items and relatively less emphasis on general items, a finding which appeared consistent with the earlier result that the applied rather than the theoretical was of primary interest in electricity. For electronics, differences between instructors and technicians appeared for three of the five generality categories.

TABLE XLVII

SUMMARY OF ANALYSIS OF VARIANCE FOR "MOST USEFUL" CATEGORY OF INITIAL SORTS

OVER GROUPS BASED ON CATEGORICAL VARIABLES

Categorical Variable	Source of Variation	df	Physics MS	Physics F	Physics P	Electricity MS	Electricity F	Electricity P	Electronics MS	Electronics F	Electronics P
Age	Groups	4	55.04	.91		16.62	.47		160.21	1.20	m.
	Error	95	60.54			35.62			133.56		
Salary	Groups	4	70.84	1.18	n.s.	32.27	.92		61.14	.44	
	Error	95	59.88			34.96			137.72		
Total Education	Groups	4	31.75	.52		16.74	.47		46.35	.33	
	Error	95	61.52			35.62			138.35		
Technical Education	Groups	3	24.63	.40		55.73	1.63	n.s.	149.75	1.12	n.s.
	Error	96	61.43			34.20			134.16		
Source of Training	Groups	2	11.30	.18		23.55	.67		266.44	2.02	n.s.
	Error	97	61.33			35.09			131.92		
Range of Experience	Groups	3	93.37	1.57	n.s.	9.21	.26		47.11	.34	
	Error	96	59.29			35.65			137.37		
Tenure of Employment	Groups	3	19.86	.32		19.97	.57		127.55	.95	
	Error	96	61.58			35.32			134.86		
Type of Work	Groups	1	9.75	.16		.35	.00		12.55	.09	
	Error	98	60.84			35.21			135.88		
Type of Equipment	Groups	4	79.93	1.34	n.s.	61.30	1.82	n.s.	272.66	2.12	n.s.
	Error	95	59.49			33.74			128.82		

Differences for the two most extreme categories were significant in the hypothesized direction, with instructors having higher means than technicians for items of greatest generality and lower means for items of least generality.

Analysis of the initial unforced sorts was conducted to determine whether any systematic tendencies existed for technicians to place different numbers of items in the "most useful" category of the sorts. In no instance was any difference between groups detected.

CHAPTER VII

SUMMARY AND CONCLUSIONS

I SUMMARY OF PURPOSES AND PROCEDURES

The present study began with the premise, grounded in the examination of the structure of technical curricula, that it is necessary to apply systematic job analysis procedures to the problem of determining curriculum requirements in programs concerned with the training of technologists. The significance of this problem is apparent in the light of the increase in the importance of technological occupations in the occupational structure of industrial societies.

Past efforts in the field of technical job analysis can at best be described as exploratory. It is, nevertheless, possible to detect a progression in research activity from the broad survey designed to identify areas of work, general worker characteristics, and manpower requirements, to more specific training oriented studies in particular occupations or occupational groups. Such studies, while supplying needed background information on occupations, have, in general, not been sufficiently specific to yield the type of detailed occupational information required in curriculum development.

In view of these considerations, the primary aim of the present study was to examine a specific technical field, electronics technology, with respect to requirements in three areas of knowledge; physics, electricity, and electronics. Three major aspects and several more minor pointc relate to this overall aim. First it was necessary to explore the structure of the subject areas as viewed by technicians. More specifically, the question was asked whether in fact certain conventional subdivisions within each subject were useful as a basis for the detailed analysis of technician requirements. The second major aspect involved an examination of the relationship to subject requirements of certain variables descriptive of job classification and of relevant characteristics of electronics technicians.

The above two aspects of the study were designed essentially to reduce the complexity of the overall picture of electronics technology occupations, preliminary to the detailed analysis of subject matter requirements. This detailed analysis involved comparisons of the relative importance of particular topics within each subject area and of the responses of various groups, isolated in the earlier phase of the analysis, with respect to these topics.

More peripheral to the main problem, but nevertheless significant for curriculum planning purposes, was the analysis of subject requirements as judged by electronics technology instructors, and the comparison of these with technician judgments. Similarly, the question of degree of generality of subject matter, as distinct from the conventional structuring of subjects, as a basis for making curriculum judgments, was of some interest.

In considering the problem of a job analysis methodology, the typical questionnaire or checklist procedure was judged inadequate to the task of supplying information in sufficient detail. In several past studies, the Q-sort technique had been adapted to problems similar to the present one and gave some indication of being an appropriate data collection technique. This technique was therefore adopted, and three Q-sort instruments, specifically designed for the present application, were constructed.

A sample of one hundred technicians employed throughout Alberta was selected to serve as primary respondents. These technicians were located through direct contacts with employing organizations. Respondents were visited on the job by the investigator and subjected to the Q-sorting procedure. In addition, information pertaining to job classification and other relevant variables was gathered by means of a short preliminary questionnaire.

The analysis techniques used represented a significant departure from convention. Typically, rank ordering techniques had been used in past studies to determine the relative importance of subject matter elements. In the present study, a three stage process formed the main analysis sequence. The first two stages were concerned with isolating those subject topics and technician groups which could be considered well defined. The third stage represented the major departure from convention in that a parametric analysis, primarily analysis of variance, was conducted for the comparison of groups and topics.

II SUMMARY AND DISCUSSION OF FINDINGS

During the analysis phase, parallel analyses were conducted where appropriate for the three subject areas. At this stage, however, it is convenient to consider the findings for each subject separately. Accordingly, the present section is divided into subsections for each of physics, electricity, and electronics. A prior subsection is concerned with aspects of the descriptive analysis.

Descriptive Analysis

Description of the sample was conducted primarily as an aid in generalizing the results to other populations. In addition, the descriptive analysis was useful in the formation of categories for the variables under consideration, and in exploring certain relationships among these variables.

From the point of view of generalization, the most significant feature of the sample was the number of technicians in service activities, as distinct from research or production type activities. This feature could be accounted for on the basis of information concerning the organizations employing electronics technicians in Alberta. In view of the fact that the nine technicians whose type of work could be classed as research and development were significantly different from others in terms of their response to the electronics sort, it must be concluded that the findings should be generalized with care to populations for which this type of work is predominent.

Certain features of the classification by type of equipment are also related to the question of generalization. During the sampling process, there was evidence that certain areas were underrepresented in the sample. The existence of only six technicians in the broadcast field is an example. Evidence that this area was underrepresented was based on the inordinate difficulty experienced in scheduling interviews with broadcast technicians, rather than on any apparent unwillingness to participate on the part of employers. Such unwillingness did, however, lead to a suspected underrepresentation in the microwave and telephone areas, to the point that the sample contained insufficient individuals in these areas to warrant analysis. The major limitation imposed by these apparent areas of bias occurred in the few aspects of the analysis which required, for example, the computation of means over all technicians for the electronics sort. This limitation arises because areas such as broadcast are clearly distinct from others with respect to electronics requirements. Underrepresentation thus tends to result in means for topics being displaced from their population values, particularly in the case of topics for which the underrepresented groups are different from others. This limitation is not serious for most aspects of the analysis since only within-group means were generally required.

In connection with the application of findings to a particular training program, it is necessary that some information be available concerning the disposition of graduates from the program. For example, if it can be determined that most graduates from Alberta technical institutes tend to remain in the province or else find themselves in areas in which the occupational structure is similar to that for Alberta, then the results may be applied with some confidence.

As part of the sample description, an attempt was made to evaluate certain possible relationships among the categorical variables. In particular, the relation between type of equipment and the remaining categorical variables was explored. By using a chi-square test, it was found that only amount of technical education was related to type of equipment.

There was some a posteriori indication that certain distinctions existed between computer technicians and others, in spite of the lack of overall significant relationships between type of equipment and other variables. Further examination showed that computer technicians tended to have higher salaries and a greater amount of technical education than others. The technical education difference was found to be attributable to company training programs. It was speculated that higher salaries could be due to the rapid expansion of the computer field and the resulting demand for technicians. However, no direct evidence relating to this point was available.

Physics

The application of factor analysis to the correlations between items in the physics sort revealed no clearly defined underlying structure for this sort. Certain factors could, in a general way, be identified with conventional subject topics as hypothesized, but results were not clearly consistent when the analysis was applied to two subsamples of the total sample. The only fully consistent factor was that for harmonic motion. The presence of this factor was, however, attributed to an anomaly caused by a particular feature of the wording of three items relating to harmonic motion.

In the second stage of the analysis, based on the comparison of within-group and between-group correlations, no clearly defined groups emerged with respect to the physics sort. Average correlations, as computed by converting correlation coefficients to Fisher Z scores, both within-group and between-group, tended to be in the .25 to .40 range, indicating only modest agreement among technicians in the placement of items.

It appears reasonable to conclude that the failure to isolate clearly defined groups for this sort was not independent of the lack of clearcut factors. The fact that person correlations tended to be significantly greater than zero indicated that all was not random with the physics sort. Interpreting the results for the analysis of groups as indicating that physics requirements were essentially the same for all respondents, it is possible to account for the lack of interpretable factors. Even if certain groups of items did in fact exist which tended to cluster about a particular point of the scale, the fact that this point would be approximately the same for all individuals would imply that there would not necessarily be a tendency for such items to correlate among themselves more highly than with items for other groups which tended to cluster about other points of the scale. This hypothetical situation is, of course, more extreme than that encountered in practise. It does, however, indicate the effect of high overall agreement.

The above type of reasoning led to the conclusion that the failure to obtain clearly defined factors and to isolate groups did not necessarily preclude the possibility of the existence of significant topic effects for the total sample. An analysis of topic effects was therefore conducted, using a slightly modified form of the topics originally proposed. An analysis of variance over topics indicated significant overall topic differences. A more specific comparison of differences between pairs of topic means showed that requirements for the waves topic were significantly greater than requirements for other topics. Atomic and nuclear physics, optics, heat, and basic mechanics tended to cluster near the mid point of the scale, with the latter two topics receiving slightly, but not significantly, lower means than the remaining topics. Relativity, kinetic theory, and advanced mechanics all received significantly lower means than those for other topics.

That items dealing with waves should be considered by technicians as more important than all others is not surprising in view of the pervasiveness of wave concepts throughout electronics, from basic signal analysis to communications. This effect is perhaps also an indication that technicians rated highly those items which had a surface similarity to concepts familiar from electronics. Certain other aspects of physics, such as atomic structure, which might logically be expected to be fundamental to the comprehension of the physical operation of electronic devices, received mean ratings which were only insignificantly higher than the topics of basic mechanics and heat. Modern physics may, in fact, be too far removed from practical electronics to show significant effects.

It was found that instructors and technicians did not differ significantly in responses to the physics sort. Again the waves topic received the highest mean, with other topics following the same general pattern as for technicians. The lack of significant overall differences between instructors and technicians also implied no differences with respect to generality scale divisions.

The trend in generality scale means was essentially the same for both instructors and technicians. The significant difference between scale values could not be attributed to a clear tendency for means to be either an increasing or a decreasing function of generality. In the absence of such a tendency, there is some question whether degree of generality forms a meaningful basis for deciding on aspects of physics to be emphasized in the curriculum, in spite of the overall significant differences between generality scale means.

Results for the physics sort must be interpreted with the relatively low reliability of this sort in mind. It is suspected that the low values of the sort-resort correlations may be attributed both to lack of familiarity with items and to very low requirements for certain items. Evidence for this suspicion, however, came only from conversation with respondents. A possible disadvantage of the forced sort lay in the fact that respondents may have been forced to place unfamiliar items at a higher point on the scale than was warranted. For items which were familiar but which were regarded as totally useless the problem is perhaps not as serious since such items would tend to be placed near the extreme low end of the scale in any event.

Electricity

The situation with respect to the isolation of factors for the electricity sort is only slightly more straightforward than for the physics sort. For the total group, factors appeared which were generally identifiable with the types of topics hypothesized. Results, however, were not sufficiently consistent over two subsamples to warrant either general acceptance of the hypothesis or its rejection on the basis of the existence of other meaningful factors. It is possible that the existence of only thirty-eight items in the electricity sort, on the basis of which eleven factors were hypothesized, exerted some effect on the interpretation of factors.

For the job classification variables, the only group isolated on the basis of the electricity sort was that for broadcast. For the secondary variables certain effects also appeared. The lower categories of the salary, total education, and technical education variables were found to be related to responses, although the effects for total education and technical education were determined to be not independent. Comparison of the broadcast group with all others combined, for each electricity topic, revealed that only the instrument principles topic was significantly different for the two groups. This topic was rated significantly lower by broadcast technicians than by others.

Since the broadcast group consisted of only six individuals, and since a moderate degree of agreement existed among all technicians, it was concluded that an analysis of topic differences over the total sample would be meaningful. This analysis revealed a strong tendency towards emphasis of the practical over the theoretical. Inductors and capacitors received the highest mean ratings, followed by instrumentation, AC circuits, and network analysis. A decided break in the general trend occurred at this point, with the topics of magnetic fields, electromagnetic waves, and electric fields forming a cluster with means significantly lower than those for any of the applied topics. The Maxwell's equations topic appeared at the lowest extreme with a mean which was significantly lower even than means for the remaining theoretical topics. In the case of broadcast technicians, an exception to this general picture was, as mentioned, the decidedly lower rating of the instrument topic. A further difference for broadcast technicians was that the most pronounced break in the general trend of means was between the upper three topics of inductors, capacitors, and AC circuits, and the remaining six topics.

Significant differences between topics were also found for instructors. Although specific tests were not made for instructors, inspection of the means indicated the same general tendency as for technicians, with practical topics being rated more highly than theoretical topics. In spite of this trend, differences between instructors and technicians did occur with respect to specific topics, leading to the isolation of instructors as a well defined group for the electricity sort. The capacitance topic, although rated above the mean for the sort by both instructors and technicians, was rated significantly higher by technicians. The network analysis topic was rated near the mean of the sort by technicians but significantly higher by instructors. Conversely, the instrument topic was rated near the mean by instructors and significantly higher by technicians.

When items were grouped by degree of generality, significant differences were detected between means for the different generality values for both instructors and technicians. An examination of trends revealed that mean ratings tended to be a decreasing function of generality. This result is consistent with that for topic comparisons since theoretical topics tended to be considered as more general than those involving applications.

Electronics

Investigation of the dimensionality of the electronics sort led to a much more clearly defined pattern than for the other two subjects. In general, it was possible to identify clearly defined and consistent factors tending to support the hypothesized structure of the sort. On the basis of the factor analysis, relatively minor modifications were made in the topics used as the basis for the remainder of the analysis.

It was possible to identify several groups which could be regarded as well defined in terms of homogeneity of responses to the electronics instrument. For the type of work classification technicians in research and development were isolated. For the type of equipment variable well defined groups appeared in the areas of broadcast, communications, navigational aids, and computers. For the secondary variables no significant influences on responses could be detected. For purposes of the detailed analysis of group responses, all technicians not belonging to the well defined groups were combined into an "others" group.

Comparison of research and development technicians with all others revealed significant differences for the vacuum tube, transister, logic circuit, and feedback topics. Research and development technicians assigned a lower mean rating to vacuum tubes and a higher mean rating to the remaining significant topics. Results for the transistor and logic circuit topics appear to warrant the conclusion that research and development technicians consider some of the more modern aspects of electronics as of greater importance. This conclusion is reinforced by the opposite result for vacuum tubes. The feedback topic, while it must be considered as part of general electronics, has many aspects which from the point of view of learning the subject may be considered more "advanced" than other topics. Thus the terms "recent developments" and "advanced electronics" may be suitable in describing the requirements of research and development technicians.

Comparison of topic means within research and development revealed that, with the exception of logic circuits, specialized areas received extremely low mean ratings. The result for logic circuits indicates that this topic is perhaps specialized only from the point of view of the structure of subject matter, not from the point of view of range of application. Vacuum tubes and physical electronics, which have conventionally been taught together as part of introductory electronics, received intermediate ratings. The topics of transistors, feedback, and logic circuits all received significantly higher ratings than any other topics.

Results for the identification of groups on the basis of the type of equipment classification yielded five groups, including that labelled "others," to be compared for each electronics topic. The resulting large number of comparisons makes the interpretation of type equipment effects a relatively complicated process, particularly since overall group differences appeared for all but one topic, that of vacuum tubes.

Comparison of topics for the broadcast group indicated that the major requirement for this group is with respect to the television topic. Furthermore, requirements for this topic appear to be almost exclusive to the broadcast field, as evidenced by group comparisons for this topic.

No significant differences between topics existed for the communications group, indicating moderate requirements on the part of this group for all topics. The result was reinforced by the comparisons between groups. Except in the case of logic circuits, topic means for communications showed only minor departures from the mean of the sort as a whole. The departure for logic circuits was, however, insufficient to lead to a significant overall topic effect for communications.

For the navigational aids group, all topics except television tended to cluster near the mean of the sort and all were significantly higher than the television mean. Overall topic effects for this group can therefore essentially be attributed to the lack of a requirement for television. As might be expected, the microwave topic received the highest mean for this group. Requirements for microwave were, in fact, essentially confined to the navigational aids and communications groups.

Requirements for logic circuits are clearly predominant for the computer group, the difference between this and all other topics being highly significant. Moderate requirements exist for this group with respect to the general electronics topics, vacuum tubes, feedback, physical electronics, and transistors. Specialized topics other that logic circuits had means that were significantly lower than those mentioned above for the computer group.

The remainder of the sample, grouped under the "others" label, showed no particular preference towards any specialized area with the exception of logic circuits. This exception is not surprising considering the wide range of uses currently being found for such circuitry.

With respect to the topic effects themselves, it is possible to draw the general conclusion that requirements for specialized topics such as radio broadcast, television, and microwave are confined to groups working with equipment based on the knowledge represented by these topics. For such groups the specialized topics tend to take precedence over more general topics. For these more general topics, differences among type of equipment groups are less pronounced than those for the specialized topics.

Analysis of instructor responses revealed that instructors formed a relatively homogeneous group in terms of the electronics instrument. It was found that overall differences between instructors and technicians could be attributed to the highly significant difference for the physical electronics topic, with instructors rating this topic substantially higher than did technicians. The general tendency in instructor responses was towards high ratings for the topics considered part of general electronics, and towards low ratings for the specialized topics.

The above tendency was also apparent from the analysis of items by degree of generality. Although no distinct trend was found to account for overall generality scale effects on the part of technicians, for instructors the trend was towards higher mean ratings with increased generality.

III DISCUSSION OF METHODOLOGY

Results of this study supported the widely held view that the Q-sort method has some valuable applications as a data collection technique in situations to which conventional testing techniques are not applicable. It is useful at this stage to examine certain aspects of the method in the light of the present experience. Some of the observations to be made pertain to the present application, while others are of more general significance.

It is clear that the outcomes of factor analysis are a function of the structure of the instrument. This becomes more evident when the analysis is conducted in terms of item rather than person correlations. Thus, for example, the identification of factors for the electricity sort was hampered by the lack of sufficient items which could be logically regarded as belonging to particular clusters. Similarly, for the electronics sort factors relating to control systems and to instrumentation seemed to exist but were not clearly identifiable because of too few items relating to these areas. It would appear expedient, therefore, if some grounds exist for the formulation of an hypothesis concerning the nature of expected factors, that a balance of items be achieved with respect to this hypothesis rather than on some external grounds as was done on the present study.

For purposes of detailed analysis of items in a Q-sort, it is essential that some basis exist for the categorization of items into a larger structure. Such a basis may be developed through a factor or cluster analysis of items or it may be developed on external grounds. It is the failure to develop such a framework that has been a drawback in the interpretation of the results of previous studies. An overall rank ordering of items is insufficient for practical purposes for several reasons. First, it fails to consider whether the range of sums or means upon which the ranks are based is a significant range or whether it arose only by chance. Furthermore, it gives no indication of the magnitude of differences between ranks, information which the raw data is capable of yielding. The grouping of items into categories permits the application of more rigorous analytical methods.

A further consequence of the grouping of items is apparent from the analysis of person correlations. Such correlations tended to be positive and significantly different from zero even when based on individuals from widely disparate groups. By developing a composite measure of the response of a group and comparing these across groups, the conclusion would tend to be that the groups exhibited a significant degree of agreement. Such a conclusion would be misleading, since particular clusters of items could show significant differences if compared separately. The hypothesis of zero correlation across groups is not a meaningful one in this context. What is meaningful is the differences based on clusters of items. The analysis of variance tends to accentuate such differences while the correlational process tends to obscure them.

Some evidence existed in the present study that the assumption that all respondents were equally familiar with all items was violated, particularly for the physics instrument, and to a lesser extent for the electricity instrument. Discussion with some respondents revealed that they had sorted items at the high end of the scale on the basis that they were familiar with and could discriminate between these items. At the lower end of the scale, however, they were forced to sort items essentially at random because all items were equally and totally unfamiliar. This point is perhaps evidenced in the relative unreliability of the physics and electricity sorts. It seems clear that the reliability of these sorts varied somewhat for different individuals because of variation in degree of familiarity with the material. The precise effects of this problem could not be assessed. They were, however, no doubt reflected in the difficulty experienced with the factor analysis for physics and electricity.

IV CONCLUSIONS, IMPLICATIONS, AND RECOMMENDATIONS

Conclusions

Taking into account limitations imposed by the nature of the sample and the methodology, it is possible to arrive at certain conclusions concerning the identification of groups of technicians and concerning the requirements of these groups for various subject topics. In addition, other conclusions can be drawn relating to the secondary aspects of the study. Conclusions are outlined here in terms of answers to the five questions proposed at the beginning of this report.

Question one involved the problem of determining subject matter clusters which could be regarded as forming a meaningful structure of each subject as seen by technicians. This question was investigated by means of factor analysis of the intercorrelations among items in each Q-sort. This analysis revealed for the electronics sort that factors identified on the basis of technician responses corresponded closely to a series of topics developed on the basis of an examination of the conventional divisions within the field of electronics. These topics, as modified for purposes of subsequent analysis, were as follows: (1) microwave, (2) vacuum tubes, (3) logic and computer circuits, (4) radio broadcast, (5) television, (6) transistor, (7) feedback, (8) physical electronics.

For the physics and electricity instruments the factor patterns were rather less well defined. The factors which emerged were not sufficiently stable when analyzed over two subsamples of the total sample to justify the conclusion that a meaningful structure of these subjects existed for technicians. For purposes of the more specific analysis of topics, the topics originally hypothesized were modified slightly on the basis of the factor analysis. It is emphasized, however, that these topics were used to simplify the analysis and are not to be construed as representing topics defined by technician responses in the same sense as the electronics topics were defined.

Question two concerned the identification of groups on the basis of job classification, where job classification was defined in terms of two variables, type of work and type of equipment. For the type of work variable only the research and development group could be considered as well defined. For the type of equipment variable the following four groups were isolated: (1) broadcast, (2) communications, (3) navigational aids, (4) computers. Technicians not belonging to any of these type of equipment groups were classified under the label "others" for purposes of analysis. With one exception, all the above groups were well defined only in terms of electronics requirements. This exception was the broadcast group which could also be defined in terms of electricity requirements.

Question three followed logically from the foregoing two questions; these three questions leading to the three stage procedure for the main analysis. Once topics and groups had been defined, it remained only to specify in detail the requirements of each group in terms of topics and to compare all groups with respect to each topic. In general, only electronics topics were of concern since groups were defined basically with respect to these topics. For physics and electricity primary interest was in comparing topics for the technician sample as a whole.

A detailed answer to question three has been presented in the summary of findings. Rather than repeating the details of topic requirements for the various groups and, in the case of physics and electricity, for the sample as a whole, an attempt is made at this point to reiterate some of the more general features of these findings.

A tendency existed for each group identified on the basis of type of equipment to assign the highest mean rating to the electronics topic most closely associated with the area of specialization of that group. Specialized topics other than that associated with a particular group tended to reseive extremely low mean ratings by that group. Topics regarded as part of basic electronics tended to receive intermediate mean ratings. The "others" group, being relatively heterogeneous in character, could not be identified with any specialized topic. Basic electronics topics thus tended to receive higher mean ratings for this group. Similarly, the research and development group, being based on type of work rather than type of equipment, could not be regarded as specialized. Requirements for this group tended towards the more modern and more advanced aspects of electronics such as transistors, logic circuits, and feedback concepts.

The analysis of responses of the total technician sample to the physics and electricity instruments is also related to question three. For convenience, the analysis was conducted in terms of conventional topics within the two subject areas, although the factor analysis did not clearly determine that these topics were used by technicians as the underlying basis for sorting. The general tendency in electricity was high mean ratings for applied topics and relatively low mean ratings for theoretical topics. For the physics sort the waves topic appeared to be most important for technicians. This topic was followed in order of importance by topics in atomic and nuclear structure, optics, basic mechanics, and heat. The topics of kinetic-molecular theory, relativity, and advanced mechanics all received significantly lower mean ratings.

Question four was formulated in order to permit a comparison of subject matter requirements as seen by technicians with the emphasis in existing programs at two technical institutes, as represented by the views of electronics instructors at these institutes. Requirements in physics were regarded as essentially the same by both technicians and instructors. The two groups differed for electricity, specifically for the topics of capacitance, instrument principles, and network analysis. The first two topics were rated significantly higher by technicians than by instructors, while the reverse was true for the third topic. Differences between instructors and technicians for the electronics sort could be attributed to the greater importance attached by instructors to physical electronics.

Question five related to certain variables, other than job classification, which could conceivably have been related to technician responses to the sorts. In general, it is concluded that these variables did not exert systematic effects on responses. Minor exceptions occurred for the electricity sort. For this sort the two lower salary ranges and those technicians having one year of technican education (or, equivalently, thirteen years of formal education) were isolated as significantly different from others. These effects were judged sufficiently minor that a detailed analysis of requirements for these groups was not carried out.

The question of degree of generality was not included in the five questions originally outlined since it was intended that this question be approached on a purely exploratory level. Results of the analysis of degree of generality revealed that instructors tended to regard the more general electronics items as most important, while no such tendency existed for technicians. The opposite tendency existed for both instructors and technicians for the electricity sort. This result is consistent with the earlier finding that applied rather than theoretical topics were preferred in electricity. No systematic tendency was found for physics.

Recommendations For Curriculum Development

While the general nature of the implications for curriculum planning is apparent from the conclusions, results of the study appear sufficiently definitive to warrant the making of certain specific recommendations for training programs. In the interest of conciseness, these are presented here in point form. Their elaboration appears in the summary and conclusion sections. In interpreting these recommendations it is most important to recognize that, because of limitations in the sample, areas of specialization may exist which were not detected on the basis of this sample.

1. It is recommended that areas of specialization be established within electronics technology training programs in the fields of computers, communications (including navigational aids), and broadcast. In addition, it is necessary to retain a more general program to meet demands in the field which do not

relate closely to the above specializations

2. It is recommended that emphasis in electricity be on circuits rather than on field theory. In particular, the operation of inductors and capacitors as circuit elements requires emphasis. The electricity aspect of the program can be common to all areas of specialization.

3. It is recommended that the orientation in physics be towards wave concepts, followed by atomic and nuclear structure, optics, and basic mechanics and heat. Concepts in advanced mechanics, kinetic-molecular theory, and relativity can receive less emphasis.

While a detailed assessment of the extent to which existing practice in technical institutes conforms to the above recommendations is beyond the scope of the present study, the relevance of the findings and recommendations to the electronics programs at the two Alberta technical institutes may be discussed in general terms.

With regard to the recommendation concerning specialization, the policy at the Northern Alberta Institute of Technology is to offer options in the final two quarters of the program. These options include specialized courses in such areas as calibration and standardization, biomedical electronics, and electronics in geophysical exploration. In addition, telecommunications technology is regarded as a separate program with emphasis on telephone switching and microwave. The program at the Southern Alberta Institute of Technology includes provision for specialization in the areas of broadcast and telecommunications, the latter program again emphasizing telephone switching and microwave.

The most notable departure of the findings from current practice at the above two institutes is the lack of provision for specialization in the computer field. While computer courses are included in the programs, the clearly identifiable computer group in the present study would imply that this area be singled out for special attention. It is also noted that the emphasis in the telecommunications programs is slightly different from requirements for the communications group isolated in the present study. The general absence of telephone technicians in the sample, however, implies that the communications group may have been biased towards radio communications. The broadcast specialization at S.A.I.T. appears justified on the basis of the findings. It would seem that an equivalent specialization at N.A.I.T. would be warranted.

The emphasis in electricity courses offered at both institutes is on circuits rather than fields. This practice is entirely consistent with the findings of the study.

All conventional physics topics are included at some point in both programs under consideration. Modern physics and waves, however, appear later in the programs, following introductory courses in such areas as mechanics and heat. At N.A.I.T. a full course in modern physics is offered as an option in the final quarter of the program. It is suggested that what is required is a reorientation rather than a fundamental change in physics courses. Perhaps a reasonable orientation would be to teach basic mechanics only to the extent necessary to develop an understanding of fundamental systems of units and of broad concepts such as energy. This should suffice as background for a detailed early treatment of modern physics including atomic and nuclear structure and waves. A topic such as optics could be taught as an extension of wave concepts.

To the extent that it is possible to generalize from the two examples of programs discussed above, it appears that the findings are not seriously inconsistent with current practice. Only in establishing a specialized program for computer technicians is a major change indicated.

Implications for Further Research

The possibility of applying the methodology used in the present study to other occupational areas is an obvious one. Such application is straightforward, requiring only the construction of instruments appropriate to the areas to be examined.

Of somewhat more interest are extensions of the limits of the study, either within electronics technology or in other fields. The importance of continuous evaluation of occupational structure in technological fields cannot be overemphasized. The rapidly changing character of such fields was emphasized early in this report. Profiles of the nature of such changes could clearly furnish a basis for projecting future requirements in a field. In particular, the nature of the process of adoption of innovations from the research stage through to the time of widespread use requires some examination.

The question of the possible existence of more than one level of technician was not directly examined in the present study. Whether, for example, research and development technicians operate at a more advanced level than others was not clearly resolved. More generally, the question might be posed whether levels of technician can be defined on the basis of type of work, and whether such levels appear within, and are distinct from, areas of specialization. In fact, the whole question of independence of type of work and type of equipment classifications needs to be explored to a much greater extent than was done in the present study. These points can be resolved only in the context of a much broader sampling of technicians than was available for the present study. Such a broader sampling would also help resolve the problem of whether areas of specialization exist which could not be detected from the sample available.

The development of a mechanism for the integration of the findings of job analysis into the process of curriculum development should receive some priority. Examination of job analysis studies and of detailed curriculum plans reveal that the two have tended to be isolated. While this is part of the broader problem of the implementation of research findings, it is of more direct concern for studies, such as the present, which are operationally oriented, and whose major justification is in their immediate impact on curriculum practice.

The present study was confined to an examination of knowledge requirements in the occupations under investigation. An important point which was omitted from the study is the question of the extent to which technicians are concerned with higher level cognitive activities such as problem solving. This question involves the extent to which an occupation is confined to routine activities, as opposed to activities which continually require that the worker resort to a wide range of knowledge in order to solve new problems. Perhaps at the problem solving level the activities of a technician would overlap considerably those of an engineer. Definitive research related to this question would contribute substantially to existing knowledge of technical occupations and would have important implications for curriculum development, in particular for teaching strategies.

Certain more specific points related to the data collection and analysis are worthy of mention, either as areas for direct study or as matters for refinement in subsequent studies. The possibility of persons being unfamiliar with material presented to them for evaluation must be accounted for. This is a relatively difficult problem in view of the apparent differences between individuals in degree of familiarity. This problem is somewhat related to that of determining the relative value of items in different subject areas. It is legitimate to ask, for example, whether physics subject matter as a whole is less valuable than, say, aspects of electronics unrelated to an individual's specialty.

While overall significant differences were detected among means assigned to items at different levels of generality, it might be argued that these differences, relative to the sorting scale as a whole, were too small to be of practical value, the level of significance being a consequence of the large number of degrees of freedom. Furthermore, the lack of clear trends for technicians limits the practical importance of generality scale differences. This matter should be further explored along the lines of the possible dependency between degree of generality and the topics within a subject, particularly as generality might relate to areas of specialization.

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APPENDIX A

Q-SORT CARD CONTENT

PHYSICS

101 The energy of an electromagnetic wave is directly proportional to its frequency.

102 Heat conduction occurs when highly energetic heated molecules in a substance transfer their energy to neighboring molecules.

103 Heat may be propagated over long distance in the form of electromagnetic radiation.

104 X-rays may be produced by the bombardment of certain metals by high energy electrons.

105 The frequency (f), wavelength (L), and velocity of propagation (v) of a wave are related by the equation v = fL.

106 If an external pressure is applied to a liquid, the change in pressure at every point in the liquid is equal to the external pressure.

107 The relative deformation of an elastic body (strain) is proportional to the applied force per unit area (stress).

108 For a fluid of constant density moving in a tube, the velocity varies inversely as the area of the tube.

109 In order to account for the energy distribution of radiation from a black-body, it is necessary to assume that the particles inside the body can acquire energy only in discrete steps.

110 The Bohr model of the atom pictures electrons revolving around the nucleus in certain definite orbits.

111 A beam of electrons can show interference and diffraction effects characteristic of waves.

112 The uncertainty principle sets absolute limits on the accuracy with which position and momentum of a particle can be simultaneously determined.

113 In quantum mechanics, the square of the wave function associated with a particle is interpreted as the probability of finding the particle in a given region.

114 The atomic nucleus is made up of protons and neutrons bound by nuclear force. Neutrons are uncharged particles while protons possess the elementary positive charge.

115 Speed is the time rate of change of position. Velocity is the vector representation of speed.

116 Acceleration is the time rate of change of velocity.

117 Inertia refers to the tendency of a body in motion to remain in motion in a straight line at the same speed. Mass is a measure of the inertia of a body.

118 Newton's law of action and reaction leads to conservation of momentum since, if two bodies interact, in the absence of external forces, the momentum lost by one is gained by the other.

119 Force is the time rate of change of momentum. In the case of constant mass, the force is given by Newton's second law $F = ma$.

120 The momentum of a body is defined as its mass times its velocity. Total momentum is conserved upon interaction of bodies in the absence of external forces.

121 Motion of a projectile in a gravitational field can, in the absence of frictional effects, be analyzed in terms of a horizontal motion with constant velocity and a vertical accelerated motion.

122 Kepler's laws describe the motion of the planets in the solar system. Newton's law of universal gravitation gives the force necessary for such motion.

123 The harmonic oscillator is a system moving under the action of a restoring force which is proportional to the displacement from a central point.

124 The work done in moving a body between any two points in a conservative force field is independent of the path chosen between the two points.

125 Power is defined as the time rate of doing work.

126 A system possesses potential energy by virtue of its position in a force field, it possesses kinetic energy by virtue of its motion.

127 Energy may be transformed from one form to another. Total energy is conserved in all interactions.

128 Mass is a special form of energy. The relation between mass and energy is given by the equation $E = mc^2$ where c is the speed of light.

129 Torque about an axis is equal to the applied force times the perpendicular distance from the force vector to the axis.

130 The moment of inertia of a body about any axis is the sum of all mass elements in the body times the square of their distance from the axis.

131 Energy cannot be propagated at a speed greater than the speed of light.

132 A small particle suspended in a liquid undergoes random motions due to bombardment by molecules of the liquid. It is possible to calculate only the average distance which the particle will travel in a given time.

133 Using the ray representation we can explain reflection and refraction on the basis that light travels the path that requires the least time.

134 Regarding light as a wave enables one to analyze many properties not possible with the ray representation.

135 If two waves are superimposed the resultant wave has an instantaneous amplitude equal to the sum of the instantaneous amplitudes of the separate waves.

136 In general light waves have components in all directions perpendicular to the direction of propagation. Under certain conditions some of these components may be suppressed.

137 Considered as a wave, light is made up of that range of wavelengths in the electro-magnetic spectrum to which the eye is sensitive.

138 Individual colors are made up of restricted ranges of the optical spectrum. Any color can be produced by mixing three independent colors in various proportions.

139 A harmonic oscillator may be damped if a force, in addition to the restoring force, is applied in opposition to the direction of motion.

140 A harmonic oscillator may be "forced" by the application of a force in the direction of motion. The oscillator is resonant if the driving force has the same frequency as the oscillator.

141 Pressure in an enclosed gas may be regarded as due to the bombardment of the container walls by the gas molecules.

142 Temperature is a measure of the average kinetic energy of the molecules of a substance.

143 Pressure in an ideal gas is directly proportional to its absolute temperature and inversely proportional to its volume.

144 The kinetic energy of a given molecule in a gas cannot be determined. It is possible only to state the probability that the energy is within a specified range.

145 The first law of thermodynamics is a statement of the law of conservation of energy in a system involving heat transfer.

146 The second law of thermodynamics expresses the impossibility of converting a given quantity of heat entirely into work.

147 The universe is in a state of tendency towards increased disorder.

148 Different types of substance of the same mass and temperature may contain different amounts of heat energy.

149 Molecules in a substance are bound together by forces which are electrical in nature.

150 There are several ways in which one element may be changed into another; for example, by spontaneous emission of particles from the nucleus, or by bombardment with nuclear particles.

151 Under certain conditions bombardment of nuclei leads to release of particles which can in turn bombard other nuclei, leading to a chain reaction.

152 Radioactive substances decay at a rate proportional to the amount of undecayed material present.

153 In addition to electrons, neutrons, and protons, a large number of other elementary particles have been found from such sources as cosmic rays and nuclear reactions.

154 The mass of a body increases with increasing velocity. At ordinary velocities this mass increase is not detectible.

155 Sound waves are longitudinal in nature, the medium being distorted in the direction of propagation.

156 Waves propagating from a moving source will have different frequencies and wavelengths as measured by observers in different directions from the source.

157 Molecules in a crystal are arranged in a repetitive symmetrical pattern.

158 Physical laws are valid in all frames of reference moving with constant velocity. Accelerated frames of reference change the characteristics of physical laws.

159 The amount of bending of a light ray in crossing the interface between two media depends upon the ratio of the velocities of light in the two media.

160 Angular momentum of a rotating body is conserved in the absence of external torques.

161 Atoms of a gas, when properly excited, emit energy in the form of a series of electromagnetic waves with frequencies characteristic of the gas.

162 A force, directed towards the center of the circle, is required to maintain uniform circular motion of a body.

ELECTRICITY

201 The resistance of a conductor is given by the ratio of applied voltage to the resulting current in the concuctor.

202 The sum of all currents at any branch point of a network is zero.

203 The capacitance of a capacitor is a measure of the amount of charge which can be stored per unit of applied voltage.

204 The voltage drop across a pure inductor is proportional to the rate of change of current in the inductor.

205 The voltage induced in the secondary winding of a transformer is a function of the primary voltage and the ratio of secondary to primary turns.

206 Any two terminal linear network is equivalent to a voltage source equal to the open cirtuit voltage between the terminals, in series with the impedance as seen from the terminals if all internal sources are replaced by their internal impedances.

207 The phase angle between current and voltage in an RC circuit is a function of the ratio of capacitive reactence to resistance.

208 In an RLC circuit the time average power dissipation all appears as heat in the resistance.

209 For a pure inductance the current lags the applied voltage by a 90 degree angle.

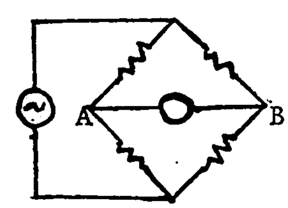
210 AC circuits may be analyzed by representing currents and voltages for individual elements as rotating vectors of magnitude proportional to the reactance of the element and phase angle depending on the type of element.

211 A series RLC circuit is resonant at the frequency for which the inductive reactance and capacitive reactance are equal.

212 Maximum power transfer to a load occurs if the internal impedance of the source is equal to the impedance of the load.

213 The galvanometer is based on the rotation of a current loop in a magnetic field. Voltmeters and ammeters may be constructed by connecting resistances in series and parallel with the galvanometer coil.

214 Bridge circuits as shown in the diagram are based on the matching of impedances for no current between points A and B.



215 Resonant circuits form the basis for filter design since such circuits present low impedance to certain frequencies and high impedance to others.

216 Certain substances may acquire electric charges by friction.

217 The force between two charges is proportional to the product of the magnitudes of the charges, and inversely proportional to the square of the distance between them.

218 The electric field intensity is the force per unit charge exerted on a charge in the field.

219 The net number of electric lines of force cutting a closed surface is a function only of the charge enclosed inside the surface.

220 The potential difference between two points in an electric field is the change in potential energy of a unit charge moved from one point to the other.

221 A dielectric placed between the plates of a capacitor acquires a charge by induction, thus increasing the capacitance of the capacitor.

222 Placing capacitors in parallel increases the total capacitance since the system is capable of holding more charge per unit applied voltage than is a single capacitor.

223 A charged capacitor possess potential energy which is proportional to the square of the charge and inversely proportional to the capacitance.

224 A potential difference exists between the two sides of a conductor carrying current perpendicular to a magnetic field.

225 A current loop in a magnetic field experiences a torque of magnitude proportional to the current, the magnetic field strength, and the area of the loop.

226 A potential difference is induced between the two ends of a conductor moves across a set of magnetic flux lines.

227 The magnetic flux density in the neighborhood of a moving charge is proportional to the magnitude and velocity of the charge, and inversely proportional to the square of the distance from the charge.

228 The induced EMF in the core of an inductor gives rise to small current loops (eddy currents) which result in energy loss in the form of heat.

229 Ferromagnetic materials may be considered as made up of a large number of small magnetic dipoles which become aligned under certain conditions (such as the application of an electric field).

230 Magnetization and demagnetization of a ferromagnetic substance take place along different paths.

231 The force on a charge in an electromagnetic field is a function of the amount of charge, its position, and its velocity.

232 The electromagnetic field resulting from oscillating electric charges radiates outward from the source at the speed of light.

233 Since electromagnetic waves cannot be propagated in a conductor, the conductor may be used to guide such waves by establishing boundaries for the waves.

234 Electromagnetic waves show reflection, refraction, and interference patterns similar to those of light.

235 The nature of the electromagnetic field is completely specified by Maxwell's equations.

236 If a capacitor is charged and then allowed to discharge through a resistor, the current flow is an exponential function of time.

237 The direction of an induced voltage is such that this voltage opposes the change that produced it.

238 The net number of magnetic flux lines cutting a closed surface is zero.

ELECTRONICS

301 For small signal cases, a triode may be replaced by a linear equivalent circuit consisting of a voltage source equal to the amplification factor times the grid voltage, in series with the plate resistance.

302 In a cathode ray tube, electrons are deflected to different portions of the screen by the application of an electric or magnetic field at some point along the electron path.

303 A metal contains a relatively large number of high energy "free" electrons which may give rise to a flow of electrons upon the application of an electric field.

304 Electrons are emitted from a metal which has been heated to incandescence. These electrons may be subjected to controlled motions by the application of electric or magnetic fields.

305 Certain impurities when added to a semiconductor result in the existence of an excess or deficiency of free electrons, thus increasing the conductivity of the semiconductor.

306 In a vacuum diode, electrons are emitted from a hot cathode and accelerated towards an anode by the application of a possitive voltage to the anode. The diode thus is a conductor in only one direction.

307 In general the detection of an amplitude modulated signal requires that part of the RF signal be suppressed (i.e. by rectification) in order that the carrier may be filtered out while retaining variations at the frequency of the intelligence signal.

308 The small signal hybrid parameters of a transistor may be used in developing four terminal linear equivalent circuits for transistor amplifiers.

309 A potential barrier exists at the junction of a p-type and an n-type semiconductor, preventing conduction across the junction. The barrier may be raised or lowered by the application of external voltages of opposite polarities.

310 Certain substances have the property of emitting electrons when exposed to light.

311 Amplification in a triode is accomplished by the application of a small signal voltage to the grid which results in a large current variation in a load and a correspondingly large voltage variation.

312 A load line superimposed on the plate characteristic curves of a triode permits the calculation of operating conditions if the supply voltage, load resistance, and bias voltage are specified.

313 The small DC bias voltage required at the grid of a triode may be supplied by placing a resistor in either the grid or cathode circuit.

314 An emitter follower (grounded collector) transistor amplifier has high input impedance enabling it to be used in circumstances in which loading of the input signal source is undesirable. The current gain of such an amplifier cannot exceed one.

315 Amplification in a transistor is achieved by the transfer of a current change from a low resistance input circuit to a high resistance output circuit.

316 Biasing a transistor amplifier must involve precautions to prevent excessive currents which lead to thermal runaway.

317 In a typical transistor amplifier the collector-base junction is biased in the reverse direction (giving a high resistance) and the emitter-base junction is biased in the forward direction (giving a low resistance).

318 Pentode type tubes have the property that plate current is independent of plate voltage over a wide range.

319 Tubes containing small amounts of a gas may be made to conduct by the application of electric fields since these fields can cause ionization of the gas to provide free electrons. Typical uses for such tubes are in high power rectifiers, light sources, and voltage regulators.

320 The vacuum tube voltmeter avoids the problems of loading the system on which measurements are being made since the vacuum tube amplifier has an extremely high input impedance.

321 The design of filters is based essentially on the property that capacitors and inductors exhibit different impedances at different frequencies.

322 The coupling of amplifier stages requires that signals be transferred from stage to stage while isolating stages from non-signal effects such as biasing voltages.

323 In a class B amplifier (either tube or transistor) no output signal is obtained for part of the input signal cycle. For a class C amplifier output signal appears for less than half the input signal cycle.

324 The current-voltage characteristics of tubes and transistors are linear over only relatively narrow ranges. Thus for large signal cases the output signal may not have exactly the same waveform as the input signal.

325 Any complex waveform may be analyzed into sine wave components consisting of a fundamental frequency and multiples of this frequency. Distortion may thus be analyzed in terms of such components.

326 Maximum power transfer from a system (such as an amplifier or oscillator) to a load occurs when the impedance of the load equals the output impedance of the system.

327 The push-pull circuit reduces distortion by balancing out all even harmonics in the output.

328 The driver stage for a push-pull circuit is any circuit which can split the input signal into two parts which are 180 degrees out of phase with each other.

329 Negative feedback involves the feeding of part of the output signal back to the input 180 degrees out of phase with the input. Such feedback increases the stability of the amplifier at the expense of gain.

330 The operational amplifier is a special case of feedback amplifier which permits the output signal to be special functions of the input depending on the characteristics of the feedback network.

331 A feedback amplifier becomes an oscillator if the feedback signal is in phase with the input and the loss of signal in feedback is not greater than the gain of the amplifier.

332 A crystal has a characteristic resonant frequency which permits it to be used as a high quality tuned circuit for high frequency oscillators.

333 Ripple filters for power supplies rely on the energy storage properties of inductors and capacitors to smooth out pulsating voltages obtained from a rectifier.

334 RF amplifiers are generally designed to provide high gain over a narrow frequency range through the use of tuned circuits.

335 The superheterodyne receiver avoids the problem of simultaneous variable tuning of many circuits by converting the input signal to an intermediate frequency which may be amplified using fixed tuned circuits.

336 AM broadcast systems transmit intelligence by changing the amplitude of a high frequency carrier signal by an amount proportional to the amplitude of the intelligence signal.

337 FM broadcast systems transmit intelligence by changing the frequency of a carrier signal by an amount proportional to the amplitude of the intelligence signal.

338 FM systems have the advantage that high amplitude noise bursts can be suppressed without also suppressing useful information.

339 Radio broadcast systems of different frequencies have different ranges because of the different reflection characteristics of electromagnetic waves of various wavelengths when in contact with certain materials (such as the ground or the atmosphere).

340 Directional antennas are based on the inteference properties of electromagnetic waves for the reinforcement of waves in the desired direction and their suppression in undesired directions.

341 A bistable multivibrator (flip-flop) may be used as a switch since a pulse applied to one stage causes the other stage to change its state from conducting to non-conducting or the reverse.

342 In the image orthicon tube the beam from an electron gun is density modulated by a field resulting from variations of photoelectrons emitted at different points on a photosensitive plate.

343 The composite TV signal contains video and audio information as well as pulses for synchronization of the receiver.

344 In a TV picture tube the incoming video signal is used to modulate the intensity of the electron beam.

345 FM stereo broadcasting is achieved by transmitting the sum and difference of the two channel signals and the adding and subtracting of these signals at the receiver to recover separate channel signals.

346 Transducers are any devices which can be used to convert between electrical energy and other forms of energy.

347 Telemetry is based on the principle that transducers can convert other forms of energy into electrical signals characteristic of the original energy. These signals can then be used to modulate a carrier.

348 Single sideband communications requires close tolerences in filter and oscillator equipment since small frequency shifts cause relative large changes in the relation of carrier to sidebands.

349 The bi-stable multivibrator (flip-flop) may be used as the basic building block for devices which perform binary operations such as counting, bit storage or adding.

350 Small magnetic cores which may be magnetized in either a positive or negative direction by an electric current may be used to store information in binary form.

351 Color TV broadcast differs from black and white in requiring the transmission of three signals corresponding to the three primary colors. The relative strength of each signal determines the resultant color.

352 In the klystron tube a beam of electrons is velocity modulated by a small input microwave signal to produce a much larger signal at the same frequency.

353 Conventional circuits become inoperative at microwave frequencies because the small capacitances and inductances of terminals and leads introduce additional significant impedances.

354 A resonant cavity is resonant at any wavelengths which are integral multiples of the cavity length.

355 Control systems are based on the conversion of a deviation from the normal (error) into an electrical signal which can be amplified and used to drive a mechanical system designed to correct the error.

356 Complex switching operations may be carried out by the use of combinations of electromagnets or multivibrators. The automatic telephone exchange is an example of such switching.

357 Integrated circuits eleminate leads and terminals by making direct contact between components. This improves the high frequency characteristics of the circuits as well as reducing physical size.

358 The electronic analog computer uses combinations of operational amplifiers to produce an output which is a specified function of the input.

359 Radar involves the transmission of a pulse which is reflected from an object, the reflected signal being detected by the receiver and the time delay between transmitted and reflected pulse measured.

360 Maser action is based on the principle that molecules or atoms excited to a high energy level by an external energy source can be made to give up their energy by the application of a small amount of microwave energy.

361 A simple AND logic circuit consists of a transistor amplifier biased beyond cutoff and fed by a series of input signals such that an output signal appears only if a signal appears at all inputs.

362 If an electromagnetic wave is reflected from a moving object, the reflected wave shows a frequency change proportional to the speed of the object. The frequency change can be detected by combining the original and reflected waves and measuring the frequency of the resultant wave.

363 The magnetic amplifier uses a core magnetized to near saturation by DC current to exert control over a large AC current in a secondary winding. Near saturation a small DC change leads to a large change in the inductance of the coil.

364 High fidelity audio reproducing equipment has a nonlinear frequency response characteristic designed to reverse the nonlinearity in the recording characteristic.

365 In the general case, the amplitude and phase of the feedback signal in a feedback amplifier is a function of frequency. In designing such amplifiers it is therefore necessary to ensure that no frequency exists for which the feedback will be such as to produce oscillation.

366 The oscilloscope permits visual display of a voltage waveform by developing a continuous sweep of the beam in a cathode ray tube in a horizontal direction, while varying the vertical position of the sweep by the voltage whose waveform is to be observed.

367 A waveguide may be used to couple the antenna of a microwave system to the transmitter or receiver since the wavelengths of signals in the microwave region are of the same order of magnitude as the dimensions of practical apparatus.

368 If the reverse voltage across the junction of a semiconductor diode is sufficiently large, the few electrons which flow under reverse conditions may acquire sufficient energy to produce ionization by collision. The current under these conditions can become very large.

369 A synchro motor as used in servo systems is one in which the position of the rotor is a function of voltages applied to three stationary windings.

370 An amplitude modulated carrier signal is equivalent to a composite signal consisting of the carrier and the sum and difference frequencies (sidebands) between carrier and modulating frequencies. All information in the composite signal is contained in one of the sidebands.

371 In the Schmitt trigger the output circuit is in a conducting state only if the input signal is above a certain level. This circuit can thus be used to shape an arbitrary input signal into a square wave pulse.

APPENDIX B

LETTER TO EMPLOYERS,

INSTRUCTION AND REPORTING FORMS

FACULTY OF EDUCATION
DEPARTMENT OF SECONDARY EDUCATION

THE UNIVERSITY OF ALBERTA
EDMONTON, CANADA

Dear Sir:

As part of a research project being conducted by members of the Department of Secondary Education, University of Alberta, in cooperation with the Northern Alberta Institute of Technology, I am engaged in the development of an instrument for determining curriculum content in the Electronics Technology training program.

Basically the instrument will consist of decks of cards containing items of subject matter which could conceivably be included in the training program. Electronics technicians and technically competent supervisory personnel will be asked to sort these cards according to the degree of need for the items in particular occupations. The results of the card sorts will be analyzed to give a picture of the degree of usefulness of various elements of subject matter as well as a view of a possible common core of subject matter and areas of specialization.

If your organization has any electronics technicians in its employ, it would be appreciated if you could see fit to permit a small sample of these technicians to participate in the study. If so, perhaps you could indicate what steps I might take to contact appropriate personnel to arrange the logistics of the study. An abstract of the research proposal is enclosed to give some indication of the procedures to be followed and the times involved. If you require any further information or clarification of any point, I should be most happy to send a copy of the proposal or to discuss the matter with you or your representative at your convenience. I may be contacted by phone at 432-3658 or 433-1083.

Yours very truly,

Robert K. Crocker

RKC:arp
Enclosure

FORM A

EDUCATIONAL AND OCCUPATIONAL INFORMATION

1. ID Number______
2. Company ID______
3. Age______
4. Highest High School Grade Completed ______
5. Salary Code See Form B______

6. Electronics Training

Source	Time (months)	
Technical Institute	______	
Armed Forces	______	
Company Programs	______	
Individual Study	______	
Other (specify)	______	______________

7. Job History

List all jobs you have held related to electronics, including all different jobs with the present company. Jobs are to be described using the codes given on Form B. Jobs are to be considered as different if they can be described by different codes. If code 9 (other) applies, use the last column to describe the job. If more than one code number applies, use that which describes your predominant activity.

	Length of Employment (years)	Type of Work	Kind of Equipment	Other
1.	______	______	______	______________
2.	______	______	______	______________
3.	______	______	______	______________
4.	______	______	______	______________
5.	______	______	______	______________
6.	______	______	______	______________
7.	______	______	______	______________
Present Job	______	______	______	______________

8. If your present job has been classified as supervisory, give the approximate number of <u>technicians</u> under your supervision. ______

ID	C	A	P	E	TE	S	R	T	J1	J2	SU

FORM B

I JOB CODES

Code	Type of Work
1	Research and Development (including design and testing of prototypes)
2	Production
3	Maintenance
4	Installation
5	Calibration and Standardization
6	Operation
7	Sales
8	Supervision
9	Other

Code	Kind of Equipment
1	General Electronics (Basic amplifiers, audio equipment, etc.)
2	Broadcast (radio and TV)
3	Communications (including VHF and UHF equipment not included in code 2)
4	Telephone switching
5	Microwave
6	Navigational aids including radar
7	Computers, data processing equipment
8	Automatic control systems and industrial electronics
9	Other

II SALARY CODES

1	$3000-3999
2	$4000-4999
3	$5000-5999
4	$6000-6999
5	$7000-7999
6	$8000-8999
7	$9000-9999
8	$10000-11999
9	12000+

FORM C

CARD SORT INSTRUCTIONS

1. Cards in each deck are initially to be sorted into three piles in response to the appropriate question as given below. For the initial sort there are no restrictions on the number to be placed in each pile. The number of cards in each pile is to be entered in the box in the upper right hand corner of the appropriate reporting form.

2. The final sort is to consist of nine categories with each category having a fixed number of cards as indicated on the reporting forms. The simplest procedure is perhaps to take the three initial piles, starting with the most related pile, and begin sorting these into categories beginning with 9 and working downward until this pile has been exhausted. The middle pile can then be sorted beginning with the category in which the first pile ended. This procedure is continued until all cards are exhausted and all categories filled. It is suggested that adjacent categories then be compared as a check on whether perhaps the categories of some cards should be interchanged. Do not begin to write card numbers on the reporting form until you are satisfied that all cards are in their proper categories.

3. For the physics deck (card numbers starting with 1) the question is: "To what extent is the knowledge expressed in the card items required as background to the electronics knowledge used on your job?"

4. For the electricity deck (card numbers starting with 2) the question is: "To what extent is the knowledge expressed in the card items required <u>either</u> as background for learning in electronics <u>or</u> directly in your present job?"

5. For the electronics deck (card numbers starting with 3) the question is: "How often is the knowledge expressed in the card items used in your job either directly or indirectly?"

ID_____

FORM D

PHYSICS SORT REPORTING FORM

(Number at top of each category indicates number of cards in that category)

Initial Sort

Least 1 2 3 Most

4	5	7	9	12	9	7	5	4
1	2	3	4	5	6	7	8	9

Least Required — Scale Value — Most Required

ID_____

FORM E

ELECTRICITY SORT REPORTING FORM

(Number at top of each category indicates number of cards in that category)

Initial Sort

Least 1 2 3 Most

3	3	4	5	8	5	4	3	3
1	2	3	4	5	6	7	8	9

Least Required — Scale Value — Most Required

ID_____

FORM F

ELECTRONICS SORT REPORTING FORM

(Number at top of each category
indicates number of cards in that category)

Initial Sort

Least 1 2 3 Most

Number of cards	5	6	8	10	13	10	8	6	5
Scale Value	1	2	3	4	5	6	7	8	9

Least Often Used — Scale Value — Most Often Used

ID_____

FORM G

COMPANY INFORMATION FORM

1. Name of Organization (or local branch or plant if applicable)
   ____
2. Address ______________________ Telephone __________
3. Company Officer Contacted:

   Name ______________________ Title ______________________
4. Number of Technicians Employed (in local branch or plant __________
5. Number of Technicians Supplied for Study __________
6. General Type of Work Done by Company ______________________
   ____
7. Copy of Report of Study Required: Yes_____ No_____

APPENDIX C

SUPPLEMENTARY TABLES

TABLE XLVIII

SIX FACTOR OBLIQUE PATTERN MATRIX, PHYSICS SORT*

Card Item	Factor I	II	III	IV	V	VI
101	-13	-10	-32	-12	15	-38
102	27	-35	-21	-09	-28	-10
103	-18	-16	-09	25	-13	-28
104	-23	12	19	32	-00	-65
105	-22	09	-38	16	-04	-37
106	56	-07	13	-17	-21	17
107	59	-21	-07	05	-08	-07
108	63	-02	32	02	01	-15
109	05	-06	07	-16	28	-25
110	-64	-18	13	-14	-02	20
111	-22	-01	-26	-16	19	-13
112	13	-10	-06	-00	64	-02
113	-17	-19	-09	-24	48	13
114	-60	-38	17	-25	-10	-00
115	-04	03	10	63	-03	-17
116	16	01	24	61	-05	-14
117	32	-24	07	26	-12	09
118	05	-22	-10	36	-10	22
119	02	-01	04	68	-04	00
120	34	-04	09	20	35	22
121	07	-10	-06	17	23	32
122	-18	-04	-08	-21	12	48
123	-17	04	-80	-04	-02	13
124	-10	-13	-13	-06	11	49
125	-13	-23	26	28	-08	02
126	-11	-16	-07	-00	-36	27
127	-02	05	-06	-03	-25	49
128	-28	-24	35	41	-02	-25
129	52	03	23	06	-09	22
130	44	-17	-11	-01	33	26
131	-52	15	14	-03	-14	19
132	-09	01	45	-07	18	-16

TABLE XLVIII (continued)

Card Item	Factor I	II	III	IV	V	VI
133	-10	69	01	13	06	12
134	-29	71	-03	03	-08	18
135	07	39	-06	-24	04	-12
136	-03	45	-15	-22	28	08
137	02	71	09	-06	-17	-03
138	12	63	19	03	-20	-18
139	-07	-04	-93	-09	-02	16
140	-03	-04	-91	-14	-04	09
141	47	-03	15	-41	-23	16
142	-04	-36	-11	-05	-20	08
143	46	20	29	-19	-25	05
144	-08	-23	02	-12	13	02
145	03	07	-03	06	-52	-04
146	04	-20	-17	03	-48	13
147	-14	38	18	-13	26	17
148	-05	-08	30	-15	-21	09
149	-17	-21	15	-49	-03	06
150	-08	-50	14	-09	-01	-61
151	-10	-47	17	-36	06	-26
152	24	-03	18	-05	-01	-53
153	-39	-23	-04	-12	34	-28
154	-15	10	23	28	24	05
155	-13	43	-20	-13	-23	-20
156	-38	27	-04	11	-31	-18
157	-08	19	12	-34	-06	31
158	-02	06	30	14	42	17
159	18	49	-01	-02	21	-06
160	36	-21	-02	22	34	03
161	06	-16	03	-33	25	-28
162	22	-13	-13	15	-06	31

TABLE XLVIII (continued)

Factor	Correlations Between Factors				
I					
II	-11				
III	13	-27			
IV	22	-11	03		
V	-11	14	-07	03	
VI	25	-32	33	23	-10

*Entries to two decimal places, decimal point omitted

TABLE XLIX

EIGHT FACTOR OBLIQUE PATTERN MATRIX, ELECTRICITY SORT*

Card Item	Factor I	II	III	IV	V	VI	VII	VIII
201	48	-10	09	10	-21	21	-13	17
202	40	-13	01	-21	-11	-04	-45	-22
203	28	-16	-06	08	69	12	-05	-25
204	05	-04	16	09	18	17	-07	-77
205	32	-03	08	05	-25	01	71	07
206	19	-10	27	-28	12	-21	-44	-18
207	-54	-23	14	13	-20	14	-15	-25
208	-68	07	25	07	-13	-03	-19	11
209	-25	-45	10	07	-15	11	13	-34
210	-37	-06	34	-03	-26	-20	-08	-28
211	-65	-14	-21	-07	-15	14	-16	01
212	-16	-36	-24	-47	-10	-06	38	04
213	-04	-08	27	-27	-13	-12	02	63
214	-17	-10	11	-60	07	14	-09	44
215	-57	05	-25	-21	-04	23	-11	12
216	38	-05	02	-03	-08	37	12	11
217	-05	-23	14	42	06	06	22	27
218	-03	-00	-06	56	21	-04	-24	01
219	-02	07	23	-09	39	-00	-03	27
220	22	-45	04	30	09	-31	10	15
221	03	03	46	-16	64	12	20	-20
222	03	-10	34	-16	-02	69	06	-10
223	-12	02	-07	07	74	-08	-17	-09
224	08	-16	-06	04	-13	-16	-16	40
225	-04	48	07	13	06	-03	19	-03
226	40	34	-08	-03	-16	-02	-15	08
227	-07	45	22	44	-22	11	-02	11
228	27	10	06	-21	06	-04	81	-07
229	02	77	18	-03	-01	18	07	06
230	06	71	06	12	-01	-25	06	-19
231	-00	00	-02	76	-04	-10	02	-23
232	06	-19	-78	01	-14	-17	-07	08

TABLE XLIX (continued)

Card Item	I	II	III	IV	V	VI	VII	VIII
233	03	-05	-59	-07	-02	03	08	-24
234	-11	-06	-66	-05	13	-11	-00	09
235	09	-18	-05	05	-02	-70	-11	20
236	-04	01	-06	-03	02	55	-22	-05
237	55	01	-04	-03	-31	14	09	-16
238	-02	43	-03	-19	-19	-51	12	19

Correlations Between Factors

Factor							
I							
II	05						
III	03	-11					
IV	17	10	02				
V	-01	04	-00	08			
VI	-02	-05	-09	13	03		
VII	-18	04	-01	10	04	-03	
VIII	14	18	04	34	33	15	-05

*Entries to two decimal places, decimal point omitted

TABLE L

TEN FACTOR OBLIQUE PATTERN MATRIX, ELECTRONICS SORT*

Card Item	I	II	III	IV	Factor V	VI	VII	VIII	IX	X
301	36	24	21	22	-26	27	-01	-40	-03	20
302	12	-03	-32	-07	-21	-02	-56	01	18	-20
303	10	-02	-05	28	-01	15	-67	08	07	16
304	-06	14	-08	22	-15	25	-66	06	-06	-00
305	02	-15	07	17	22	21	-54	00	-06	07
306	14	26	-04	06	-03	66	-12	04	-05	-31
307	07	14	35	12	-08	03	16	34	-08	-21
308	12	-10	11	20	24	-26	02	-11	-34	05
309	17	-03	13	11	33	-09	-25	-20	-29	-02
310	22	-22	-39	-08	-03	37	-23	-04	18	-01
311	29	76	-03	-01	-03	33	02	-07	-24	-41
312	10	34	08	13	01	27	00	05	-62	-22
313	-21	31	09	00	20	72	02	-09	-03	-17
314	09	-08	-10	05	55	-27	23	12	10	09
315	05	17	-03	-04	69	03	-10	-05	02	-01
316	24	19	03	-22	68	-16	11	14	06	-04
317	06	-10	10	08	81	16	22	-01	10	-26
318	-01	65	15	11	23	36	-07	-04	-07	-04
319	01	01	02	12	-37	51	-21	-11	-03	04
320	13	22	-12	15	06	29	-03	23	54	-03
321	15	-22	15	14	-09	25	06	13	08	52
322	-17	65	-25	-30	18	16	28	-11	-05	-07
323	17	54	03	03	03	-07	05	04	08	15
324	07	34	-34	10	28	-25	-34	03	-17	19
325	-19	-11	-06	02	-16	-23	-08	01	14	75
326	04	05	06	00	21	-09	16	62	24	08
327	25	07	16	-11	-06	06	26	17	47	24
328	06	31	06	10	01	13	34	03	16	23
329	08	10	-23	17	06	07	51	24	07	18
330	07	05	-29	12	01	-29	35	-32	-18	09
331	07	01	-06	30	03	-03	62	19	-14	01

TABLE L (continued)

Card Item	I	II	III	IV	Factor V	VI	VII	VIII	IX	X
332	-15	06	22	22	02	-14	-07	03	36	-11
333	10	-02	-08	-16	-06	62	-09	-16	17	06
334	-35	42	25	13	-05	08	02	-07	03	-09
335	-03	53	11	10	-10	-20	-06	17	06	-29
336	09	14	40	-05	-08	-19	07	35	06	-25
337	23	-15	37	-10	01	-35	04	64	-04	-16
338	13	-12	53	-15	-09	-07	07	44	-15	04
339	-00	12	42	-19	-07	-28	-30	-02	09	-04
340	-32	11	30	-01	-32	-36	-12	03	03	06
341	-16	-48	-25	03	19	-00	25	-35	10	-16
342	09	-09	-12	-71	-05	10	-01	-08	-23	01
343	14	11	-09	-87	02	-03	-01	15	05	-10
344	-07	16	-21	-78	-07	-05	-10	09	09	-10
345	06	-12	16	-45	02	-11	17	35	-18	05
346	34	-04	-51	-02	-01	-17	-12	09	06	11
347	27	-28	-06	03	-19	-10	06	06	-37	05
348	-15	-08	72	21	-13	00	19	12	-09	11
349	07	-56	01	15	14	-06	12	-45	22	-12
350	40	-52	-10	-02	-08	09	-05	-35	11	-08
351	06	-00	00	-89	-08	06	18	07	03	-00
352	-78	04	-02	03	-13	-11	14	-09	-03	00
353	-82	-11	16	06	05	23	03	-03	-09	10
354	-71	-11	28	-03	-24	00	-03	-18	03	22
355	-05	01	-70	05	-39	-12	03	-09	01	08
356	36	-28	10	14	-09	-08	-05	05	-03	-11
357	25	-43	14	17	-00	-19	-17	-37	22	18
358	26	-27	-11	04	-17	-13	12	-45	-24	-06
359	-75	12	-27	18	-13	-12	-05	07	-06	-02
360	-42	-45	-10	-05	14	06	-06	01	-35	08
361	14	-47	06	13	14	-23	12	-43	-05	-21
362	-52	-15	-25	34	-15	-14	-15	29	02	07
363	08	-09	-21	25	-32	22	13	-10	-11	-29
364	31	22	-00	-49	-15	-12	-01	08	-01	40

TABLE L (continued)

Card Item	I	II	III	IV	Factor V	VI	VII	VIII	IX	X
365	09	11	-07	20	-19	-18	30	-16	-23	57
366	21	-16	-21	04	14	08	-20	-05	66	-03
367	-83	-15	10	01	-13	01	03	06	-08	-04
368	15	-10	11	15	64	-01	-12	10	-05	-18
369	-13	-06	-74	-05	-28	-16	12	03	07	-10
370	-01	22	63	19	-14	-09	-02	19	-06	-03
371	06	-14	-25	12	01	-44	26	-31	06	-13

Factor	Correlations Between Factors								
I									
II	-28								
III	-22	30							
IV	08	-02	-27						
V	22	-14	-19	06					
VI	23	01	-11	11	02				
VII	08	03	01	14	-06	-10			
VIII	-20	17	16	-14	-31	02	02		
IX	-25	31	27	-10	-25	-04	00	18	
X	30	04	-09	01	22	22	02	-03	-11

*Entries to two decimal places, decimal point omitted

TABLE LI

CORRELATIONS BETWEEN ITEMS, PHYSICS

Item	1	2	3	4	5	6	7	8	9	10
101	1.00									
102	.02	1.00								
103	.14	.14	1.00							
104	.25	-.21	.15	1.00						
105	.46	-.05	.28	.26	1.00					
106	-.31	.17	-.15	-.26	-.37	1.00				
107	-.18	.22	-.04	-.20	-.20	.38	1.00			
108	-.18	.11	-.19	-.14	-.22	.42	.37	1.00		
109	.09	-.10	.10	.00	.09	-.04	-.19	-.05	1.00	
110	-.05	-.18	.10	.02	.04	-.16	-.30	-.37	.12	1.00
111	.46	-.04	.05	.18	.30	-.14	-.27	-.25	.02	.14
	1.00									
112	-.11	-.07	-.11	-.03	.07	-.21	.00	.06	.16	-.08
	.11	1.00								
113	.11	-.10	.06	.00	.01	-.11	-.19	-.27	.23	.16
	.07	.26	1.00							
114	.01	-.03	.01	.00	-.02	-.22	-.19	-.21	.01	.52
	.07	-.04	.04	1.00						
115	-.24	-.00	.05	.11	.10	-.07	.01	.12	-.16	-.05
	-.14	.12	-.19	-.04	1.00					
116	-.13	-.06	-.02	-.03	-.07	.12	.18	.20	-.18	-.10
	-.23	-.11	-.22	-.16	.45	1.00				
117	-.37	.22	-.10	-.25	-.32	.27	.36	.27	-.19	-.21
	-.33	-.14	-.16	-.10	.20	.30	1.00			
118	-.19	.12	.02	-.24	-.10	.12	.22	.08	-.07	-.05
	-.23	-.09	-.17	-.12	.14	.16	.22	1.00		

TABLE LI (continued)

Item	1	2	3	4	5	6	7	8	9	10
119	-.16	-.04	-.03	.05	-.03	-.01	.08	.15	-.16	-.18
	-.19	.06	-.11	-.30	.35	.32	.29	.20	1.00	
120	-.20	.09	-.14	-.25	-.19	.23	.24	.30	-.07	-.17
	-.20	.19	-.05	-.25	.16	.29	.23	.13	.17	1.00
121	-.21	-.13	-.08	-.08	-.26	.09	.22	.12	-.12	-.09
	-.13	.14	.04	.06	-.06	.14	.15	.22	.15	.12
	1.00									
122	-.16	.01	-.17	-.26	-.28	-.01	.03	.04	-.14	.19
	-.08	-.03	.01	.05	-.10	-.22	-.10	.03	-.02	.11
	.07	1.00								
123	.27	-.05	-.04	.05	.29	-.29	-.18	-.36	.02	.01
	.22	.00	.09	-.05	-.09	-.20	-.30	-.04	-.11	-.28
	.02	-.13	1.00							
124	-.05	-.02	.11	-.25	-.16	.08	-.04	-.01	.04	.09
	-.05	-.10	.15	-.03	-.12	-.11	.12	.24	.14	.08
	.10	.19	-.15	1.00						
125	-.06	-.10	-.02	-.06	-.21	.15	.10	.19	-.03	.11
	-.12	-.15	-.12	.08	-.01	.25	.07	.15	.21	.20
	.15	.02	-.10	.13	1.00					
126	-.26	.08	-.00	-.24	-.05	.17	-.02	.00	-.18	.05
	-.04	-.12	-.12	.16	.06	.04	.04	.08	.01	.12
	.01	-.04	.03	.05	.22	1.00				
127	-.17	.26	-.14	-.31	-.24	.19	.05	-.03	-.07	.10
	-.10	-.20	.02	-.09	-.10	.03	.06	.22	.15	.10
	.02	.08	-.04	.19	-.03	.19	1.00			
128	-.03	.03	.13	.22	-.16	-.10	-.07	-.06	-.02	.11
	-.04	-.01	.09	.10	.12	.13	.03	.09	.34	-.09
	.08	-.02	-.13	-.13	.22	-.11	.02	1.00		
129	-.35	.07	-.13	-.26	-.40	.44	.46	.37	-.14	-.27
	-.35	-.11	-.21	-.25	.00	.28	.43	.35	.18	.27
	.14	.08	-.39	.17	.13	-.06	.11	-.05	1.00	
130	-.21	.09	.04	-.28	-.17	.28	.24	.20	-.01	-.19
	-.15	.14	-.01	-.20	.05	.12	.39	.10	.07	.44
	.17	.01	-.22	.23	-.08	.01	-.06	-.15	.31	1.00

TABLE LI (continued)

Item	1	2	3	4	5	6	7	8	9	10
131	.09	-.18	-.07	.08	.09	-.17	-.32	-.15	-.09	.25
	-.01	-.13	-.03	.32	-.16	-.20	-.06	-.05	-.11	-.07
	-.08	.08	-.07	.23	.03	.01	.03	-.03	-.11	-.14
	1.00									
132	.01	-.09	-.09	.05	-.07	-.04	-.06	.07	.07	.04
	.00	.16	.09	.07	-.13	-.03	-.10	-.06	-.02	.03
	-.06	.06	-.24	-.06	.09	.09	.08	.10	-.10	-.14
	.04	1.00								
133	-.04	-.30	.01	.20	.28	-.18	-.22	-.07	.04	-.16
	-.03	.04	-.11	-.19	.07	-.13	-.15	-.05	-.06	-.01
	-.02	-.11	.10	-.06	-.17	-.04	-.21	-.27	-.12	-.08
	.13	.08	1.00							
134	.07	-.27	-.07	.15	.20	-.31	-.36	-.25	-.07	-.06
	.17	.01	-.11	-.02	.07	-.15	-.23	-.14	-.06	-.31
	-.15	-.16	.22	-.06	-.20	-.07	-.06	-.15	-.26	-.14
	.15	-.04	.48	1.00						
135	.27	-.06	-.04	.22	.22	-.11	-.07	.07	.04	.05
	.24	-.03	-.03	-.04	-.14	-.25	-.26	-.28	-.28	-.08
	-.10	-.12	.13	-.17	-.14	-.23	-.08	-.24	-.19	-.25
	.07	-.03	.22	.14	1.00					
136	.24	-.16	-.10	.04	.21	-.30	-.15	-.13	.03	-.14
	.16	.16	.08	-.08	-.11	-.26	-.21	-.18	-.21	-.13
	.01	-.04	.13	-.08	-.28	-.35	-.25	-.24	-.17	.02
	.04	-.16	.43	.49	.22	1.00				
137	.07	-.14	-.09	.12	.11	-.12	-.16	-.10	.02	-.16
	-.00	-.17	-.15	-.21	-.04	.01	-.20	-.22	-.08	-.12
	-.29	-.04	.13	-.19	-.20	-.11	-.05	-.20	-.01	-.27
	.15	-.07	.28	.50	.23	.22	1.00			
138	.02	-.07	-.05	.18	.01	-.01	-.05	-.06	.08	-.18
	-.06	-.12	-.09	-.33	-.20	.03	-.18	-.11	-.06	-.12
	-.19	-.15	.05	-.20	-.13	-.26	.08	-.04	.05	-.20
	.05	.10	.26	.26	.10	.21	.48	1.00		
139	.30	.00	-.01	-.01	.31	-.22	-.09	-.38	-.05	-.04
	.22	.05	.03	-.10	-.10	-.23	-.19	-.13	-.06	-.09
	-.05	-.12	.77	-.03	-.27	-.03	-.03	-.22	-.36	-.09
	-.08	-.28	.08	.12	.13	.15	.04	-.01	1.00	
140	.33	-.01	.04	.00	.37	-.21	-.09	-.35	-.05	-.06
	.20	.01	.05	-.10	-.13	-.21	-.21	-.19	-.12	-.18
	-.14	-.11	.78	-.08	-.27	-.04	-.09	-.27	-.36	-.09
	-.05	-.26	.08	.11	.12	.16	.09	.01	.93	1.00

TABLE LI (continued)

Item	1	2	3	4	5	6	7	8	9	10
141	-.21	.04	-.14	-.33	-.26	.40	.11	.26	.01	-.11
	-.26	-.20	-.10	-.12	-.17	.06	.16	.04	-.06	.04
	-.04	-.06	-.22	.16	-.01	.20	.20	-.12	.33	.13
	-.10	.01	-.18	-.22	-.07	-.19	.05	-.06	-.17	-.11
	1.00									
142	-.21	.04	-.14	-.33	-.26	-.40	.11	.26	.01	-.11
	-.26	-.20	-.10	-.12	-.17	.06	.16	.04	-.06	.04
	-.04	-.06	-.03	-.02	.18	.18	.01	.01	-.04	-.02
	-.01	-.03	-.19	-.14	-.20	-.03	-.24	-.25	.01	.02
	.04	1.00								
143	-.23	.02	-.10	-.13	-.23	.34	.07	.39	-.11	-.16
	-.23	-.09	-.23	-.18	.02	.03	.05	-.03	.06	-.01
	.01	-.14	-.17	-.03	.04	.14	.16	.03	.23	.14
	-.18	.06	-.05	.00	.01	-.15	.00	.05	-.22	-.23
	.61	.07	1.00							
144	-.03	-.07	-.06	-.02	-.09	-.09	-.11	-.05	.10	-.06
	-.01	-.01	.07	.25	-.08	-.02	.07	-.05	-.07	-.00
	.00	-.06	.02	.17	.14	.26	-.05	-.03	-.09	.18
	.03	.18	.02	-.00	-.26	-.05	-.10	-.17	-.03	-.01
	.13	.11	.00	1.00						
145	-.12	.21	.08	.02	-.04	.17	.13	-.03	-.10	-.13
	-.09	-.12	-.14	-.02	.11	-.05	.02	-.03	.04	-.17
	-.09	.01	-.05	-.14	-.10	.16	.09	-.00	.03	-.15
	-.12	-.18	-.12	.10	-.06	-.08	.02	.13	.02	-.02
	-.01	.12	.09	-.26	1.00					
146	-.27	.21	.00	-.14	-.12	.13	.15	-.00	-.16	-.10
	-.10	-.14	-.16	-.06	.06	-.10	.17	.18	.04	-.10
	-.06	.15	-.02	-.03	.03	.31	.14	.05	.06	-.05
	-.13	-.22	-.17	-.04	-.19	-.18	-.11	-.04	-.01	-.01
	.14	.21	.06	.03	.47	1.00				
147	.06	-.20	-.08	.06	-.03	-.09	-.27	-.15	-.06	.00
	.09	.18	.22	-.10	-.05	-.12	-.23	-.27	-.11	.04
	.02	.18	-.01	-.09	-.13	-.04	-.14	-.02	-.18	-.07
	-.01	.06	.15	.24	.08	.17	.24	.21	-.04	-.05
	-.10	-.04	-.06	-.06	-.03	-.13	1.00			
148	-.13	.13	.01	-.19	-.25	.15	-.09	.03	-.11	-.09
	-.17	-.20	-.01	.10	-.10	-.06	.07	-.13	-.01	.01
	-.06	.08	-.29	-.06	.07	.16	.02	.10	.06	-.01
	-.06	.03	-.07	-.13	-.10	-.05	-.24	-.08	-.21	-.22
	.11	.19	.28	-.08	.27	.09	.09	1.00		

TABLE LI (continued)

Item	1	2	3	4	5	6	7	8	9	10
149	-.06	-.02	-.10	-.12	-.05	-.04	-.08	-.04	-.04	.29
	.10	.01	.00	.53	-.20	-.14	-.12	-.14	-.36	-.21
	-.00	.05	-.00	-.12	-.03	.03	-.02	.07	-.08	-.07
	.03	.05	-.23	-.04	-.02	-.10	-.00	-.12	-.10	-.06
	.14	-.01	.06	.10	-.13	-.01	.02	-.02	1.00	
150	.16	.06	.06	.19	.03	-.14	-.04	-.15	.05	.02
	-.00	-.04	.07	.18	-.09	-.03	.00	-.10	-.14	-.24
	-.05	-.06	-.05	-.13	-.02	-.04	-.31	.20	-.17	-.08
	.01	.09	-.23	-.21	-.22	-.08	-.10	-.04	-.04	.01
	-.05	-.01	-.18	.17	.01	.04	-.02	.04	.11	1.00
151	.07	-.03	-.09	.12	-.16	-.01	.00	-.05	-.09	-.15
	.04	-.02	.09	.29	-.21	-.29	.01	-.06	-.18	-.11
	-.14	.09	-.16	-.01	.01	-.07	-.21	-.02	-.04	-.07
	.14	.05	-.26	-.15	-.05	-.06	-.17	-.24	-.09	-.06
	.01	.05	-.13	-.06	-.09	.06	-.01	.17	.29	.46
	1.00									
152	-.11	.00	-.10	.17	-.01	-.02	-.04	.08	.30	-.07
	-.06	.05	-.11	-.14	-.01	.01	-.06	-.00	-.07	-.03
	-.15	-.11	-.04	-.13	-.02	-.02	-.10	-.07	-.15	-.16
	-.08	.07	-.00	-.12	-.02	-.09	.09	.20	-.06	-.02
	.10	-.06	.01	.07	-.15	-.10	-.01	-.17	-.10	.25
	.07	1.00								
153	.37	-.12	.01	.21	.17	-.39	-.26	-.30	.22	.11
	.28	.11	.25	.29	-.08	-.25	-.26	-.12	-.22	-.08
	-.25	.09	.10	-.01	.01	-.22	-.14	-.06	-.37	-.25
	.12	.15	-.01	.03	.01	.19	-.00	-.05	.11	.10
	-.34	-.06	-.46	.10	-.18	-.16	.01	-.08	.07	.24
	.31	.10	1.00							
154	-.06	-.18	-.05	.11	-.10	-.13	-.12	-.07	-.09	-.01
	.04	.01	-.04	-.03	.00	.25	.20	-.04	.05	.18
	.05	-.01	-.10	-.19	.13	-.09	-.02	.17	-.04	.10
	-.01	.06	.01	.06	-.02	.06	.03	-.00	-.14	-.16
	-.12	-.03	-.15	.00	-.09	-.08	.07	.05	-.08	-.10
	-.06	-.16	.13	1.00						
155	.28	-.04	.14	.22	.36	-.22	-.11	-.13	.07	-.09
	.24	-.21	-.08	.01	-.11	-.21	-.20	-.36	-.19	-.30
	-.24	-.06	.21	-.11	-.32	-.17	-.13	-.30	-.27	-.23
	.16	-.02	.33	.29	.37	.29	.30	.23	.26	.31
	-.18	-.10	-.16	-.11	.02	-.19	-.01	-.07	-.09	-.09
	-.17	.05	.17	-.13	1.00					

TABLE LI (continued)

Item	1	2	3	4	5	6	7	8	9	10
156	.07	-.14	.24	.18	.36	-.30	-.18	-.22	.08	.13
	.09	-.21	-.17	.14	.00	-.12	-.21	-.07	-.12	-.27
	-.09	-.12	.13	-.08	-.18	-.06	-.14	-.07	-.21	-.25
	.32	-.11	.24	.16	.23	.10	.12	.16	.14	.15
	-.24	-.19	-.16	-.15	-.03	-.13	-.04	.02	-.02	.01
	-.01	.09	.06	-.19	.47	1.00				
157	-.14	-.00	-.12	-.17	-.15	.04	-.03	-.13	-.02	.17
	-.06	-.11	.10	.10	-.08	-.03	-.08	-.18	-.21	-.11
	-.09	.18	-.05	-.06	.03	-.10	.06	.02	.18	-.01
	-.08	-.09	.01	.06	.06	.11	.07	-.04	-.05	-.06
	.03	-.08	-.01	-.08	.02	-.01	-.02	.05	.30	-.13
	-.01	-.08	-.14	.06	.01	.02	1.00			
158	-.12	-.11	-.03	-.08	-.26	-.02	-.06	.07	.08	-.03
	-.08	.25	.17	-.10	.22	.14	-.05	.04	.06	.17
	.17	.20	-.23	.07	-.08	-.15	.07	.16	.03	.05
	-.11	.15	.05	-.13	-.05	.02	-.17	-.13	-.22	-.27
	-.02	-.09	.06	-.08	-.02	-.21	.18	.17	-.14	-.07
	-.06	-.12	.05	.10	-.19	-.07	-.01	1.00		
159	.08	-.23	-.05	.15	.03	-.15	.02	-.15	.01	-.19
	.19	.16	-.02	-.26	-.00	-.03	-.27	-.23	-.00	-.01
	.06	-.14	.20	-.19	-.17	-.07	-.14	-.01	-.16	-.08
	-.21	.01	.25	.37	.20	.17	.27	.25	.10	.09
	-.09	-.37	.17	-.01	-.04	-.14	.20	-.18	.06	-.13
	-.17	.11	-.09	.04	.07	-.05	-.06	-.00	1.00	
160	-.12	-.03	.04	-.08	-.20	.13	.14	.28	.11	-.09
	-.12	.19	.04	-.19	.15	.19	.22	.13	.15	.26
	.08	-.02	-.06	.04	.11	-.11	-.02	.03	.33	.32
	-.19	-.12	-.19	-.20	-.01	-.24	-.18	-.15	-.11	-.11
	.01	-.11	.09	-.08	-.13	.01	-.13	.03	-.11	-.18
	-.06	-.06	-.13	.15	-.38	-.26	-.23	.15	.01	1.00
161	.25	-.03	.01	.02	.14	-.25	-.18	-.06	.07	.06
	.16	.16	.14	.12	.01	-.15	-.13	-.14	-.20	-.14
	-.10	-.02	-.03	-.10	-.23	-.10	-.17	-.09	-.14	-.03
	-.12	.02	-.10	.03	.09	.26	-.01	-.19	-.03	-.02
	.03	-.03	.03	.06	-.03	-.11	-.07	.07	.08	.16
	.21	.10	.17	.01	.01	-.07	.12	-.06	.06	-.03
	1.00									
162	-.19	.11	-.14	-.13	-.23	.28	.09	.12	-.26	-.15
	-.08	-.06	-.12	-.23	-.04	.18	.20	.34	.10	.08
	.19	.15	-.09	.06	.03	.09	.11	.05	.37	.09
	-.09	-.15	-.05	-.21	-.10	-.29	-.11	-.13	-.02	-.04
	.13	.13	.09	-.22	-.10	.24	-.16	.06	-.05	-.09
	.02	-.11	-.24	.04	-.29	-.19	-.04	.13	-.09	.39
	-.24	1.00								

TABLE LII

CORRELATIONS BETWEEN ITEMS, ELECTRICITY

Item	1	2	3	4	5	6	7	8	9	10
201	1.0									
202	.31	1.00								
203	.12	.02	1.00							
204	-.13	.04	.00	1.00						
205	.11	.23	-.06	-.06	1.00					
206	-.06	.30	.02	.20	-.19	1.00				
207	-.14	.02	-.11	.21	-.23	-.10	1.00			
208	-.27	-.23	-.21	-.09	-.14	-.05	.30	1.00		
209	-.17	.04	-.10	.37	-.03	-.09	.54	.05	1.00	
210	-.20	.07	-.29	.13	-.06	.14	.27	.30	.18	1.00
211	-.25	-.10	-.15	.04	-.13	-.06	.33	.35	.22	.17
	1.00									
212	-.17	-.02	-.11	-.05	.09	-.01	.14	.02	.26	.23
	.21	1.00								
213	-.01	-.03	-.11	-.20	-.06	-.00	-.05	.02	-.09	-.03
	-.10	-.13	1.00							
214	-.09	-.05	.02	-.09	-.21	.15	.03	.06	.05	.00
	.09	.15	.15	1.00						
215	-.17	-.16	-.11	-.02	-.22	-.12	.30	.15	.08	.01
	.48	.20	-.09	.18	1.00					
216	.16	.04	.01	-.05	-.01	-.15	-.10	-.05	-.05	-.28
	-.21	-.06	-.06	-.14	-.24	1.00				
217	.02	-.21	.01	-.15	.08	-.18	-.07	-.08	.07	-.19
	-.11	-.21	.15	-.05	-.13	.01	1.00			
218	.02	-.11	.21	-.11	-.01	-.08	-.11	.10	-.15	-.24
	-.16	-.29	-.10	-.10	-.06	-.18	.07	.18	1.00	

TABLE LII (continued)

Item	1	2	3	4	5	6	7	8	9	10
219	.02	-.14	.14	-.05	-.10	-.03	-.16	.01	-.10	-.18
	-.16	-.13	.16	.20	-.03	.06	.02	1.00		
220	.13	-.09	.08	-.00	.13	.13	-.15	-.14	-.07	-.06
	-.19	-.11	.05	-.15	-.24	-.01	.19	.06	.07	1.00
221	-.15	-.10	.28	.04	.04	.06	-.07	-.07	-.06	.08
	-.08	-.04	.11	.10	-.08	.01	.09	-.07	.25	-.04
	1.00									
222	.10	.01	.01	.19	.04	.04	.07	.09	.13	.03
	.03	.06	-.05	.11	.06	.21	.09	-.12	-.04	-.13
	.09	1.00								
223	-.10	-.01	.28	-.08	-.27	-.05	-.12	.09	-.16	-.15
	-.06	-.04	.00	-.03	.02	-.03	.05	.15	.20	.02
	.30	-.06	1.00							
224	.09	-.05	.02	-.11	.02	.02	-.14	-.02	-.21	-.05
	-.07	-.12	-.04	.05	.00	.06	.04	.10	.02	.15
	-.19	-.04	.04	1.00						
225	-.11	-.25	-.13	-.06	.04	-.19	-.07	-.09	-.27	.01
	-.14	-.11	-.05	-.04	-.08	-.00	.04	.04	.02	-.06
	.03	-.11	.05	.08	1.00					
226	.14	.11	-.09	-.08	-.02	.02	-.15	-.22	-.25	-.28
	-.25	-.37	.08	-.14	-.15	.16	-.05	-.05	.02	-.07
	-.11	-.19	-.08	.10	.21	1.00				
227	.11	-.18	-.16	-.21	.10	-.21	-.11	-.03	-.16	-.07
	-.19	-.32	.10	-.17	-.14	.08	.12	.20	.11	-.08
	-.01	-.01	-.14	-.13	.20	.05	1.00			
228	-.11	-.23	.01	.01	.44	-.23	-.09	-.11	.02	-.13
	-.22	.14	-.03	-.13	-.07	.06	.07	-.18	-.06	.04
	.16	-.02	-.07	-.14	.17	.02	-.14	1.00		
229	.03	-.20	-.10	-.17	.09	-.07	-.31	.02	-.37	-.11
	-.15	-.33	.07	-.05	.04	-.07	.01	.01	.07	-.11
	-.01	.00	-.00	-.18	.23	.12	.41	.10	1.00	
230	-.04	-.11	-.11	.00	.05	-.11	-.21	-.01	-.21	-.11
	-.23	-.24	-.11	-.18	-.10	-.13	-.04	.04	.02	-.12
	-.14	-.21	-.00	.01	.28	.17	.22	.16	.45	1.00

TABLE LII (continued)

Item	1	2	3	4	5	6	7	8	9	10
231	.15	-.11	.03	-.05	.16	-.18	-.06	-.12	-.10	.02
	-.12	-.21	-.16	-.38	-.13	-.08	.22	.13	-.02	.11
	-.03	-.11	-.05	-.02	.10	.04	.32	-.05	-.03	.02
	1.00									
232	-.07	.01	-.07	.01	-.09	-.12	-.06	-.23	-.01	-.17
	.09	.12	-.10	-.04	.10	-.09	-.11	-.01	-.07	.02
	-.44	-.25	-.02	.04	-.10	.12	-.16	-.12	-.21	-.09
	-.03	1.00								
233	-.16	-.01	.02	.04	-.04	-.10	-.11	-.07	-.01	.04
	.11	.26	-.19	-.07	.04	-.11	-.13	-.09	-.23	-.10
	-.15	-.07	-.12	-.15	-.13	.01	-.11	-.04	-.14	-.07
	-.03	.42	1.00							
234	-.19	.02	-.04	-.15	-.15	-.15	-.08	-.18	-.03	-.18
	.17	.13	-.07	-.03	.16	.01	-.10	-.04	-.12	-.02
	-.19	-.21	.15	-.09	-.01	-.13	-.13	-.06	-.03	-.08
	-.02	.31	.20	1.00						
235	-.00	.06	.00	-.17	-.03	.21	-.19	-.02	-.10	-.04
	-.17	-.03	.07	-.12	-.17	-.11	-.05	.06	-.08	.18
	-.05	-.32	-.03	.03	-.11	.08	-.06	-.00	-.20	.04
	.03	.03	-.08	.05	1.00					
236	.06	-.03	.09	.05	-.06	.04	.05	.06	-.11	-.09
	.14	-.06	-.10	.03	.14	.06	-.04	.01	-.08	-.15
	.03	.27	-.12	-.04	-.12	.01	-.03	-.17	-.02	-.24
	-.03	-.06	.11	.02	-.16	1.00				
237	.14	.24	.01	.02	.20	.02	-.15	-.25	.02	-.02
	-.20	-.10	-.07	-.09	-.27	.18	-.11	.08	-.19	-.01
	-.16	-.03	-.23	.04	-.07	.14	-.01	.07	.05	.01
	.02	.11	.01	-.11	-.15	-.08	1.00			
238	-.14	-.02	-.14	-.19	.10	-.07	-.15	.06	-.24	-.01
	-.10	.02	.03	-.05	-.09	-.09	-.15	-.07	.00	-.24
	-.08	-.36	-.11	.06	.07	.09	.12	.16	.16	.39
	-.02	-.01	-.06	.01	.27	-.23	-.08	1.00		

TABLE LIII

CORRELATIONS BETWEEN ITEMS, ELECTRONICS

Item	1	2	3	4	5	6	7	8	9	10
301	1.00									
302	-.14	1.00								
303	.07	.30	1.00							
304	.11	.32	.61	1.00						
305	.04	.24	.47	.44	1.00					
306	.27	.17	.15	.29	.03	1.00				
307	-.16	-.07	-.18	-.12	-.25	.03	1.00			
308	.18	-.09	-.12	-.18	.04	-.23	-.17	1.00		
309	.01	-.01	.21	.07	.30	.02	-.27	.29	1.00	
310	.09	.22	.34	.25	.21	.26	-.32	-.00	.16	1.00
311	.30	-.03	.06	.12	-.05	.42	.09	-.03	-.01	-.03
	1.00									
312	.13	-.11	.03	.20	.10	.18	.03	.15	.09	.01
	.30	1.00								
313	.21	-.07	.08	.23	.12	.44	.02	-.14	-.09	.09
	.36	.21	1.00							
314	-.08	-.15	-.14	-.16	.00	-.18	-.17	.25	.12	-.06
	-.20	-.02	-.14	1.00						
315	.05	-.12	-.02	.06	.24	.05	-.23	.13	.26	.05
	-.02	.11	.12	.33	1.00					
316	.02	-.25	.02	-.11	.03	-.04	-.09	.29	.23	-.07
	.11	.02	.05	.39	.32	1.00				
317	-.02	-.22	-.09	-.16	.10	.01	-.23	.15	.31	.07
	-.05	.01	.09	.39	.51	.35	1.00			
318	.26	-.06	.09	.19	.10	.35	.08	-.09	-.07	-.08
	.43	.25	.46	-.12	.23	.11	.06	1.00		
319	.28	.24	.26	.39	.23	.38	.00	-.23	-.06	.15
	.09	.14	.25	-.24	-.05	-.23	-.11	.15	1.00	

TABLE LIII (continued)

Item	1	2	3	4	5	6	7	8	9	10
320	.17 .21	.05 -.05	.11 .31	.18 -.17	.01 -.10	.25 -.01	.07 -.08	-.18 .23	-.30 .11	.08 1.00
321	.22 -.12 1.00	-.10 .09	.16 .08	.06 .01	.12 -.02	.13 -.05	-.15 .00	-.01 .01	-.08 .04	.26 .04
322	-.02 .38 -.10	-.19 -.03 1.00	-.19 .29	-.18 -.07	-.12 .16	.02 .10	.11 .06	-.20 .36	-.06 -.04	-.22 .09
323	.14 .13 -.00	-.01 .18 .15	-.01 .09 1.00	.02 .08	-.02 .06	.07 .11	.10 -.03	-.21 .33	.09 .00	-.26 .28
324	.03 .01 .04	.11 .09 .07	.21 -.05 -.00	.09 .22 1.00	.15 .25	.05 .26	-.19 .07	.29 .09	.26 -.17	.17 -.02
325	.04 -.22 .23	-.07 -.10 -.06	.01 -.17 .14	.04 .13 .09	-.05 .04 1.00	-.17 -.05	-.09 -.23	-.05 -.02	-.12 -.01	-.08 .05
326	-.20 .01 .09	-.11 .00 .07	-.12 .01 .16	-.14 .15 -.09	-.13 -.11 .15	-.11 .11 1.00	.25 -.07	-.14 .11	-.36 -.18	-.24 .25
327	.14 .03 .13	-.07 -.23 .07	-.13 .02 .23	-.15 .02 -.22	-.22 -.04 .14	.00 -.06 .32	.13 -.12 1.00	-.18 .13	-.18 .11	-.09 .23
328	.20 .14 .04	-.18 -.05 .14	-.07 .19 .24	-.19 -.02 .02	-.18 -.13 .01	.08 .14 .21	.11 -.07 .51	-.10 .27 1.00	-.05 .03	-.08 .23
329	.02 .06 .31	-.19 -.04 .11	-.04 -.11 .14	-.12 .16 .02	-.18 -.07 .01	-.01 .16 .12	-.00 .09 .21	-.10 .03 .25	-.03 -.02 1.00	.05 .08
330	.10 -.07 .02	-.20 .00 .07	-.19 -.25 -.12	-.21 .29 .11	-.09 .08 -.01	-.20 .25 -.23	-.23 .13 -.23	.35 -.21 -.01	.14 -.11 .19	-.02 -.23 1.00
331	-.04 -.04 .14 1.00	-.26 .11 .06	-.24 -.12 .07	-.31 .20 -.10	-.23 -.11 -.01	-.05 .13 .01	.20 .09 .08	.11 -.05 .21	-.04 -.11 .49	-.11 .03 .37

TABLE LXXI (continued)

Item	1	2	3	4	5	6	7	8	9	10
332	-.10	.04	-.06	-.04	-.12	.01	.28	-.11	-.18	-.18
	.01	-.23	-.03	-.13	-.14	-.02	-.12	.10	-.10	.14
	-.07	.06	-.02	-.07	-.05	.05	.24	.11	-.13	-.24
	-.01	1.00								
333	.27	.05	.22	.25	.22	.35	-.12	-.16	.01	.43
	.17	.10	.28	-.22	.07	-.02	.08	.12	.27	.12
	.29	.08	-.05	-.04	.01	-.10	.13	.04	-.02	-.23
	-.25	-.08	1.00							
334	-.07	-.16	-.01	.05	-.11	-.01	.37	-.24	-.23	-.29
	.23	.01	.24	-.14	-.13	-.19	-.15	.31	-.03	.17
	-.11	.34	.14	-.05	-.13	-.17	.07	.14	-.04	-.25
	-.03	.33	-.10	1.00						
335	-.15	-.01	-.14	.02	-.30	.01	.42	-.25	-.29	-.27
	.24	.02	.11	-.17	-.21	-.10	-.19	.22	-.16	.17
	.25	.19	.28	-.06	-.12	.24	.09	.14	-.11	-.26
	-.07	.37	-.12	.59	1.00					
336	-.12	-.13	-.23	-.19	-.27	-.03	.45	-.35	-.28	-.35
	.10	-.09	-.10	-.21	-.17	-.20	-.10	.07	-.13	.06
	-.16	.14	.11	-.31	-.10	.35	.22	.05	-.06	-.26
	-.10	.29	-.18	.28	.42	1.00				
337	-.30	-.03	-.22	-.17	-.18	-.24	.24	-.10	-.24	-.32
	-.09	-.05	-.21	.07	-.17	-.08	-.05	-.18	-.18	-.00
	-.09	-.13	.02	-.26	.01	.36	.23	-.02	-.08	-.21
	.02	.12	-.33	.02	.22	.63	1.00			
338	-.14	-.21	-.12	-.09	-.17	-.10	.31	-.20	-.16	-.27
	.02	-.05	.10	-.16	-.21	-.09	-.13	-.01	-.09	.01
	.02	-.02	.13	-.30	.03	.27	.20	.03	-.-1	-.30
	-.08	.12	-.02	.10	.19	.44	.62	1.00		
339	-.17	.04	-.15	-.03	-.07	-.09	.06	-.19	-.06	-.29
	-.01	-.12	-.10	-.20	-.05	-.17	-.09	.13	-.10	.02
	-.16	.08	.09	-.10	.03	.09	.03	-.10	-.32	-.37
	-.31	.23	-.16	.25	.35	.39	.36	.33	1.00	
340	-.27	-.02	-.12	-.04	-.33	-.17	.32	-.21	-.24	-.40
	-.01	-.23	-.11	-.31	-.37	-.25	-.32	.01	-.15	-.05
	-.16	-.01	.09	-.21	.17	.19	.09	-.01	-.15	-.32
	-.17	.37	-.30	.45	.55	.47	.30	.29	.51	1.00
341	-.09	-.04	-.12	-.13	.06	-.24	-.35	.23	.25	.20
	-.31	.08	-.19	.27	.09	.13	.29	-.32	-.13	-.18

TABLE LIII (continued)

Item	1	2	3	4	5	6	7	8	9	10
	-.15	-.19	-.20	-.01	-.03	-.26	-.32	-.20	.08	.29
	.13	-.22	.02	-.28	-.37	-.40	-.26	-.31	-.31	-.33
	1.00									
342	-.14	.10	-.07	-.07	.07	-.04	-.11	.01	.04	.17
	.00	-.00	-.01	.01	-.02	-.12	-.02	-.17	-.09	-.19
	-.06	-.02	-.06	-.02	.12	-.02	-.14	-.15	-.24	-.01
	-.16	-.34	.11	-.24	-.27	-.06	.10	.02	.00	-.08
	.05	1.00								
343	-.27	.15	-.08	-.11	-.15	-.11	.13	-.22	-.17	-.04
	.10	-.13	-.11	-.11	-.04	-.19	-.04	-.09	-.11	-.07
	-.06	.14	.02	-.10	-.04	.18	.19	-.05	-.14	-.28
	-.28	-.05	-.02	-.00	.11	.21	.27	.25	.27	.19
	-.22	.49	1.00							
344	-.29	.32	-.12	-.06	-.14	-.05	.14	-.32	-.25	-.04
	-.01	-.15	-.04	-.14	-.07	-.22	-.15	-.03	-.02	-.08
	-.19	.13	.08	-.11	-.07	.12	.18	.01	-.23	-.25
	-.32	.06	-.02	.06	.21	.21	.25	.18	.33	.26
	-.26	.36	.75	1.00						
345	-.16	-.23	-.21	-.17	-.10	-.08	.01	.04	-.06	-.18
	-.01	-.19	-.14	-.04	-.07	-.12	-.03	-.06	-.21	-.05
	-.05	-.04	-.08	-.27	.01	.11	.20	-.08	.01	-.12
	-.05	-.03	-.15	-.12	.01	.31	.45	.46	.16	.19
	-.18	.19	.40	.29	1.00					
346	.14	.12	.11	.02	.08	-.09	-.24	.16	.26	.34
	-.08	-.15	-.21	.09	.16	.02	.05	-.22	-.04	.03
	.08	.02	-.15	.21	.03	-.08	-.11	-.17	.13	.20
	.04	-.20	.06	-.33	-.34	-.25	-.24	-.21	-.36	-.38
	.07	.04	-.09	-.10	.03	1.00				
347	.10	.01	-.06	-.14	-.05	.01	-.20	.23	.11	.09
	-.17	.04	-.18	.08	.01	.03	-.02	-.29	-.03	-.40
	.14	-.19	-.18	.13	-.06	-.07	-.10	-.09	.02	.13
	.07	-.21	.00	-.40	-.29	-.24	-.08	.04	-.28	-.27
	.11	.05	-.06	-.16	-.01	.34	1.00			
348	.01	-.30	-.23	-.20	-.19	-.06	.42	-.12	-.17	-.35
	-.07	-.11	.07	-.12	-.25	-.09	-.14	.06	-.05	.05
	.05	.01	.09	-.27	-.04	.19	.17	.17	.01	-.21
	.08	.14	-.17	.42	.35	.34	.30	.34	.34	.41
	-.31	-.12	-.05	-.08	.10	-.42	-.05	1.00		

TABLE LIII (continued)

Item	1	2	3	4	5	6	7	8	9	10
349	.05 -.30 .05 .02 .67	-.02 -.09 -.29 -.12 -.02	-.06 -.18 -.25 .05 -.24	-.17 .20 .00 -.27 -.31	.10 .13 -.07 -.36 -.23	-.18 .11 -.29 -.36 .13	-.35 .26 -.21 -.30 .24	.27 -.33 -.17 -.22 -.26	.23 -.13 .03 -.28 1.00	.19 -.21 .24 -.32
350	.18 -.24 .16 -.01 .47	.13 .00 -.37 -.31 .14	.07 -.13 -.25 .23 -.15	-.05 .15 .03 -.56 -.20	.27 .03 -.08 -.53 -.11	.03 .07 -.40 -.43 .30	-.42 .20 -.14 -.24 .37	.21 -.36 -.21 -.29 -.32	.31 .08 -.12 -.26 .53	.49 -.20 .20 -.50 1.00
351	-.22 .05 -.01 -.18 -.15 1.00	.02 -.11 .13 -.03 .50	-.25 -.07 .04 .04 .81	-.16 -.04 -.21 .02 .65	-.21 -.17 .04 .07 .46	-.10 -.21 .17 .19 -.20	.06 -.02 .21 .31 -.08	-.21 -.16 -.06 .33 .04	-.22 -.11 -.09 .32 -.23	-.07 .00 -.29 .18 -.09
352	-.29 -.01 -.34 -.02 -.05 .03	-.03 -.03 .10 .26 -.18 1.00	-.21 -.02 .07 -.30 -.06	-.14 -.18 -.18 .38 .12	-.26 -.28 .09 .30 .02	-.19 -.20 .11 .22 -.30	.24 -.22 -.08 .07 -.34	-.09 .02 -.04 -.00 .14	-.31 -.11 -.05 .15 -.22	-.46 -.00 -.07 .51 -.44
353	-.20 -.02 -.12 -.08 -.08 -.05	-.04 -.07 .15 .25 -.19 .47	-.01 .17 -.13 -.12 -.07 1.00	-.04 -.12 -.11 .29 .03	-.09 -.03 -.01 .11 -.04	.10 -.16 .02 .14 -.25	.23 -.09 -.16 -.06 -.13	-.20 .12 -.00 .06 .27	-.11 .02 -.11 .11 -.22	-.16 -.03 -.19 .27 -.40
354	-.10 -.07 -.18 -.19 -.17 .08	-.01 -.11 .08 .24 -.13 .67	-.02 .07 .02 -.16 .04 .53	-.01 -.23 -.23 .43 .16 1.00	-.18 -.19 .09 .15 .01	-.20 -.37 .08 .31 -.28	.22 -.26 .04 .10 -.32	-.26 .01 -.10 .23 .28	-.27 .04 -.12 .31 -.21	-.40 -.01 -.25 .48 -.44
355	.01 -.06 -.04 .03 .22 -.18	.06 -.06 .08 -.14 -.12 -.03	-.04 -.11 -.06 .06 -.22 -.06	-.02 -.04 .10 -.20 -.16 -.12	-.08 -.12 .07 -.12 -.18 1.00	-.02 -.09 -.16 -.26 .30	-.33 -.14 -.16 -.21 .29	-.08 -.26 -.05 -.26 -.31	-.07 .08 .09 -.18 .08	.17 -.09 .14 -.15 .21

TABLE LIII (continued)

Item	1	2	3	4	5	6	7	8	9	10
356	.13	.05	.04	-.03	-.05	-.05	-.06	.18	.10	.02
	-.11	.01	-.20	.05	-.04	.05	.01	-.22	.13	-.04
	.02	-.09	-.25	-.04	-.05	-.07	-.07	-.24	-.06	.04
	.08	-.12	-.01	-.25	-.25	-.12	.04	.02	-.05	-.21
	.21	-.09	-.11	-.21	-.05	.19	.25	-.06	.20	.28
	-.09	-.21	-.15	-.13	.12	1.00				
357	.21	.04	.13	-.03	.16	-.14	-.35	.18	.28	.18
	-.30	-.25	-.16	.14	.09	.12	.09	-.25	-.00	-.21
	.15	-.26	-.28	.08	.01	-.23	-.11	-.09	-.12	.27
	-.04	-.20	-.03	-.32	-.37	-.24	-.18	-.18	-.04	-.28
	.27	.03	-.17	-.22	-.21	.21	.25	-.12	.41	.49
	-.18	-.38	-.19	-.16	.08	.12	1.00			
358	.15	-.04	-.03	-.13	.08	-.10	-.34	.33	.35	.30
	-.12	.04	-.24	.11	.01	.00	.10	-.26	-.11	-.37
	-.03	-.27	-.23	.01	-.08	-.46	-.24	-.12	-.01	.52
	.14	-.27	-.05	-.42	-.41	-.31	-.25	-.22	-.37	-.33
	.37	.16	-.28	-.31	-.04	.30	.34	-.28	.53	.63
	-.24	-.24	-.26	-.32	.16	.10	.29	1.00		
359	-.27	.10	-.07	.07	-.15	-.02	.14	-.20	-.23	-.25
	-.06	-.10	.05	-.11	-.13	-.23	-.24	-.03	-.03	-.04
	-.25	.13	-.02	-.06	.07	.01	-.12	-.02	-.06	-.03
	-.02	.27	-.23	.34	.42	.13	.00	-.15	.05	.45
	-.08	-.28	-.16	.16	-.04	-.21	-.20	.07	-.22	-.46
	-.20	.60	.40	.39	.16	-.31	-.31	-.23	1.00	
360	-.13	.02	-.03	-.06	.17	-.12	-.14	.38	.15	.12
	-.32	.01	-.10	-.01	.04	-.02	.11	-.21	-.08	-.19
	-.14	-.19	-.29	.17	-.02	-.16	-.31	-.18	-.25	.09
	-.01	-.18	-.03	-.27	-.24	-.35	-.21	-.12	-.16	-.21
	.30	.20	-.08	-.07	-.03	.07	.31	-.08	.22	.19
	-.05	.04	.08	-.06	.08	.06	.14	.18	.08	1.00
361	-.05	.02	-.11	-.16	.06	-.23	-.26	.41	.31	.08
	-.30	.06	-.25	.28	.15	.13	.30	-.33	-.25	-.42
	-.05	-.38	-.23	.04	-.11	-.36	-.25	-.23	-.05	.38
	.13	-.21	-.13	-.38	-.35	-.33	-.20	-.28	-.28	-.30
	.58	.05	-.24	-.29	-.15	.12	.31	-.27	.78	.59
	-.23	-.13	-.26	-.22	.03	.21	.42	.64	-.23	.23
	1.00									
362	-.26	.05	.00	-.01	-.08	-.06	.12	-.05	-.23	.00
	-.17	-.08	.01	-.12	-.15	-.10	-.33	-.09	-.00	.03
	-.12	-.10	-.13	.00	.16	.05	-.11	-.01	-.11	-.10
	-.04	.13	-.13	.09	.24	.09	.13	-.03	.00	.26

TABLE LIII (continued)

Item	1	2	3	4	5	6	7	8	9	10
362	-.06	-.22	-.26	-.01	-.08	-.09	-.15	-.01	-.07	-.23
	-.32	.35	.26	.21	.28	-.16	-.01	-.07	-.23	
	-.17	1.00								
363	.11	.06	.01	.08	.01	.18	-.03	.04	-.12	.04
	.06	.16	.04	-.03	-.18	-.13	-.14	-.09	.18	.04
	.01	-.13	-.18	-.05	-.13	-.14	-.16	-.06	.12	.18
	.25	-.16	-.03	-.03	-.16	-.28	-.17	-.26	-.22	-.19
	.19	.04	-.27	-.29	-.26	-.01	.09	-.10	.14	.20
	-.22	-.00	-.17	-.13	.17	.15	.09	.21	.00	.06
	.16	.09	1.00							
364	.10	-.09	-.01	-.07	-.14	-.07	.01	-.11	-.12	-.02
	.04	-.13	-.10	-.03	.00	-.01	-.12	-.01	-.05	.10
	.17	.09	.07	.15	.13	.05	.23	.09	-.01	-.04
	-.11	-.09	.10	-.07	-.03	.05	.13	.24	.15	-.01
	-.37	.30	.40	.34	.29	.06	-.04	.06	-.31	-.13
	.43	-.18	-.15	-.00	-.08	.13	-.08	-.10	-.32	-.16
	-.28	-.25	-.18	1.00						
365	.20	-.26	-.04	-.14	-.04	-.23	-.09	.20	.11	.01
	-.16	.16	-.15	.11	.00	.17	-.03	.00	.05	-.10
	.28	-.03	.17	.08	.20	-.13	.01	.23	.31	.39
	.42	-.22	-.03	-.15	-.20	-.23	-.21	-.15	-.24	-.21
	.09	-.10	-.27	-.31	-.03	.09	.09	-.04	.04	.11
	-.16	-.14	-.18	-.18	.16	-.01	.09	.24	-.15	-.01
	.10	-.09	-.01	.17	1.00					
366	.04	.17	.21	.07	.11	.10	-.07	.00	-.12	.27
	-.05	-.24	.01	-.00	.09	.11	.05	.01	.04	.43
	.06	-.13	-.01	-.01	.07	.06	-.00	-.13	-.17	.03
	-.15	-.05	.16	-.20	-.16	-.20	-.20	-.26	-.03	-.24
	.04	.01	.02	-.08	-.15	.18	-.17	-.18	.07	.24
	-.08	-.08	-.13	-.16	.01	.07	.17	.01	-.23	-.03
	-.01	-.04	.08	.06	-.13	1.00				
367	-.35	.03	-.14	-.04	-.11	-.07	.32	-.20	-.24	-.39
	-.16	-.16	.01	-.22	-.35	-.26	-.27	-.07	-.01	-.02
	-.30	.07	-.12	-.17	-.08	.08	-.15	-.03	-.10	-.11
	-.12	.31	-.27	.34	.21	.29	.15	.12	.23	.45
	-.11	-.13	.02	.20	.14	-.37	-.30	.29	-.28	-.44
	.06	.72	.58	.62	-.05	-.20	-.30	-.34	.60	.12
	-.24	.36	-.03	-.19	-.28	-.16	1.00			
368	.00	-.03	.20	-.05	.21	-.02	-.17	.21	.41	.08
	-.09	.07	.00	.10	.37	.40	.53	.00	-.11	-.10
	.02	-.10	-.15	.21	-.23	-.20	-.15	-.07	.03	.11

TABLE LIII (continued)

Item	1	2	3	4	5	6	7	8	9	10
368	.08	-.12	-.07	-.24	-.27	-.15	-.10	-.17	-.11	.30
	.12	-.04	-.07	-.19	-.07	.14	.00	-.15	.19	.14
	-.22	-.22	-.19	-.24	-.15	.09	.25	.16	-.16	.15
	.25	-.14	-.01	-.05	-.02	.09	-.20	1.00		
369	-.20	.04	-.10	.06	-.10	-.16	-.22	-.14	-.13	.12
	-.23	-.09	-.21	-.06	-.09	-.21	-.12	-.21	-.04	.00
	-.17	.03	-.15	.03	-.09	-.08	-.17	-.15	.16	.19
	.08	-.17	-.08	-.12	-.07	-.10	-.10	-.25	-.18	-.10
	.31	-.05	-.08	-.01	-.06	.25	.08	-.23	.11	.09
	-.08	.06	-.07	-.07	.61	-.04	-.03	.11	.22	.14
	.04	.22	.26	-.12	.11	.04	.08	-.13	1.00	
370	-.03	-.17	-.18	.04	-.11	-.05	.51	-.22	-.24	-.50
	.15	.06	.08	-.23	-.11	-.10	-.23	.21	.05	-.12
	-.05	.07	.24	-.31	-.01	.29	.14	.15	-.11	-.31
	-.05	.22	-.20	.42	.44	.55	.38	.32	.41	-.45
	-.44	-.10	.09	.05	.09	-.44	-.25	.64	-.36	-.52
	.07	.19	.18	.26	-.32	-.17	-.19	-.48	.10	-.27
	-.35	.07	-.14	.07	-.06	-.03	.28	-.22	-.22	1.00
371	-.15	-.12	-.19	-.23	-.13	-.30	-.19	.20	.00	-.09
	-.21	-.03	-.31	.25	.10	.16	.07	-.31	-.23	-.28
	-.22	-.11	-.16	.03	-.07	-.14	-.20	-.16	.11	.49
	.19	-.01	-.19	-.26	-.15	-.15	-.14	-.25	-.20	-.04
	.44	-.08	-.19	-.20	-.14	.08	.20	-.18	.40	.20
	-.19	.02	-.09	-.15	.20	.10	.24	.35	.02	.00
	.48	-.03	.10	-.22	.24	.01	-.03	.03	.30	-.20
	1.00									

TABLE LIV

FREQUENCY DISTRIBUTIONS OF TECHNICIAN RESPONSES

	Scale Value								
Item	1	2	3	4	5	6	7	8	9
					Physics				
101	0	0	5	5	7	16	22	20	25
102	1	2	4	12	16	24	14	20	7
103	1	1	6	11	33	23	16	7	2
104	1	7	8	13	24	16	16	13	2
105	1	1	4	8	8	8	13	17	40
106	13	13	22	13	12	12	7	3	5
107	15	20	15	8	16	10	6	4	6
108	11	15	14	19	16	12	10	3	0
109	13	14	21	20	16	9	6	0	1
110	9	13	4	12	16	13	11	8	14
111	0	0	2	7	15	17	20	32	7
112	28	18	15	21	12	3	1	1	1
113	27	26	11	14	13	7	1	1	0
114	1	2	5	5	15	14	8	20	30
115	0	3	12	15	20	20	14	12	4
116	1	3	6	20	13	17	24	12	4
117	6	3	11	20	31	7	12	6	4
118	3	10	14	14	32	12	9	1	5
119	3	9	11	17	34	10	11	3	2
120	2	4	18	34	19	17	3	1	2
121	6	11	19	32	19	7	4	2	0
122	36	16	18	9	7	8	3	3	0
123	2	4	5	10	15	14	26	16	8
124	4	9	22	20	26	14	3	2	0
125	0	0	3	7	15	12	24	19	20
126	2	4	3	11	29	27	18	4	2
127	0	4	6	7	15	21	22	16	9
128	5	7	11	18	31	14	10	1	3
129	4	20	13	18	17	9	9	4	6
130	9	14	23	20	20	9	3	1	1
131	3	3	2	9	23	15	15	20	10
132	13	22	31	15	15	4	0	0	0
133	0	1	8	13	27	26	18	4	3
134	2	6	7	17	27	21	13	6	1
135	0	0	3	2	11	10	21	18	35
136	3	4	10	19	23	20	15	4	2
137	1	4	4	6	14	26	28	13	4
138	7	15	10	9	15	20	8	9	7
139	0	3	5	5	15	15	28	15	14
140	1	2	6	5	11	16	26	15	18
141	9	17	16	15	30	8	2	2	1
142	3	4	8	17	26	20	17	3	2
143	6	17	19	23	19	9	3	4	0
144	12	14	21	27	21	5	0	0	0

TABLE LIV (continued)

	Scale Value								
Item	1	2	3	4	5	6	7	8	9
145	1	9	17	16	32	16	4	3	2
146	6	8	16	19	28	18	3	2	0
147	62	12	8	6	8	2	0	2	0
148	2	7	10	16	32	23	4	5	1
149	0	0	0	3	14	16	23	20	24
150	5	12	9	16	26	14	4	8	6
151	2	3	13	16	17	18	16	10	5
152	8	11	7	17	24	14	10	4	5
153	4	5	9	17	14	24	11	8	8
154	7	8	21	27	18	13	3	3	0
155	2	4	7	10	16	15	17	19	10
156	2	3	3	10	15	21	14	21	11
157	5	1	3	4	19	27	13	11	17
158	6	22	26	14	18	8	3	3	0
159	4	4	4	25	21	19	14	7	2
160	10	8	32	20	21	5	2	2	0
161	1	3	6	18	28	23	13	6	2
162	10	15	28	24	11	7	4	1	0

Distribution of Item Modes

Scale Value	1	2	3	4	5	6	7	8	9
Frequency	4	2	6	8	22	6	7	2	5

TABLE LIV (continued)

Item	1	2	3	4	5	6	7	8	9
					Scale Value				
					Electricity				
201	1	2	2	6	16	11	18	15	29
202	3	6	4	4	24	17	16	11	15
203	0	1	4	7	22	22	21	14	9
204	1	1	4	7	26	27	19	10	5
205	1	0	0	1	8	9	27	17	37
206	11	11	11	17	25	12	2	5	6
207	1	3	8	11	22	21	18	13	3
208	7	4	12	15	34	15	8	4	1
209	4	2	4	10	19	20	16	18	7
210	9	9	9	14	21	17	7	8	6
211	2	2	4	1	19	16	24	15	17
212	0	2	4	6	18	9	18	11	32
213	2	3	3	8	26	23	13	10	12
214	1	2	3	4	16	29	16	12	17
215	2	0	3	4	15	18	19	16	23
216	27	9	16	13	15	9	5	1	5
217	11	11	16	30	20	4	5	2	1
218	12	15	26	19	19	6	2	1	0
219	23	25	24	13	13	1	0	1	0
220	5	10	19	25	24	6	5	3	3
221	5	3	12	11	33	16	13	6	1
222	0	0	0	3	7	17	23	28	21
223	0	2	4	16	32	24	14	6	2
224	6	9	15	26	28	9	5	0	2
225	6	8	19	23	36	4	2	2	0
226	3	9	12	18	30	17	3	7	1
227	14	17	21	19	20	6	1	2	0
228	2	4	5	10	39	20	9	9	2
229	15	7	17	21	18	8	5	2	8
230	22	15	19	18	11	6	4	2	3
231	11	23	16	26	15	5	1	2	1
232	18	16	8	12	24	11	4	3	4
233	15	13	15	20	19	7	7	3	1
234	14	15	20	14	19	6	5	3	4
235	24	17	12	19	13	7	3	0	5
236	1	0	1	3	16	17	21	26	15
237	0	3	5	12	24	24	19	10	3
238	21	21	23	15	13	5	1	1	0

Distribution of Item Modes

Scale Value	1	2	3	4	5	6	7	8	9
Frequency	2	1	4	6	13	5	1	2	4

TABLE LIV (continued)

Item	1	2	3	4	5	6	7	8	9
					Scale Value				
					Electronics				
301	9	10	11	25	31	8	4	1	1
302	2	4	8	11	21	29	14	10	1
303	11	10	8	17	26	13	11	4	0
304	8	5	12	26	24	14	4	5	2
305	7	8	10	12	24	14	19	5	1
306	1	1	6	12	20	27	19	10	4
307	1	10	11	21	25	15	6	3	8
308	5	13	18	19	16	15	5	6	3
309	1	3	4	11	21	17	18	17	8
310	5	11	11	16	17	14	7	10	9
311	2	1	3	12	22	22	23	11	4
312	3	6	14	22	35	10	7	3	0
313	0	2	5	12	28	27	13	12	1
314	0	0	0	7	16	28	21	22	6
315	0	0	1	8	22	19	19	23	8
316	0	1	1	9	19	18	23	18	11
317	0	1	1	6	19	21	14	24	14
318	5	6	13	22	30	14	6	3	1
319	2	5	5	21	30	18	11	3	5
320	1	1	3	3	13	25	25	6	23
321	0	1	3	11	17	24	20	14	10
322	1	0	3	13	20	28	15	13	7
323	4	2	4	23	24	22	15	5	1
324	1	1	5	12	32	25	17	5	2
325	3	2	9	20	28	15	15	3	5
326	0	0	3	6	16	23	22	9	21
327	2	1	5	21	31	21	10	8	1
328	1	1	2	24	33	17	14	7	1
329	0	0	3	8	23	21	19	18	8
330	2	6	7	10	31	14	13	9	8
331	1	0	4	13	23	21	26	10	2
332	1	2	6	15	25	18	11	14	8
333	0	0	4	2	16	24	13	23	18
334	3	7	8	22	24	12	16	5	3
335	4	11	17	29	15	6	7	4	7
336	9	18	19	16	18	7	5	4	4
337	3	22	19	25	10	8	7	3	3
338	1	15	18	20	19	6	10	9	2
339	9	18	23	23	17	2	3	1	4
340	14	17	22	17	11	6	5	4	4
341	1	1	3	4	13	9	25	19	25
342	20	22	24	13	11	2	2	5	1
343	29	11	22	15	7	5	2	2	7
344	16	15	24	10	17	9	8	1	0

TABLE LIV (continued)

Item	Scale Value 1	2	3	4	5	6	7	8	9
345	16	27	26	15	7	8	2	3	1
346	6	6	14	9	12	17	10	10	16
347	15	13	19	13	13	12	7	5	3
348	15	20	25	12	6	7	4	5	6
349	4	0	6	6	12	10	17	16	29
350	14	14	13	10	11	4	10	8	16
351	47	11	16	8	5	4	1	4	4
352	22	20	18	14	9	9	3	2	3
353	6	12	18	19	19	14	6	6	0
354	16	19	14	15	15	9	5	3	4
355	5	7	4	12	14	22	13	10	13
356	1	10	19	19	17	13	13	4	4
357	1	3	10	7	17	16	8	21	17
358	12	15	10	8	10	15	13	9	8
359	17	23	22	14	6	7	0	4	7
360	53	20	13	5	6	1	0	1	0
361	7	5	6	5	10	8	14	16	29
362	16	15	22	18	12	9	2	4	2
363	4	16	12	17	22	11	7	8	3
364	6	25	28	16	14	8	3	0	0
365	1	5	9	11	39	16	15	3	1
366	0	0	3	2	9	17	19	20	30
367	18	21	18	19	8	7	1	5	3
368	0	4	7	8	19	21	21	13	7
369	5	3	13	19	18	13	11	8	10
370	2	10	24	21	16	7	6	8	6
371	4	5	9	14	13	7	19	13	16

Distribution of Item Modes

Scale Value	1	2	3	4	5	6	7	8	9
Frequency	4	4	9	9	21	11	5	4	4

TABLE LV

DEGREE OF GENERALITY 'G' OF ALL ITEMS

Physics				Electricity		Electronics			
Item	G	Item	G	Item	G	Item	G	Item	G
101	4 *	137	1 *	201	3	301	4	337	4 *
102	1	138	1 *	202 *	3 *	302	4 *	338	2
103	3 *	139	1	203	3	303	5 *	339	4
104	1 *	140	2	204 *	3 *	304	5 *	340	4
105	3	141	2 *	205 *	1 *	305	4	341	3
106	1	142	4	206	3 *	306	3	342	1 *
107	1 *	143	2	207	1	307	3 *	343	3
108	1	144	3 *	208	2 *	308	4	344	3
109	3 *	145	4 *	209	1 *	309	3	345	3 *
110	2 *	146	5 *	210	2 *	310	5 *	346	5 *
111	4	147	5	211	2	311	4 *	347	3
112	4 *	148	2 *	212	2 *	312	3	348	1 *
113	5 *	149	4	213	1	313	2 *	349	3
114	3	150	3	214	1	314	1 *	350	2 *
115	2	151	2	215	1 *	315	4	351	2
116	2 *	152	3 *	216	1	316	2	352	2 *
117	3 *	153	3	217	5 *	317	3	353	4 *
118	4	154	4 *	218	4 *	318	2 *	354	4
119	4 *	155	1	219	4 *	319	4	355	4
120	5 *	156	3 *	220	3	320	1 *	356	3
121	2	157	1	221	1 *	321	5 *	357	1 *
122	3	158	5 *	222	1	322	2	358	4 *
123	1 *	159	1	223	3	323	3 *	359	3 *
124	3 *	160	1 *	224	1	324	3	360	3
125	2 *	161	2 *	225	3	325	5 *	361	1 *
126	4 *	162	1	226	3 *	326	3	362	2
127	5 *			227	4 *	327	3	363	2 *
128	5 *			228	2	328	2 *	364	2
129	1			229	2 *	329	4 *	365	4 *
130	1 *			230	2	330	3 *	366	2
131	4 *			231	4 *	331	3	367	3
132	3			232	3 *	332	4	368	3 *
133	1			233	2 *	333	3	369	2 *
134	2			234	4 *	334	3	370	5 *
135	3			235	5 *	335	3 *	371	3
136	2 *			236	1	336	4		
				237	1 *				
				238	5 *				

*Item selected for sample used in comparisons

APPENDIX D

LIST OF PARTICIPATING ORGANIZATIONS

Bailey Meter Company

Canada Department of Transport, Western Air Services Region

Canadian Forces Base Edmonton

Canadian Broadcasting Corporation

Canadian Electronics Limited

Canadian Laboratory Supplies Limited

Canadian National Telecommunications

Canadian Pacific Telecommunications

CFCN Television Limited

City of Edmonton

Defense Research Establishment Suffield

Dresser Atlas Limited

Hillhurst Electronics Limited

Honeywell Controls Limited

Imperial Oil Enterprises Limited

International Business Machines Limited, Edmonton

International Business Machines Limited, Calgary

Johnson Controls Limited

National Cash Register Company

Northern Alberta Institute of Technology

Pan American Petroleum Company

Research Council of Alberta

Schlumberger of Canada Limited

Shell Canada Limited, Exploration and Production Department

Southern Alberta Institute of Technology

University of Alberta, Technical Services Division