To the Graduate Council:

I am submitting herewith a dissertation written by James T. Blackmon, Jr., entitled "An Exercise in Group Communication—A Nonconventional Delphi Study of Ionizing Radiation." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Education, with a major in Health Education.

Warren J. Huffman

Warren J. Huffman, Major Professor

We have read this dissertation
and recommend its acceptance:

Bill C. Wallace

Robert H. Kirk

William J. Bogly, Jr.

John R. Jotter

Accepted for the Council:

L. Evans Peik

Vice Chancellor
Graduate Studies and Research

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AN EXERCISE IN GROUP COMMUNICATION—A NONCONVENTIONAL DELPHI STUDY OF IONIZING RADIATION

A Dissertation

Presented for the

Doctor of Education

Degree

The University of Tennessee, Knoxville

James T. Blackmon, Jr.

June 1978

1361734

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ACKNOWLEDGMENTS

This unusual page for this dissertation is required to tender appreciation for the frankness, trust and hard work performed by all of the unseen faces who participated in this study. Especial thanks are offered to the 72 members of the Delphi Panel who possessed the perseverence to examine one or more of the three questionnaires; to members of my committee—W. J. Boegly, Jr., R. H. Kirk, J. R. Totter, and B. C. Wallace—who encouraged by listening and suggesting; to Warren J. Huffman, major professor, a dedicated education professional who especially knows how to encourage by listening and speaking quietly.

When the others were not around, my beloved wife of 29 years, a dedicated professional nurse, encouraged completion of this project by listening and, when necessary, suggesting, and in general foregoing things she would like to have been doing while I worked on this project.

ABSTRACT

This study was undertaken in an attempt to determine whether a modified version of the Delphi Forecasting Method developed in the early 1960's could be utilized as a pedagogical tool to help the specialist communicate with the nonspecialist. This was to be accomplished by finding out the nonspecialists' concerns and translating these concerns into a language understandable to the nonspecialist.

Ionizing radiation was the controversial and technical subject chosen. This subject, while having potential environmental, safety and health problems, was being utilized in a varied number of medical situations and further offered a solution to our country's fuel problems. It was believed that laypersons were being asked to make judgments regarding whether to have X-rays made or vote upon the acceptance of nuclear fueled electric generating stations in their neighborhood, with the only understandable information—whether it was correct or not—being provided by activists. These persons seemed to be using this emotional and technical subject to dispel a feeling of alienation and disenfranchisement from the political and regulatory process.

This study was designed to answer the following questions:

1. Can specialists and nonspecialists exploring a technical field of endeavor interface well enough to exchange meaningful and understandable knowledge?
2. In the opinion of this Delphi panel, was it desirable and important that laypersons have a general knowledge about:

A. the paradox that radiation may be both harmful and beneficial;

B. the concept that the effects of radiation depend upon the amount and type of radiation;

C. the idea that there are methods by which harmful effects of radiation may be prevented and/or treated;

D. the belief that regulatory agency requirements mitigate the possibilities of radiation releases which could do harm to the layperson; and

E. the explanation of how radiation influences mankind through its interaction with the environment?

3. In the opinion of the panel, did the information presented to support conceptual and behavioral objectives seem valid?

The questions were answered by submitting statements through three questionnaires over a period of one year to 72 Delphi Panel members who had been divided into three separate groups—Health Science Educator/ Practitioners, Laypersons with Energy Concerns, and Nuclear Specialists. These groups rendered opinions about the desirability, importance and feasibility of teaching the subject of radiation to laypersons. The panel also rendered opinions regarding the truthfulness of a number of the statements.

The panel believed that it was desirable and important that the public know a great deal more about ionizing radiation than it now seems to know. The panel also learned from each other which was the principal goal of this study. Of concern, however, is the fact that nonspecialists gained false information from other uninformed persons on the panel.

One of the strengths of the Delphi Technique is consensus, and this strength in the opinion area may be a weakness when dealing with the physical truths.

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CHAPTER I

THE PROBLEM

During the latter half of the 1970's, the requirement for additional sources of power was growing at an ever-increasing rate. This requirement coincided with an increasing concern for the protection of our environment and thusly our health and safety. It was imperative that unbiased, factual, and understandable information be made available to laypersons in order that each individual might more intelligently weigh the costs versus the benefits of new energy technologies.

Energy was and is central to the security and economic stability of the United States. The basis for peace and international cohesion is plentiful energy because plentiful energy means jobs.

It took the United States approximately 120 years to move from wood to coal to oil and/or gas as primary energy resources. The world, in 1977, had begun another cycle from oil and gas to something else. It was doubtful whether 60 years would be available to convert from an oil and gas economy to something else.[1] Something else might be, as suggested by Starr, "the clean air option of nuclear power."[2] Uranium

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[1]Robert W. Fri, "An Overview of Our National Energy Needs, Resources and Future Developments," Impact of Energy Production on Human Health—An Evaluation of Means for Assessment (Oak Ridge: ERDA Technical Information Center, 1976), pp. 1-8.

[2]Chauncey Starr, "International Realities of the Energy Crisis," The Environmental Impact of Electrical Power Generation: Nuclear and Fossil (Washington: Government Printing Office, 1975), pp. 15-21.

and the fast breeder offered us potentially ample energy. "Obviously, the rate at which nuclear power comes on the scene is dependent on public acceptance."[3]

Public concern, however, had been aroused about potential safety and health issues related to energy production and converted the subject into a political problem in several states. Some considered nuclear energy to be an ethical and moral issue, although these issues were not always clearly defined.[4] However, it was immaterial why this had come about. The important point was that there were questions being asked about the public's health, safety, and welfare by concerned citizens.

This "question asking" phenomena was being called a "Public Interest" movement. Only a dozen or so years young, in 1978, the movement had become an instrument of social and political change. Epstein stated that such

> . . . public interest groups are ad hoc organizations which have generally arisen from the initiatives of a handful of young activist lawyers and other professionals and from spontaneous expressions of citizen and consumer concerns. They embrace a wide spectrum of heterogenous styles and objectives ranging from conservationists and environmentalists, some of whom are traditionalist and conservative, to more activist consumer and citizen groups. The "Public Interest" movement appeared to be an expression of alienation and disenfranchisement from the political and regulatory process. . . .[5]

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[3]Ibid., p. 20.

[4]R. J. Campana and Sidney Langer, "Nuclear Power and the Environment—Questions and Answers" (Hinsdale, Illinois: American Nuclear Society, 1976), p. v.

[5]S. S. Epstein, "Developing Health Policies and Standards: Responsibility of the Scientist in Developing and Interpreting

The feeling of disenfranchisement was surprising as the United States Supreme Court had reiterated in 1964 in Reynolds versus Sims (37U533) the constitutional right of equality of representation—one man, one vote.[6] A citizen of our country had a vote whether facts or myths were available. To participate in such a process one should try to make intelligent judgments and this cannot be accomplished without facts.

It would be an oversight in this brief introduction not to suggest that if ionizing radiation from nuclear fueled electric generating stations might be harmful to the public, are we not harming ourselves by agreeing to accept the seemingly increased number of diagnostic X-rays suggested by our physicians and dentists? It would seem that these same public interest groups should be as concerned with the carcinogenic effects of exposure from these supposedly slight and inconsequential ionizing radiations as they seem to be with the nuclear power plants. Very few of us live near nuclear installations but the majority of us accept X-rays and have television sets. What did the public interest groups know that the general public did not?

Thus it appeared, in 1977 and 1978, that the general public was not receiving facts that could be easily understood and was being exposed to whatever material various groups wanted to print to further whatever goals they were trying to achieve. The energy production industry, the

---

the 'Public Interest' Viewpoints," Impact of Energy Production on Human Health—An Evaluation of Means for Assessment (Oak Ridge: ERDA Technical Information Center, 1976), pp. 42-50.

[6]R. C. Costner and C. M. Lytle, "Modern Constitutional Law" (New York: The Free Press, 1971), p. 425.

consumer advocate, the environmentalist, the health specialist and the government has an obligation to provide factual information to each citizen in a manner that could be readily understood.

I. THE PURPOSE OF THE STUDY

In 1964 Helmer and Gordon completed the development of a method for soliciting informed judgments regarding what is likely to happen and when in the stream of events it might happen. This technique now known as the Delphi Forecasting Method can be described as an intuitive methodology for organizing and sharing "expert" forecasts about the future.

The major purpose of this study was an attempt to determine if this technique could be utilized as a pedagogical tool to help the specialist to communicate knowledge of a technical nature to nonspecialists in the subject area as follows: (1) finding out the nonspecialists' concerns; and (2) translating these concerns into a language understandable to the nonspecialist. This method would also allow the specialist to suggest content areas to the nonspecialist. The controversial and technical subject chosen was a potential environmental, safety and health problem that could result from the continued development and use of nuclear fueled electric generating stations and medical diagnostic tools, i.e., radiation.

II. RATIONALE FOR THE STUDY

The introduction pointed out the fact that public interest groups seemingly use the potential hazards of radiation in arguing their point.

The planner of this study in 1978 had worked for 26 years in a nuclear materials production plant in a nonnuclear engineering capacity. Duties required that he go to locations on a routine basis that contained varied quantities of radioactive material. The duties were carried out without fear because he believed the nuclear specialist had successfully protected him as an employee. If the employee is safe inside a nuclear facility, it follows that the general public who is not associated on a day-to-day basis with radioactive materials should be safer than the employee. The question in the planner's mind was why a nuclear facility employee accepted the risk of working around radioactive material and subjecting his or her family to potential radiation hazards by living adjacent to these facilities. Perhaps it is because employees, particularly the nonnuclear specialists, are taught by their employers that radiation is something to be respected and that one does not have to live and work in fear. The employee obviously must be teaching his or her family not to fear the potential hazards of radiation. Thus, it was believed that a practical procedure that could determine knowledge needs would be helpful so that others could gain respect for instead of fear of radiation.

III. STATEMENT OF THE PROBLEM

The environmental data on radiation levels, as well as studies on health effects, were well advanced in the latter half of the 1970's

compared to those on chemical constituents in our environment.[7] However, the general public was receiving information from the "public interest" movement with very little understandable material from the advocates.

Nuclear specialists seemingly had difficulty explaining to the public in simple terms this complex subject. For example, Campana and Langer expressed the opinion that the usual answer to the critic's cry that nuclear power is "unsafe, uneconomic, unreliable and unnecessary" was an hour long discourse. Effectively answering this type of criticism is somewhat like having first rebuttal to the cry of "fire" in a crowded theatre.[8]

This study was designed to answer the following questions:

1. Can specialists and nonspecialists exploring a technical field of endeavor interface well enough to exchange meaningful and understandable knowledge?
2. In the opinion of this Delphi panel, was it desirable and important that laypersons have a general knowledge about:
   a. the paradox that radiation may be both harmful and beneficial (Concept A and Concept I);
   b. the concept that the effects of radiation depend upon the amount and type of radiation (Concept B and Concept II);

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[7] A. P. Hull, "Radiation in Perspective: Some Comparisons of the Environmental Risks from Nuclear and Fossil-Fueled Power Plants," Nuclear Power and Radiation in Perspective (Oak Ridge: Nuclear Safety Information Center, March 1974), pp. 58-69.

[8] Op. cit., Campana and Langer, p. vi.

c. the idea that there are methods by which harmful effects of radiation may be prevented and/or treated (Concept C and Concept III);

d. the belief that regulatory agency requirements mitigate the possibilities of radiation releases which could do harm to the layperson (Concept D); and

e. the explanation of how radiation influences mankind through its interaction with the environment? (Concept E and Concept IV).

3. In the opinion of the panel, did the information presented to support conceptual and behavioral objectives seem valid?

IV. STATEMENT OF HYPOTHESES

Several hypotheses were postulated concerning the views of the three groups of judges rendering opinions about the information that might be needed by laypersons in order that meaningful judgments could be made about the potential costs and benefits of using radiation for various purposes. Stated in the null form, these hypotheses were as follows:

Null Hypothesis A—There were no differences of opinion among the three groups of judges concerning the five sets of behavioral objectives grouped by concepts in Round One of the study.

Null Hypothesis B—There were no differences of opinion among the three groups of judges concerning the feasibility of teaching the behavioral objectives presented in Round One of the study.

Null Hypothesis C—There were no relationships between the feasibility of teaching the behavioral objectives in Round One and the opinions of the judges regarding these objectives.

Null Hypothesis D—There were no opinion changes among the judges concerning the desirability or importance of having laypersons understand the behavioral objectives developed for the four concepts between Round Two and Round Three.

Null Hypothesis E—All three groups of judges believed that the cognitive statements presented to support the behavioral objectives in Concepts I, II, III, and IV have a substantial risk of being incorrect.

Null Hypothesis F—There were no changes in the validity rating of statements between Rounds Two and Three.

V. LIMITATIONS

Seaborg has stated that "the sheer magnitude and complexity of the national nuclear energy effort make difficult the task of anyone seeking a better understanding of the scientific and technical developments involved and the administrative environment in which they take place."[9] Thus a major limitation of this study was the breadth of the scope of the subject.

The study planner established the criteria that if a panel member were a member of a national radiation standards setting organization or worked in the area of radiation medicine or was known by reputation to be a specialist in some field of radiation then he or she would be classed as a nuclear specialist. The rationale for this decision was

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[9]J. F. Hogerton, The Atomic Energy Deskbook (New York: Reinhold Publishing Company, 1963), p. iii.

that these persons would be expected to have more general knowledge about radiation than the other panel members.

A similar arbitrary decision was made to establish the Health Science Education Practitioner Group. When it was determined that a person was a health, safety, or engineering educator, he or she was placed in this group. Physicians and occupational nurses were also classed as members of this group.

All other panel members were categorized as interested laypersons selected from fraternal, civic, religious, business, and trade association organizations. All persons in this group were deliberately chosen because they were known to have an interest in the nation's energy problems as evidenced by their attending the first annual Public Awareness Symposium held in Knoxville, Tennessee during February 1976. The exception was a group of Presbyterian ministers selected from the study planner's church magazine. A copy of the letter used to recruit Delphi Panel members may be found in Appendix A.

VI. DELIMITATIONS

In order to have a manageable study, the following parameters were established:

1. The initial Delphi Probe was entitled "Round One—Seeking Input." In order to stimulate input on the part of participants, a series of conceptual statements followed by a sequence of behavioral objectives were presented. Conceptual statements one through four were developed during a school health curriculum workshop conducted by the Health Education Department (now

Division of Health & Safety), of the University of Tennessee, summer quarter, 1967. The behavioral objectives were selected from two documented studies. The first was a 1960 Stanford Research Institute (SRI) report that elicited attitudes toward radiation. The second was a 1972 Doctoral dissertation by H. Crater entitled "The Identification of Factors Influencing College Students' Attitudes Toward Radiation."

2. The population for this study consisted of persons willing to assist without financial reward and included persons employed in the fields of education, medicine, engineering, business (including clerical), profit and nonprofit commercial and trade associations, religious leaders and physical scientists.
3. The study planner rewrote the 1967 and 1972 statements at the request of several members of the panel before they were placed in Round Two of this study.
4. All panel member responses were checked for duplications of content and approximately one-half were eliminated.

VII. SIGNIFICANCE OF THE STUDY

Major choices were required concerning our country's energy future, and each citizen, as a voter, a consumer, an employee, a home owner, had a stake in and some influence over future energy policy. The production and use of energy was considered by some to be the single most important cause of environmental degradation—ranging from the devastation of

lands by surface mining, and to the hazards of deep mining, to oil spills, to sulfur emissions, and to other problems.[10]

Paradoxically, the country needed energy to keep its economy going, although it would have been a mistake to trade a power crisis for an environmental crisis with its resultant health crisis. While nuclear power was not a panacea for the energy problems of the country, it seemed to be the major choice available until economical and scientific breakthroughs occurred in other forms of generation. Therefore, the layperson needed to consider radioactivity, i.e., how it is generated, how it is moved in the environment, how it affects man, and how the long-range effects can be estimated. Nuclear specialists had this knowledge, and they had the responsibility of translating it into terminology which could be understood by the nontechnically oriented individual. It was believed that if the health and safety education problems regarding nuclear energy could be translated into layperson language by means of the Delphi Technique, this methodology could be used to develop informational programs. It was also believed that the Delphi Technique could be developed as a tool to explain even more esoteric technologies of energy production—such as fusion or fast breeder reactors.

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[10]Milton Katz, "Decision Making in the Production of Power," Energy and Power (San Francisco: Scientific American, 1971), pp. 131-134.

VIII. DEFINITIONS OF SELECTED TERMS

The following are generic terms[11] that were cited throughout this study:

Alpha Particle or Alpha Ray—The least penetrating of the three common types of ionizing radiation (alpha, beta, and gamma) emitted by radioactive material. It is not dangerous to plants, animals, or man unless the alpha-emitting substance has entered the body. This type of radiation can be stopped by a sheet of paper.

Beta Particle or Beta Ray—An elementary particle emitted from a nucleus during radioactive decay. Beta radiation may cause skin burns and beta-emitters are harmful if they enter the body. Beta particles are easily stopped by a thin sheet of metal.

Gamma Rays—High-energy, short wave length electromagnetic radiation. Gamma radiation frequently accompanies alpha and beta emissions and always accompanies fission. Gamma rays are very penetrating and are best stopped or shielded against by dense materials, such as lead or depleted uranium. Gamma rays are essentially similar to X-rays but are usually more energetic and are nuclear in origin.

Ionizing Radiation—Any or all of the following: alpha rays, beta rays, gamma rays, X-rays, neutrons, high speed electrons, high speed protons and other atomic particles; but not sound or radio waves, or visible, infrared or ultraviolet light.

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[11] For a complete glossary of generic radiation definitions written in layperson terminology, see J. D. Lyman's Nuclear Terms (Oak Ridge: ERDA Technical Information Center, 1974).

Layperson—A person who has not been trained in one of the fields required to become a nuclear specialist.

Neutron—An uncharged elementary particle with a mass slightly greater than that of the proton and found in the nucleus of every atom heavier than hydrogen. Neutrons sustain the fission chain reaction in a nuclear reactor.

Nuclear Specialist—A person trained in one or more of the following fields: atomic and nuclear physics; radio and nuclear chemistry; health physics; radiobiology (biographics, environmental radiology, radiation effects, radiological physics); reactor safety; nuclear technology (nuclear engineering, reactor laboratory); radiation hazards and control (radiation shielding, waste disposal); reactor material (nuclear metallurgy); reactor fuel technology; thermonuclear plasmas; radio-isotope techniques; environment and nuclear power; geochemistry; nuclear material safeguarding; nuclear explosives; nuclear geology; nuclear medicine; radiation chemistry; and/or radiopharmacy.

X-rays—High-energy, short wave length electromagnetic radiation produced by machines. These rays are essentially similar to gamma rays except that they are usually less energetic than gamma rays and are not nuclear in origin.

IX. ORGANIZATION OF THE STUDY

A brief historical review of the history of public safety and public health concerns throughout the world, a short review of layperson education relating to radiation, and a review of the Delphi Technique are presented in Chapter II. An attempt to explain the approach that

was followed as well as the detailed techniques that were employed in conducting this study are presented in Chapter III. The results of the study are presented and discussed in Chapter IV. Chapter V summarizes and presents the conclusions. The study planner owed the panel a final report concerning the results of the study, and Chapter VI was developed to answer this need.

CHAPTER II

REVIEW OF THE LITERATURE

I. PUBLIC HEALTH WORLDWIDE—A BRIEF HISTORICAL OVERVIEW

Ramazzini, in his 1700 edition of De Morbis Artificum, wrote

> . . . manifold is the harvest of diseases reaped by certain workers from the crafts and trades that they pursue; all the profit they get is injury to their health. That stems mostly, I think, from two courses. The first and most potent is the harmful character of the materials they handle; noxious vapors and very fine particles, inimical to human beings, inducing specific diseases. As to the second cause, I assign certain violent and irregular motions and unnatural postures of the body, by reason of which the natural structure of the living machine is so impaired that serious disease gradually develops therefrom . . .[1]

Ramazzini was discussing in the first instance what we know today as industrial hygiene—and in the second instance, what McFarland described as human factors engineering.[2] The key phrase used by Ramazzini was "injury to their health." McKee, in the book Environmental Problems in Medicine, states that the two central issues of our time are the increasing number of environmental problems throughout the world and the health status of the population which is in many respects related to environmental hazards. "Many of the major diseases in this country are

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[1]Bernardo Ramazzini, De Morbis Artificum: Diseases of Workers (New York: New York Academy of Medicine, 1964), pp. 7-485.

[2]E. R. Tichaue, "Chapter 32—Ergonomic Aspects of Biomechanics," The Industrial Environment—Its Evaluation and Control (Washington: U.S. Government Printing Office, 1973), p. 431.

caused, in part, by a variety of contributing factors in our modern environment."[3]

"The public has become inundated with information about a number of present or threatening crises. The problems appear to be growing in both frequency and magnitude . . ."[4]

Hippocrates wrote 25 centuries ago, "It is changes that are chiefly responsible for disease, especially the great changes, the violent alterations both in the seasons and in other things." We are now witnessing rapid and profound modifications of our environment and in our ways of life, and we are now beginning to recognize how these changes affect our health.[5] Modern technical and medical advancements have proven to be mixed blessings. Technology and education have, on the one hand, raised standards of living and freed millions from degrading and menial jobs. Similarly, these changes have created social upheaval, have brought about the threat of nuclear annihilation, and have so poisoned our physical environment that continued survival is being questioned by knowledgeable experts. Many of the traditional causes of illness and early death have been overcome by medical science. In so doing, the world now has a population growth rate that threatens massive famine. Populations are becoming so dense that living may become a

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[3]William D. McKee (ed.), Environmental Problems in Medicine (Springfield, Ill.: Charles C. Thomas, Publisher, 1976), p. xiii.

[4]Ibid., p. xii.

[5]Ibid., p. xiv.

burden instead of a pleasure.[6] All of these developments relate directly to our physical and emotional health—the most important parts of any study of health science. These complex interactions between man's internal biological system and the total external environmental system have been summarized by Purdom and are shown in his "The Environmental System" which is reproduced in Figure II-1.[7]

Rosen, a distinguished historian of public health, has stressed the fact that government has been concerned with public health from antiquity to the present. He indicated that in ancient Athens there were public health officials responsible for such matters as drainage and water supply systems. By 33 B.C. the Roman government had separate public health officials to deal with the baths. Their duties included the testing of the heating apparatus, cleaning, policing and maintaining streets. Other officials in the area of food distribution could forbid the sale of spoiled food.

In the Middle Ages, regulatory health practices were promulgated, including the isolation of diseased persons. As industrialization increased during the Eighteenth and Nineteenth Centuries, the tempo of regulation also increased greatly. Regulations were extended to improve streets, lighting, housing conditions, water supplies, and sewers. The period of 1750 to 1850 saw the development of the sanitary movement in

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[6]K. L. Jones, L. W. Shanberg and C. O Byer, Health Science (New York: Harper and Row, 1974), p. 1.

[7]P. W. Purdom, "Environment and Health," Environmental Health (New York: Academic Press, 1971), p. 6.

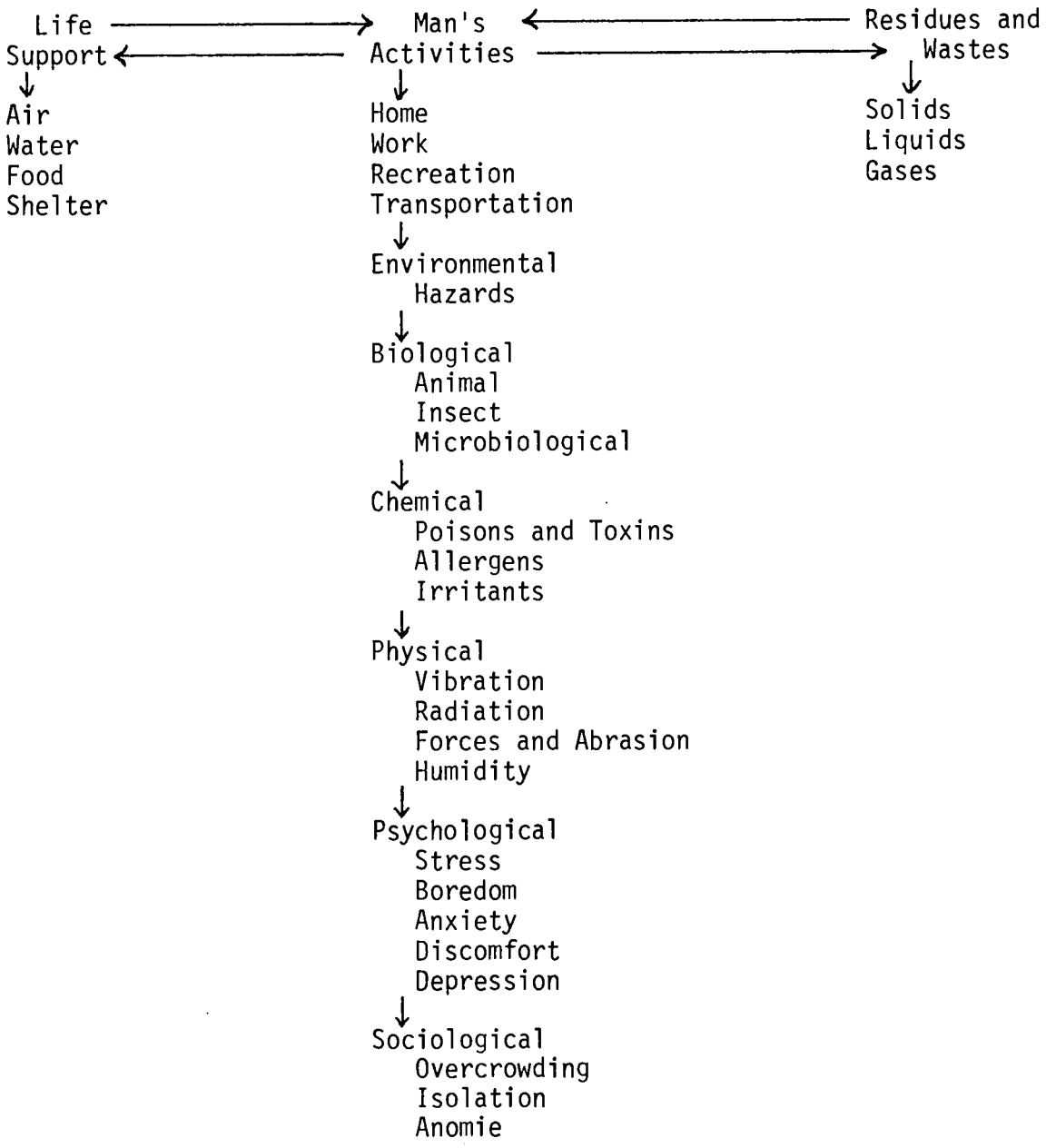


Figure II-1. Purdom's "The Environmental System."

England which resulted in an organized municipal effort and a systematic approach by professionals to public health regulation.[8]

The bacteriological approach which followed held members of society responsible for the domain in which they lived and served upon them civil and criminal penalties if a developed standard was not acceded to in a particular domain. "The justification for these penalties was that the general welfare of the public could be seriously affected by the contamination of milk, water, or food if regulations and standards were not observed."[9]

II. SAFETY—HEALTH—ENVIRONMENTAL—FIRE MOVEMENT IN THE UNITED STATES

Health, safety, and the improvement in the quality of life in the United States are major goals of the United States Government. These are not new goals—the Preamble to our Constitution states that one of the purposes of our government, through the mechanism of the Constitution is "to promote the general welfare," meaning health, happiness, and prosperity for all.[10] A review of the 200 year history of the American Republic revealed that however crowded our national agenda, safety and health have been omnipresent issues. We began to emphasize our national

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[8]George Rosen, The History of Public Health (New York: M. D. Publications, 1958), p. 157.

[9]Morton and Jacqueline K. Corn, "Setting Standards for the Public: An Historical Perspective," Impact of Energy Production on Human Health (Oak Ridge: ERDA Technical Information Center, 1976), p. 29.

[10]Bruce and Esther Findlay, Your Rugged Constitution (Palo Alto, California: Stanford University Press, 1950), p. 9.

health and safety priorities in the mid-1960's when we were approaching an environmental crisis. Next we were confronted with an energy crisis. There were those who said that the health-safety-environmental-ecology priority goals being emphasized in our country in 1976 had been the major factors contributing to our energy crisis. The emphasis on national health and safety was evidenced by the following quotations from recent national legislation.

1. Federal Water Pollution Control Act—"The objective of this Act is to restore and maintain the chemical, physical, and biological integrity of the nation's waters."[11] This was followed by a summation of six additional national goals necessary to achieve this particular priority.
2. Federal Clean Air Act (Title I)—The purposes of this Title are (1) to protect and enhance the quality of the nation's air resources so as to promote the public health and welfare and the productive capacity of its population. . . ."[12]
3. The National Environmental Policy Act stated that its purpose is "to declare a national policy which will encourage productive and enjoyable harmony between man and his environment; to promote efforts which will prevent

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[11]Environmental Reporter, Federal Water Pollution Control Act (Washington: The Bureau of National Affairs, 1972), pp. 71: 5101-71: 5130.

[12]Environmental Reporter, Clean Air Act (Washington: The Bureau of National Affairs, 1973), pp. 71: 1101-71: 1126.

or eliminate damage to the environment and biosphere, and stimulate the health and welfare of man. . . ."[13]

4. Resource Conservation and Recovery Act of 1976—The stated findings of Congress in this act with respect to the environment and health are that "open dumping is particularly harmful to health, contaminates drinking water from underground and surface supplies, and pollutes the air and the land; and hazardous waste presents, . . . special dangers to health and requires a greater degree of regulation than nonhazardous solid waste. . . ."[14]
5. The Consumer Product Safety Act—This act has as its stated purpose "to protect consumers against unreasonable risks of injury from hazardous products."[15]
6. The Occupational Safety and Health Act of 1970—This act has as its stated purpose "to assure safe, healthful working conditions for working men and women by authorizing enforcement of the standards developed under the act. . . ."[16]

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[13]Environmental Reporter, The National Environmental Policy Act (Washington: The Bureau of National Affairs, 1970), pp. 71: 0101-71:0103.

[14]U.S. Congress, Senate, Committee on Public Works, Resource Conservation and Recovery Act of 1976, Hearing, 94th Congress, Second Session, to amend the Solid Waste Disposal Act of 1970, October 21, 1976 (Washington: U.S. Government Printing Office, 1976), p. 3.

[15]Donald R. Thoreen, "Product Liability: The Arms Grow Longer," Chemical Engineering (New York: McGraw Hill Publishing Company, June 11, 1973), p. 69.

[16]J. A. Page and Mary-Win O'Brien, Bitter Wages (New York: Grossman Publishers, 1973), pp. 167-189.

7. The Fire Prevention and Control Act of 1974—This act stated that "the Congress has found that the life, health, and safety of the American people are in jeopardy from fire."[17]

Safety and health as major issues have fluctuated throughout the United States' history. These issues were rather dormant in the post-revolutionary period when the first stirrings of industrialization impacted on our then agrarian society.[18] This could have been due to the hardships of survival, which made our ancestor unknowingly follow Maslow's theory. Maslow believed that human needs arrange themselves in hierarchies of prepotency. In other words, the appearance of a new need usually rests upon the prior satisfaction of another. The base of this hierarchy is satisfaction of physiological needs with food being paramount—meaning one will do practically anything necessary to stay alive.[19]

This revolutionary period was followed by a turbulent period characterized by strikes, riots, power grabs, and legal chicanery. During this rapid industrialization period between 1850 and 1900, very little concern was given to health and safety.

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[17]G. L. Moatman, "With the Society," Fire Technology (Boston: Society of Fire Protection Engineers, December 1973), pp. 299-302.

[18]"Special Bicentennial Issue," Occupation Hazards (Cleveland, Ohio: Industrial Publishing Company, September 1975), p. 51.

[19]A. H. Maslow, "A Theory of Human Motivation," Organization Theories (Columbus, Ohio: C. E. Merrill Pub. Co., 1970), pp. 143-166.

The period of 1900 to 1916 was called the Progressive Period. This time period saw the advent of the modern safety movement, though it was a secondary consideration at the time. It was during this period that the U.S. Public Health Service and the Bureau of Mines conducted exploratory studies in the mining and steel industries and industrial hygiene programs were started in New York and Ohio.[20]

The 1920's produced the first safety theorists. Some were from outside of the country, such as Greenwood and Newbold.[21] These safety pioneers were primarily concerned with the causes of accidents.

The troubled 1930's saw the first signs of a significant federal presence in occupational safety and health, consonant with Roosevelt's "New Deal," when the Walsh-Healy Act was passed. Also during this period Heinrich expressed his domino theory of accident causation and the TVA began offering federal employees health services.[22]

During the 1940's safety and health advocates on the homefront put aside differences of opinion to maximize a precious and indispensible resource: manpower and womanpower. The production lines provided the necessities to win a worldwide conflict.[23]

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[20]G. D. Clayton, "Chapter I, Introduction," The Industrial Environment—Its Evaluation and Control (Washington: U.S. Department of Health, Education and Welfare, Public Health Service, Center for Disease Control and National Institute for Occupational Safety and Health, 1973), p. 2.

[21]W. Haddon, E. A. Suchman and David Klein, Accident Research-Methods and Approaches (New York: Harper and Row Publishers, 1974), pp. 389-409.

[22]Op. cit., Industrial Environment, p. 51.

[23]Op. cit., Industrial Environment, p. 51.

While the Depression of the 1930's went far to convince federal authorities of a real need for intervention in the economy and welfare of American Life, the creation of international bodies such as the International Labor Organization and the World Health Organization gave real impetus to worldwide health goals.[24]

In the United States during the early Twentieth Century the champion of the cause of social responsibility for workers' health and welfare was a physician by the name of Alice Hamilton. She presented substantial evidence of a relationship between illness and exposure to toxins, and she suggested concrete solutions.[25] Even though information was available from scores of sources such as Ramazzini and Hamilton, it took a tragedy in 1932 like the silicosis deaths of the Gauley Bridge, West Virginia, tunnel project[26] to start individual states to begin liberalizing the compensation laws regarding occupational health matters. It causes one to wonder why it took a tragedy like the loss of 430 lives, 230 years after Ramazzini reported facts regarding the cause of silicosis, to arouse a people to do something.[27] This tragedy further strengthens this author's belief in Maslow's theory, i.e., people will work at almost

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[24]Op. cit., Clayton, p. 2.

[25]Ernest Mostromatteo, "From Ramazzini to Occupational Health Today from an International Perspective," Journal of Occupational Medicine, No. 5 (Research Triangle Park, N.C.: Burroughs Wellcome Co., May 1975), pp. 289-294.

[26]Op. cit., Page and O'Brien, p. 180.

[27]Op. cit., Mostromatteo, p. 290.

any job for food and that human nature will take advantage of those in need for the sake of profit.

The Gross Report to the Surgeon General of the Public Health Service in 1962, The Tukey Report to the President's Scientific Advisory Committee in 1965, the Spilhaus Report to the National Academy of Sciences in 1966, and the Linton Report to the Secretary of Health, Education and Welfare in 1967 all were unanimous in their assessment of the deterioration of the environment of the United States. These reports identified by the names of their committee chairmen were written by experts and citizens of high reputations. All the reports expressed concern about the pressures generated by technological escalation, population escalation, and urban concentration. The reports addressed health effects, comfort, convenience, efficiency, aesthetics, and last but not least, the effects on the balance of ecosystems and natural resources caused by these three main pressures.[28] As an example, in 1973 the United States, the most technologically advanced nation in the world, held the dubious honor of leading the rest of the free world in per capita deaths and property loss from fire, according to the 1973 report of the National Commission on Fire Prevention and Control.[29] The death rate per million population was nearly twice that of the closest contender, second ranking Canada. The United States exceeded Canada by

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[28]E. T. Chanlett, Environmental Protection (New York: McGraw Hill, 1973), pp. 1-27.

[29]National Commission on Fire Protection and Control, "American Burning: The Report of the National Commission on Fire Prevention and Control" (Washington: Government Printing Office, 1973), p. 1.

one-third in per capita economic losses. The four major causes of fire problems seemed to be indifference of the population, ignorance on the part of people, economic problems which stood in the way of fire prevention investment, and lack of understanding of fire threat. These factors accounted for the low priority given to fire prevention matters.[30]

This brief outline of the history of safety, health, environmental, and fire prevention movements in the United States points up the fact that throughout our history these concerns have not always been paramount in the country's list of priorities, though in 1976 they seemed to be increasingly important.

III. RADIATION PROTECTION CRITERIA FOR PROMOTION OF THE PUBLIC

In 1964 approximately 20 years after the beginning of the "Atomic Age" the United States Congress, seeing a need for collecting, analyzing, developing and disseminating information and recommendations about radiation, incorporated the nonprofit National Council on Radiation Protection and Measurements (NCRP) to:

1. Collect, analyze, develop, and disseminate in the public interest information and recommendations about (a) protection against radiation and (b) radiation measurements, quantities, and units, particularly those concerned with radiation protection;
2. Provide a means by which organizations concerned with the scientific and related aspects of radiation protection and of radiation quantities, units, and measurements may cooperate for effective utilization of their combined resources, and to stimulate the work of such organizations;

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[30] Ibid., p. 1.

3. Develop basic concepts about radiation quantities, units, and measurements, about the application of these concepts, and about radiation protection;
4. Cooperate with the International Commission on Radiological Protection, the Federal Radiation Council, the International Commission on Radiation Units and Measurements, and other national and international organizations, governmental and private, concerned with radiation quantities, units, and measurements and with radiation protection.[31]

The Council was the successor to the unincorporated association of scientists known as the National Committee on Radiation Protection and Measurements and was formed to carry on the work begun by the Committee.

The Council was composed of the members and the participants who served on the 34 Scientific Committees of the NCRP. The Scientific Committees, composed of experts having detailed knowledge and competence in the particular area of the Committee's interest, proposed and drafted recommendations. These were then submitted to the full membership of the Council for careful review and approval before being published.

In the United States in 1929 a voluntary group known as the Advisory Committee on X-ray and Radium Protection began developing a philosophy and criteria for the maximum permissible occupational exposure to ionizing radiations. The basic intent of this group was that the exposure, continued over a working lifetime (50 years), would not result in any detectable injury to the individual. Additional criteria applicable to both radiation workers and the general public have been

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[31] H. M. Parker, Chairman, "Basic Radiation Protection Criteria," NCRP Report No. 39 (Washington: National Council on Radiation Protection and Measurements, January 1971), p. 113.

established by the NCRP for the purpose of minimizing the possibility of deleterious effects of radiation on life span and heredity.[32]

This concern for preparation of criteria to protect the public from radiation was not limited to the United States. A report entitled "Risk Evaluation for Protection of the Public" was issued in 1967 by the International Commission on Radiological Protection (ICRP) in behalf of the World Health Organization and the International Atomic Energy Agency. This report cited the work of the United Kingdom Medical Research Council as well as another group in the United States known as the Federal Radiation Council.[33] A citation contained in the NCRP Report No. 39 entitled "Basic Radiation Protection Criteria" gave credit to the work accomplished by the International Commission on Radiological Protection. The citation, written in 1954, made a significant observation to the effect that basic principles developed in 1934 and combined with new concepts in 1949 were in the report's words:

> Continued examination of the recommendations did not result in any essential changes . . .

And, in 1971:

> . . . the same document stated reevaluation of the overall basic radiation protection criteria, and updating the 1949 and 1957 amendments have been underway for a number of years, and

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[32] G. V. LeRoy, Chairman, "Exposure to Radiation in an Emergency," NCRP Report No. 29 (Washington: National Council on Radiation Protection and Measurement, January 1962), p. 1.

[33] L. Bugnard, Chairman, "Risk Evaluation for Protection of the Public in Radiation Accidents," Safety Series No. 21 (Vienna, Austria: International Atomic Energy Agency and World Health Organization, 1967), p. 1.

> the general recommendations of the report have been subjected to considerable scrutiny outside of the committee . . .[34]

Radiation criteria had been developed over a period of approximately 48 years and not in a "vacuum." It may be of significance to mention that the above cited criteria were designed to deal with situations in which someone had control over the source of radiation, the exposure of persons to the radiation, or both.

> For most conditions encountered in everyday uses of radiation, the criteria are considered to be adequate and reasonable.
>
> Emergency situations can occur, however, wherein large numbers of people may be heavily exposed to radiation under circumstances beyond their control. Such an exposure may result from a nuclear war, or, for a limited region, from the breakdown of a nuclear reactor or an accident in a nuclear energy industrial establishment.[35]

Concerned citizens had a right to question whether or not the risks were worth the benefits of accidental exposure. They also had the right to question whether there would be a risk of injury from exposure to increases in low levels of radiation as a result of normal radioactive releases from a nuclear fueled electric generating plant. In 1976 a citizen's concern needed to include a comparison of the risks from radiation exposure with the risks from the other chemical constituents in our environment. It required knowledge to prevent unintentional misinterpretation or, more likely, misapplication when comparing such data.

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[34] Op. cit., NCRP 39, p. iii; p. v.

[35] Op. cit., NCRP 29, p. vii.

IV. RADIATION ACCIDENT HISTORY

The recommendations of the criteria developing organizations prior to World War II were for the radiation worker. There was such limited use of ionizing radiation that the need to protect the public had not yet risen.

Eisenbud has stated that prior to World War II there were few X-ray machines and that the radioactive material to which people were exposed was some part of the two pounds of radium that had, by that time, been extracted from the earth's crust. However, an inadequate understanding of the principles of radiation hygiene resulted in hundreds of deaths and unaccounted injuries. Eisenbud stated

> Fortunately the effects of the misuses of these sources of ionizing radiation were studied with such extraordinary diligence and perception by our colleagues of a generation ago that much of the basic information needed for protecting the employees of the atomic energy program was already on hand when it was needed during World War II.[36]

In the book We Almost Lost Detroit, one of the few books that have been written in layperson language, Fuller noted that until the creation of the Manhattan Project in World War II, radium was the only source of radioactive poison. He then emphasized that the world's supply at that time was 1,000 curies.[37] As has been noted above, Eisenbud expressed the world's supply of radium at that time as two pounds. A layperson

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[36]Merril Eisenbud, "Radiation Standards and Public Health," Nuclear Power and Radiation in Perspective (Oak Ridge: Nuclear Safety Information Center, March 1974), pp. 51-58.

[37]John G. Fuller, We Almost Lost Detroit (New York: Ballentine Books, October 1976), p. 29.

can visualize these two pounds as approximately two loaves of sandwich bread. One wonders how that same person associates the fact that one curie (Ci) equals 3.7×10^{10} disintegrations per sec, which is approximately the decay rate of one gram of radium with a half life of 1,620 years.[38]

Fuller, in the above reference, correctly stated the 1,000 curies number though the context in which he stated the value leads one to believe he was utilizing scare tactics.

The most significant statistic, however, is the fact that there had been no known radiation injuries to any member of the public resulting from any of the civilian activities of the Atomic Energy Commission.[39]

The April 21, 1976, issue of Newsweek magazine reported that the safety record of the commercial nuclear power industry had been remarkable. In April 1976, 162 reactors were on stream worldwide with 60 of them located in the United States. This industry employed some 25,000 people. A good number of them were technicians, guards, and security officers whose main interest was safety. The article continued by noting that after hundreds of reactor years in the United States and other open societies there had been no radiation fatality at any of these commercial plants. There had been, however, a number of

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[38]James D. Lyman, "Nuclear Terms—A Glossary" (Oak Ridge: USAEC Technical Information Center, March 1974), pp. 51-58.

[39]Op. cit., Eisenbud, p. 52.

casualties and a few fatalities as a result of conventional industrial accidents.[40] Figure II-2 presents statistics regarding radiation-related injuries and fatalities from 1943 to 1975.

Until 1975 the Atomic Energy Commission had the dual responsibility for the development of nuclear power and the protection of the public. The Energy Reorganization Act of 1974 abolished the U.S. Atomic Energy Commission. The Commission's functions of research, development, nuclear materials production and promotional activities were assigned to the U.S. Energy Research and Development Administration (ERDA). In 1977 these same activities became the responsibility of the U.S. Department of Energy. Licensing and regulatory activities for all types of nuclear installations were in 1977 the responsibility of the U.S. Nuclear Regulatory Commission.

The licensing process of a nuclear power reactor began with the preparation of an environmental impact statement that related the impact of the station on the overall program of nuclear power generation. A utility was required to obtain as many as 52 different licenses or operating permits from federal, state, and local agencies. The steps in the process are as shown in Figure II-3.

It took a knowledgeable public to comprehend and participate in the process shown in Figure II-3. It required knowledgeable persons to review, to evaluate, to make recommendations and to decide on the proper course of action in this complicated licensing procedure.

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[40]P. Gwynne James Bishop, Jr. and S. G. Michaud, "How Safe is Nuclear Power?," Newsweek (Washington: Newsweek, Inc., April 12, 1976), pp. 70-75.

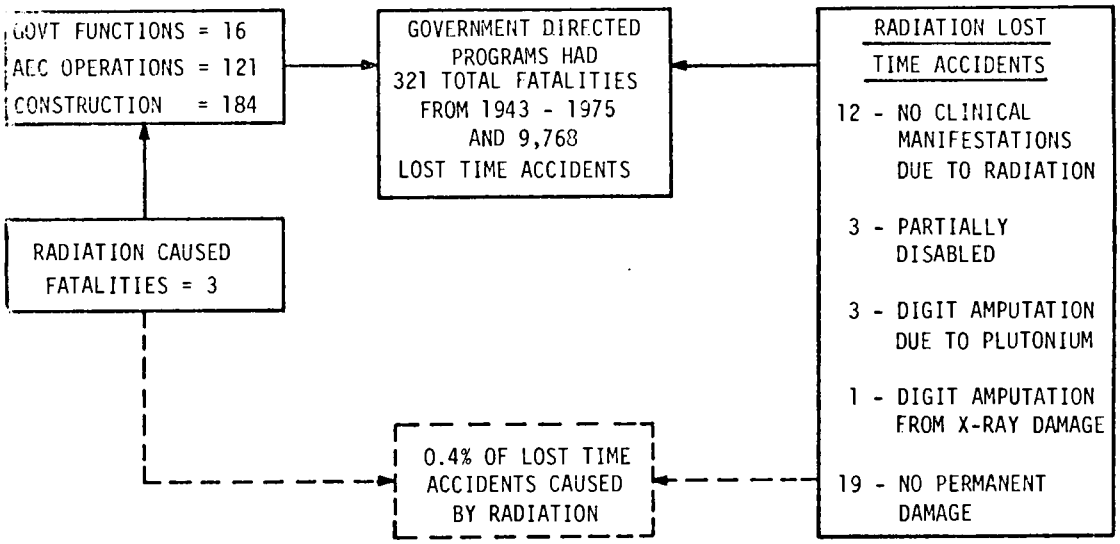


Figure II-2. Atomic Energy Commission Operations; radiation injury summary, 1943-1975.

Note: Three additional radiation deaths could be added to the three listed above resulting from SL-1 reactor excursion as radiation levels were extremely high and probably would have been fatal had the person involved not been killed by the blast and flying missiles.

Source: Wash. 1192—Operational Accidents and Radiation Exposure Experience within the United States Atomic Energy Commission—1943-1975.

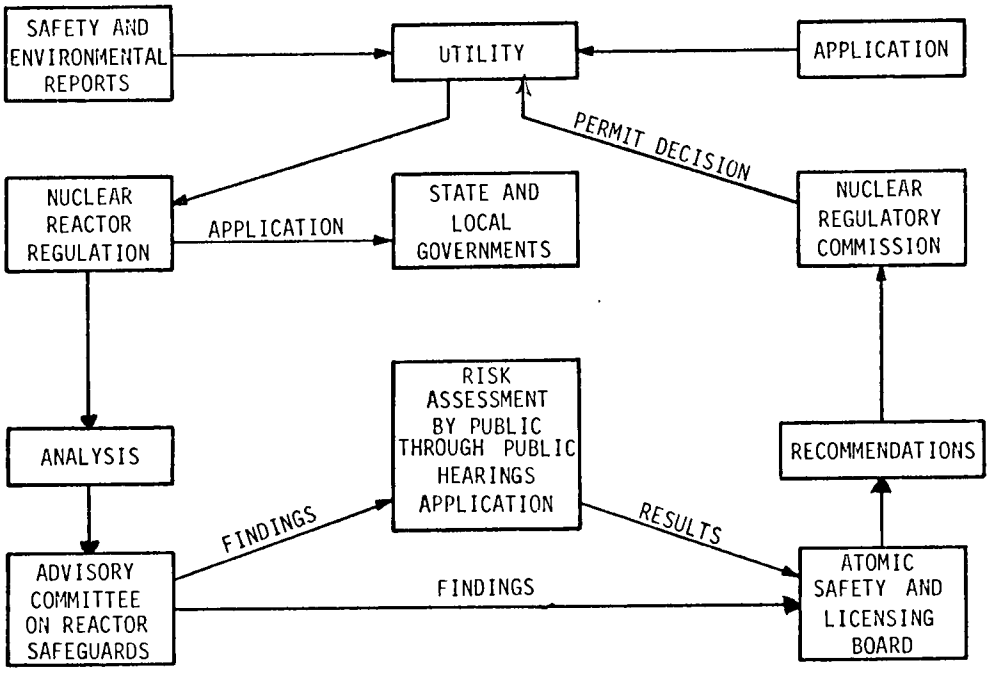


Figure II-3. Nuclear Power Reactor Licensing Procedure.

Source: R. J. Campana and Sidney Langer, "Nuclear Power and the Environment." (Hinsdale, Ill.: American Nuclear Society, 1976), p. 81.

V. EDUCATION AND THE ATOM

The passage of the Atomic Energy Act of 1946 passed the responsibility of the nation's nuclear energy program for the Manhattan District of the U.S. Army Corps of Engineers to the newly formed United States Atomic Energy Commission. This event started a program to develop the full potential of nuclear energy and its associated materials such as radioactive isotopes for peaceful use. "From the start, the Commission recognized that a key element in the success of the programs would be the availability of talented people with the requisite level of education and training in the variety of specialties which had emerged from the work of the Manhattan District during World War II."[41] The initial breakthroughs into what has been called the "Nuclear Age" were "accomplished by relatively few scientists, drawing upon their grounding in conventional scientific disciplines, thousands of hours of patient experiment, rather narrow circles of communication and some bold leaps of imagination and insight."[42]

The Atomic Energy Commission looked to the established education system as a primary source of training for nuclear energy. It accomplished this role by supporting graduate education in basic nuclear science. Because of security restrictions in the early days, nuclear engineering and other nuclear technologies were limited for some years

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[41] "Scientists and Engineers for the Nuclear Age," (Oak Ridge: Oak Ridge Associated Universities, 1974), pp. 4 and 5.

[42] G. T. Seaborg and D. M. Wilkes, Education and the Atom (New York: McGraw Hill Book Company, 1964), Preface.

to the National Laboratories and other Commission facilities.[43] During the same period undergraduate level assistance to universities for teaching nuclear science was retarded for lack of authority.

The Atomic Energy Act of 1954 and subsequent amendments in 1957 authorized the Commission "to engage directly in support of 'training' as well as in research and development." The Commission was further authorized to make grants and contributions to the cost of construction and operation of reactors and other facilities and equipment to colleges, universities, hospitals, and charitable institutions for the conduct of educational and training activities.[44]

The Commission supported education by several distinct fellowship programs in response to various needs as follows:[45]

1. AEC Predoctoral and Postdoctoral Fellowships in Physical and Biological Science (Program was terminated in 1954)
2. Health Physics Fellowships (Program was terminated in 1973)
3. Nuclear Science and Engineering Fellowships (Program was terminated in 1973)
4. Advanced Health Physics Fellowships (Program was terminated in 1969)
5. Industrial Hygiene Fellowships (Program was terminated in 1966).

Table II-1 summarizes these very vital programs. It was this cadre of able and dedicated scientists and engineers with their evergrowing

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[43]Ibid., p. 59.

[44]Ibid., p. 5.

[45]Op. cit., Scientists and Engineers, pp. 5 and 6.

base of knowledge and skills that made the United States a continuing leader in nuclear science and its related fields.

Table II-1. Summary of Atomic Energy Commission Graduate Fellowship Program.

Program	Fellows	Fellowship Years	Cost (in thousands)
Predoctoral and Postdoctoral	920	1,061	$ 4,382
Health Physics	910	1,381	6,078
Advanced Health Physics	30	77	597
Industrial Hygiene	80	89	466
Nuclear Science and Engineering	1,380	2,457	12,960
Totals	3,320	5,065	$24,483

Source: See footnote 46.

In February of 1975 there were 182 four-year educational institutions and 79 technical training institutions with nuclear and nuclear-related programs.[46] The courses offered by these institutions are summarized in Table II-2.

Another facet of the Atomic Energy Commission programs for education was to share the task of teaching down to the grade school level through traveling lecture demonstrators, printed educational materials and films to answer questions and to help youngsters in science projects. A now discontinued program that was conducted for a number of years was the Teachers' Institute. The high school teachers were often inexperienced in the use of nuclear equipment. The teachers' knowledge had primarily been obtained from only descriptive materials. Many of the teachers had

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[46]"Educational Programs and Facilities in Nuclear Science and Engineering" (Oak Ridge: Oak Ridge Associated Universities, 1975), p. iii.

Table II-2. Nuclear-Related Courses.

Health Physics; Radiobiology	Nuclear Technology	Radiation Hazards Control
Biophysics	Nuclear Engineering	Radiation Shielding
Environmental Radiology	Reactor Analysis	Waste Disposal
Radiation Effects	Reactor Design	
Radiological Physics	Reactor Instrumentation	REACTOR MATERIALS
Reactor Safety	Reactor Laboratory	Nuclear Metallurgy

Source: "Educational Programs and Facilities in Nuclear Science and Engineering" (Oak Ridge: Oak Ridge Associated Universities, 1975), p. 47.

been isolated from scientific environments. The Teachers' Institute invited them to the stimulation of a summer at a National Laboratory or university.[47]

Contracts were awarded to various organizations to develop educational materials. Examples of such materials developed by the Stanford Research Institute[48] during the late 1950's and early 1960's are as follows:

1. Instructor's Guide: Survey of Nuclear Fundamentals and Radioisotope Application in Industry.
2. Instructor's Guide: Radiation Safety.
3. Instructor's Guide: Survey of Nuclear Energy and Power Plant Applications.
4. Development of a Radiation Safety Training Program for Industrial and Public Service Personnel.
5. Development of a Radiation Safety Training Program in a Naval Shipyard.
6. Development of Training Programs for Operating and Maintenance Personnel in Nuclear Power Generation Systems.
7. Trial Presentations of a Nuclear Energy Training Course in Two Adult Vocational Education Programs.
8. Preparations for Nuclear Energy Training in a Trade Union.

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[47] Op. cit., Scientists and Engineers, p. 89.

[48] H. M. Vollmer and L. H. Towle, Radiation Safety Training in a Naval Shipyard (Washington: U.S. Government Printing Office, 1960), pp. 2 and 3.

This is a sample of the types of materials developed for the Atomic Energy Program. The planner of this research found the above manuals in a library where they had been placed in February of 1961. As best can be determined, April 1976 was the first time this material had been removed from this particular library. In October 1976, during a visit to Stanford Research Institute, a question was posed as to whether this material had been expanded. Personnel at this Institute stated that to the best of their knowledge no other organization had conducted further research in this area.[49]

No description of the educational activities of the former Atomic Energy Commission, the Energy Research and Development Administration, or the new U.S. Department of Energy (DOE) would be complete without mentioning the Technical Information Center in Oak Ridge, Tennessee.

The DOE Technical Information Center (TIC) was the collection, processing and distribution point for scientific and technical information generated by DOE programs. One of the primary objectives of TIC was to insure that government-sponsored research was reported promptly and that reports were distributed to DOE, to its contractors, and when suitable, to the general public.

The TIC located and acquired energy-related scientific and technical information nationally and internationally through bilateral agreements with foreign countries, special exchange programs, and organization-to-organization agreements.

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[49]Personal Interview with Phillip S. Sorensen, Senior Psychologist, Stanford Research Institute, Menlo Park, California, on October 6, 1976.

It provided technical reference services, document and film request services, and an education services program devoted to aiding students and teachers in their studies of energy.

Scientists, linguists, editors, craftsmen, educators, writers, engineers, librarians, computer specialists, and information specialists maintained the center's centralized technical information activity.[50]

In pursuing the information center's acquisition and evaluation activities, some 1,000,000 pieces of literature were received and evaluated annually.[51]

The information center's computerized data bases contained in 1976 nearly 800,000 items that were machine searchable in all areas of nuclear science, power reactor licensing and regulation, energy policy, coal technology, solar energy, geothermal energy, oil shale, magnetohydrodynamics, superconductivity, conservation, electric power engineering, direct energy conversion, thermonuclear power, environment and safety, and basic research and development supporting all the above.[52]

The information center provided highly diversified publishing and graphics services and products for the ERDA information program. Typical publications produced on a regular basis include "Nuclear Science Abstracts," "Nuclear Safety," "ERDA Research Abstracts," and "Energy Abstracts for Policy Analysis," the volumes in the ERDA Symposium

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[50]"ERDA Technical Information Center—Its Functions and Service," (Oak Ridge: ERDA Technical Information Center, July 1975), pp. 1 and 2.

[51]Ibid., p. 55.

[52]Ibid., p. 9.

Series, the monographs in the ERDA Critical Review Series, a series of information and educational booklets for the general public, bibliographies, and conference proceedings. In addition to these, many scientific textbooks, handbooks, and specialized reviews were published along with countless research and development reports.[53]

The Educational Services Program (1) provided information on energy production, use, and conservation to students, teachers, and nontechnical people at all age and educational levels; (2) advised educators of available materials and services; and (3) prepared materials and guides.

The Center (TIC) had the responsibility of responding to public requests for information on energy, science, and technology.[54]

When one reviews the statistics of the operation of this Center, the words of Seaborg come to mind:

> The sheer magnitude and complexity of the national nuclear energy effort make difficult the task of anyone seeking a better understanding of the scientific developments involved and the administrative environment in which they take place. Responsible citizenship requires the layman to acquire a grasp of nuclear matters if he is to pass intelligent judgments in pressing domestic and international issues.[55]

The publications, abstracts, and other information were filed in the Center's computerized data bases. A cursory search was made of this material utilizing the remote access retrieval system (RECON). This search produced a large amount of material that, in the study

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[53]Ibid., p. 12.

[54]Ibid., p. 16.

[55]J. F. Hogerton, The Atomic Energy Deskbook (New York: Reinhold Publishing Corporation, 1963), p. iii.

planner's opinion, was not suitable for this study. One major facet of this study was to find out whether complex material such as nuclear-related material could be put in language understandable to the average layperson. Finding the TIC material unsuitable for purposes of this study, it was decided that perhaps a search should be made of the usual data bases available to the professional educator. The descriptors contained in Figure II-4 were used in a search of the information compiled by the Educational Research Information Center (ERIC).

When the descriptors were matched only twenty-six abstracts were available from a data base containing over 13,000 items. Of these abstracts, nine of the twenty-six were promulgated and were available from the DOE Technical Information Center in Oak Ridge.

Thus, it appears that while the government had spent large sums of money sponsoring the education of nuclear specialists, little had been spent in a direct manner to inform the laypersons or the nonscience oriented student in understanding nuclear science. Some programs promulgated the education of secondary school science students and their teachers through the traveling exhibits, teacher programs, and the "Understanding the Atom" series of booklets. Little has been done for the students or teachers who have little interest in the physical sciences.

In 1967 a School Health Curriculum Workshop was conducted by the Health Education Department of the University of Tennessee. Participants in this workshop assisted in the development of a teacher's guide entitled "Health Aspects of Radiation" for the U.S. Atomic Energy

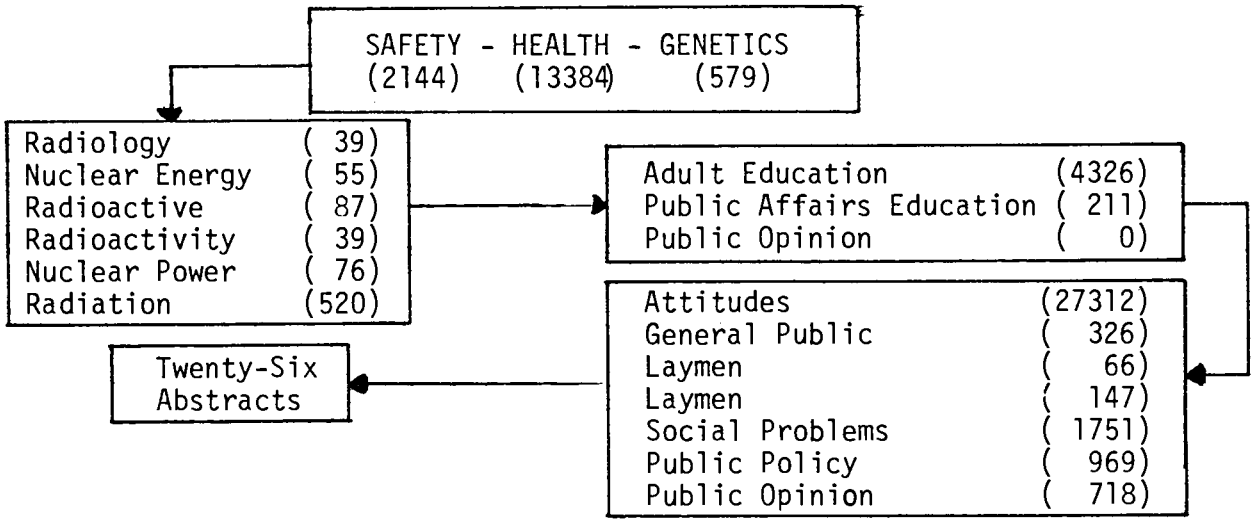


Figure II-4. ERIC descriptors. ( ) denotes number of abstracts for given descriptor.

Commission Division of Technical Information. This guide was published only in draft form.[56]

In 1975 the Pennsylvania Department of Education prepared and tested, under an Energy Research and Development Administration contract, a minicourse to describe the needs, environmental costs, and benefits of electrical power generation. Only one chapter was devoted to nuclear fueled electric generating stations.[57]

The American Nuclear Society had prepared a booklet entitled "Nuclear Power and the Environment—Questions and Answers" to assist in helping its membership present credible information concerning the nuclear industry.[58] The International Atomic Energy Agency has prepared a summary of training programs relating to radiation, health, and safety entitled "Training on Radiological Protection: Curricula and Programming." One of the five types of courses described was for the education of the general public, published in 1964.[59] It may be of interest to the reader that the material cited in references 57, 58, and 59 was found by means of the ERIC search.

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[56]B. C. Wallace, "Health Aspects of Radiation-Draft" (Oak Ridge: AEC Technical Information Center, 1967), pp. 6-80.

[57]Pennsylvania Department of Education, "The Environmental Impact of Electrical Power Generation: Nuclear and Fossil" (Washington: U.S. Government Printing Office, 1975), pp. 55.

[58]Op. cit., Langer and Campana, pp. 1-122.

[59]Educational Resource Information Center, "Dialog Search File 1 for User 1099-Blackmon-ERIC Full Text-August 1976" (Knoxville: University of Tennessee, 1976), p. 791.

VI. MEASUREMENT OF ATTITUDES TOWARD RADIATION

In 1959 Towle, by combining the (Guttman) Cornell Technique for Scale and Intensity Analysis with Wallis and Roberts' h Coefficient of Rank Order Association constructed and tested a consistent scale to measure the degree of concern with radiation hazards. This scale is now referred to as the Stanford Research Institute Scale of Attitude Toward Radiation (SRI-AR Scale).[60] The major difficulty encountered in the development of this scale was defining what would be a proper attitude toward radiation. The scale that evolved was based on the premise that the best attitude toward radiation hazards lay somewhere between the extremes of very high concern and very low concern for these hazards. This premise was tested on an attitude group of 10 persons, a group of 25 persons working with radiation, and a group of 100 non-radiation workers. The conclusion from Towle's work was that a "best" attitude for radiation employees to adopt would be one of moderate concern.[61]

This attitude scale can be contrasted with Crater's Attitude Toward Radioactivity Scale (ATRS) developed and tested at the University of Texas at Austin.[62] This scale was a Likert-type summated rating scale

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[60] Op. cit., Vollmer and Towle, pp. 10-17.

[61] Ibid., p. 26.

[62] H. L. Crater, "The Identification of Factors Influencing College Students' Attitudes Toward Radioactivity," unpublished Doctoral dissertation (Ann Arbor, Michigan: University Microfilms, August 1972), pp. 25-30.

consisting of twenty statements that had been given to 1,205 undergraduate students. Seven hypotheses predicted no relationship toward radioactivity and (1) an understanding of radioactivity; (2) grade level; (3) subject matter; (4) grade point average; (5) number of high school science courses taken; (6) number of semester hours of college science studied; and (7) political leanings. The results of Crater's study indicated that only hypothesis 4, expressing no relationship between a student's grade point average and attitude toward radioactivity, was accepted.

Rejection of the other six hypotheses at or beyond the .01 level showed the following characteristics to be associated with the college students who hold the more favorable attitudes toward radioactivity.

They tended to be more knowledgeable about the principles and applications of radioactivity. They were likely to be seniors or graduate students majoring in science-related subjects. They typically took four or more science courses in high school and would have completed more semester hours of science courses in college than students less favorably disposed toward radioactivity. They also tended to be more conservative in their politics.

The subjects of this study did not seriously disagree with the ATRS statements linking the work of nuclear scientists in the military-industrial complex and a disregard for the needs of society. While the students generally approved of developing a nuclear power industry in the United States, they expressed concern that nuclear pollution would become an increasing problem as more facilities are brought into operation.

Crater recommended that subsequent studies should attempt to discriminate between the effectiveness of knowledge gained inside and outside of the science classroom and the students' attitudes toward radioactivity.[63]

VII. THE DELPHI TECHNIQUE

A panel of knowledgeable persons is interrogated by a sequence of questionnaires in which the responses to one questionnaire are used to produce the next questionnaire. Any set of information available to part of the group and not others is thus passed to the others enabling the entire panel to have access to all of the available information for forecasting. This technique eliminates the bandwagon effect of majority opinion.[64]

"The original use of the technique was to establish a chronology of scientific and technological events and to judge when the events might occur through the speculations of several experts."[65] Gordon and Helmer in the introduction of their Report on a Long Range Forecasting Study stated that

> Prediction-making is a fundamental part of technological, commercial, social, military and political planning in the modern world. Relatively short-term forecasts of events of

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[63] Ibid., pp. 55-71.

[64] J. C. Chambers, S. K. Mullick and D. D. Smith, "How to Choose the Right Forecasting Technique" (Boston: Harvard Business Review, July/August 1971), p. 55.

[65] W. T. Weaver, "The Delphi Forecasting Method," Phi Delta Kappa (Bloomington, Ind.: Phi Delta Kappa, Inc., January 1971), p. 267.

> the next twenty-four hours, the next year, or even trends of the next decade are often accurate enough to be of demonstrably practical use. But as the period of concern is moved further and further into the future uncertainties multiply, confidence in prediction is decreased, and the scientific theories and techniques of forecasting increasingly give way to intuitive judgment.[66]

Chambers, Mullock and Smith found that the accuracy of Delphi business forecasts varied from fair to good for short term (0-3 months), medium term (3 months to 2 years), and long term (2 years and up). They utilized the technique for forecasting of long range sales, new product sales, and margins. They further stated that "forecasters were able to identify turning points with fair to good accuracy."[67]

Helmer in his paper The Use of the Delphi Technique in Problems of Educational Innovations concluded that not much weight could be given to substantive findings based on the pilot study but that methodologically the endeavor was promising.[68] Cyphert and Gant utilized the technique to determine the needs, desires, and opinions of students, faculty, and administrators of the School of Education, University of Virginia. Their conclusions were that this technique made influential persons in the Commonwealth of Virginia aware of the School of Education

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[66]Theodore Gordon and Olaf Helmer, Report on a Long Range Forecasting Study (New York's Basic Books, Inc., 1963), p. 44.

[67]Op. cit., The Right Forecasting Technique, p. 55.

[68]Olaf Helmer, The Use of the Delphi Technique in Problems of Education Innovations (Santa Monica, California: The Rand Corporation, December 1966). p. 22.

and gave the study participants a vested interest in its future accomplishments.[69]

Weaver has drawn a conclusion as a result of his studies and studies by others that the more promising educational applications of the Delphi Technique are:

(a) a method for studying the process of thinking about the future,
(b) a pedagogical tool or teaching tool which forces people to think about the future in a more complex way than they ordinarily would, and
(c) a planning tool which may aid in probing priorities held by members and constituencies of an organization.[70]

Martino conducted a regression analysis of 42 published and unpublished Delphi forecasts concerning such diverse subjects as computer technology, communications technology in Czechoslovakia, various aspects of the future of medical care, and the original Gordon-Helmer study. His conclusion was that there is clearly a relationship between the remoteness of the event being forecast and the uncertainty in the date of the forecast on the part of the panel. He further concluded that the intuitively satisfactory nature of the results and his finding that the Delphi process is not a chaotic process, but one possessing some underlying order, served to give more confidence in the

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[69] F. R. Cyphert and W. L. Gant, "The Delphi Technique: A Case Study", Phi Delta Kappan (Bloomington, Ind.: Phi Delta Kappa, Inc., January 1971), pp. 272 and 273.

[70] Op. cit., Weaver, p. 271

Delphi procedure as a means for obtaining a group consensus on a forecast.[71]

It has been suggested that new approaches to old problems like group communication inevitably spawn criticism. When it serves a constructive purpose, the criticism can be healthy. In 1978, the most extensive critique of the Delphi Technique available was the Sackman Report. In essence Sackman recommended that except as an exercise for informal heuristic purposes, the conventional Delphi Technique should be dropped from institutional, corporate and governmental use until its principles, methods, and fundamental applications could be established scientifically tenable. Sackman believed that a whole series of issues related to the design and development of questionnaires as applied to experts, needed resolving. The planner for this study tried to keep several of Sackman's criticisms in mind and these criticisms will be addressed in Chapter VI of this study.[72]

VIII. SUMMARY OF CHAPTER II

Health, safety, and improvement of the quality of life have been the concern of governments and individuals throughout recorded history. These concerns have been receiving increasing priority throughout the world, especially in the United States, as evidenced by more and more

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[71] J. P. Martino, "The Precision of Delphi Estimates," Technological Forecasting 1 (Elsevier Publishing Co., Inc., 1970), pp. 293-299.

[72] H. Sackman, "Delphi Assessment: Expert Opinion, Forecasting, and Group Process," Rand Report R-1283-PR (Santa Monica, California: Rand Corporation, April 1974), p. 71.

national legislation in areas of health, safety, and environment promulgated since the mid-1960's. The need for this proliferation of legislation indicated that these areas had not received the emphasis required.

The fact that radiation has the potential of being a hazard to the health and safety of citizens has been increasingly emphasized by critics opposing expansion of nuclear fueled electric generating plants. This chapter explored the criteria used to set standards of radiation protection for both power generation and diagnostic radiation since 1929. A review of radiation history during the Atomic Energy Commission era revealed that while 41 persons have had lost-time from work due to exposure to radiation, only three had perished in the previous 32-year period. No one had perished as a result of radiation exposure at any of the 162 commercial fueled generating facilities located in the free areas of the world.

This literature review indicated that while the United States government had spent large sums of money sponsoring the education of nuclear specialists, little seemed to have been spent to assist the layperson or nonscience oriented student in understanding nuclear science. This lack of information was reflected in the results of student scores on radiation attitude tests given at the University of Texas in 1972. Students with more science training were more favorably disposed toward accepting the hazards of radiation than those who had not obtained such training.

Chapter III presents the rationale and methodology used in the study.

CHAPTER III

METHODS AND PROCEDURES

The Conventional Delphi Technique was developed by the Rand Corporation through the efforts of Helmer and Dalkey in 1963. Although many variations of the Technique have appeared in literature since that time, Conventional Delphi Technique is basically an iterative opinion questionnaire technique, with anonymous statistical feedback. This feedback after each iteration is applied to a panel of experts until optimal consensus is reached among the panelists. "The original use of the Technique was to establish a chronology of scientific and technological events and to judge when the events might occur through the speculations of several experts."[1]

The methodology conceived by the originators of the Technique has been changed for this study in two significant ways:

1. The panel consisted of 72 participants, however, fewer than one-third of the group were assumed to be experts in the field of radiation.
2. The study was designed to establish a compendium on concepts, behavioral objectives, and technological information necessary for layperson understanding of radiation rather than a

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[1]W. T. Weaver, "The Delphi Forecasting Method," Phi Delta Kappan, (Bloomington, Ind.: Phi Delta Kappa, Inc., January 1971), p. 267.

chronology of scientific and technological events for the study of radiation.

This study consisted of four separate and distinct parts labeled: panel selection; solicitation of panel input through preparation and completion of an initial questionnaire entitled "Round One-Seeking Input"; preparation and completion of a second questionnaire entitled "Round Two-Evaluation"; reevaluation of the Round Two questionnaire by the panel; and data analysis.

I. PANEL SELECTION

The method of selecting the members of this Delphi Panel is discussed in Chapter I, Part V—Limitations, and Part VI—Delimitations. Little is to be gained by reiterating the selection process in this chapter on methodology—though this may be the most important determinant in the success or failure of a Delphi study. If the planner is unsuccessful in gaining the respect of potential panel members, the study, at best, will be mediocre. A Delphi study is not just another polling scheme but a true exchange of ideas. The planner must keep the confidentiality of the panel members, particularly when probing such an emotional and technical subject as radiation. The political consequences could be overwhelming to an expert if it were divulged that his or her stated beliefs were contrary to policies he or she publicly supported. The consensus results guarantee the anonymity of personal beliefs.

II. THE INITIAL DELPHI QUESTIONNAIRE—ROUND ONE—SEEKING INPUT

During the summer quarter of 1967, the Health Education Department of the University of Tennessee conducted a School Health Curriculum Workshop in Radiation under the leadership of B. C. Wallace. This Workshop resulted in an unpublished Teachers' Guide, "Health Aspects of Radiation,"[2] which contained conceptual statements followed by a sequence of suggested behavioral objectives.

During the early 1960's, Towle and others at Stanford Research Institute (SRI) developed training programs for Naval shipyard workers, radioisotope workers in industry, and public service personnel. These training programs were designed for the technician who worked with various forms of radiation on a daily basis. SRI prepared methods for evaluating the effectiveness of the training programs as well as ways of identifying other employees who might need training. These methodologies resulted in analytical devices that measured worker knowledge about radiation safety and their attitudes toward radiation hazards. The SRI Attitude Scale utilized L. Guttman's Cornell Technique to determine the consistency of responses to a series of attitude items.[3]

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[2]B. C. Wallace, Editor, "Health Aspects of Radiation—Draft," (Oak Ridge: AEC Technical Information Center, 1967), pp. 6-80.

[3]H. M. Vollmer and L. H. Towle, "Radiation Safety Training in a Naval Shipyard" (Washington: U.S. Government Printing Office, 1960), pp. 43-46.

In 1972, Crater developed an Attitude Toward Radioactivity Scale (ATRS)[4] consisting of 20 statements used to sample a student's beliefs about specific areas of radioactivity. The score on the ATRS was considered an indicator of a particular subject's attitude toward radioactivity and was used as the primary dependent variable in the 1972 study. This ATRS instrument was a Likert-type summated rating scale. It was used by Crater to discriminate among the attitudes of the population of his study and to rank by percentages the college students who agreed or disagreed with a particular belief statement. However, the scale could not be used to determine whether a given score represented a positive or negative attitude toward radioactivity.

The attitude statements, the conceptual statements, and the behavioral objectives developed in 1960 by SRI, in 1967 by Wallace, and in 1972 by Crater, were placed into this initial Delphi questionnaire, "Round One-Seeking Input." The purpose of the questionnaire was to solicit information from the panel. The statements submitted were to stimulate ideas by having a panel member indicate whether he or she agreed or disagreed with the statement and to determine whether it would be feasible to try to teach the contents of the statement. Each panel member was requested to comment on the material contained in each statement in addition to expressing their degree of agreement or disagreement and teaching feasibility. Space was provided on the questionnaire

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[4]H. L. Crater, "The Identification of Factors Influencing College Students' Attitudes Toward Radioactivity," unpublished Doctoral dissertation (Ann Arbor, MI: University Microfilms, August 1972), pp. 75-76.

for these comments and the addition of new material. A copy of the initial questionnaire is found in Appendix B and the resulting questionnaire used in Round Two is located in Appendix C.

III. EVALUATION BY PARTICIPANTS—ROUND TWO

Step six in the Methodology Flow Chart (Figure III-1) called for the editing of panel member responses submitted as part of Round One. The purpose of step six was to eliminate duplications, to improve clarity, and to avoid distortions of meaning and intent. This was a very important step, because if a panel member took the time to write out a suggestion, he or she had the right to see an acknowledgment that their suggestion was received and considered. Certain of the original statements plus a digest of the 650 comments received in Round One evolved into the 275-Statement Round Two Questionnaire.

The panel members were asked to evaluate these new conceptual statements and behavioral objectives on two separate scales. The first scale, "Desirability," judged the effectiveness or benefits to be gained by having laypersons <u>know</u> the information in a given statement. The second scale, "Importance," ranked the priority or relevance of having a layperson <u>understand</u> the information contained in the statement. All statements presented to support individual behavioral objectives were rated for validity. A panel member was asked to express personal confidence in the validity of the information in the statement. Table III-1 summarizes the range of values used by panel members for evaluating the statements.

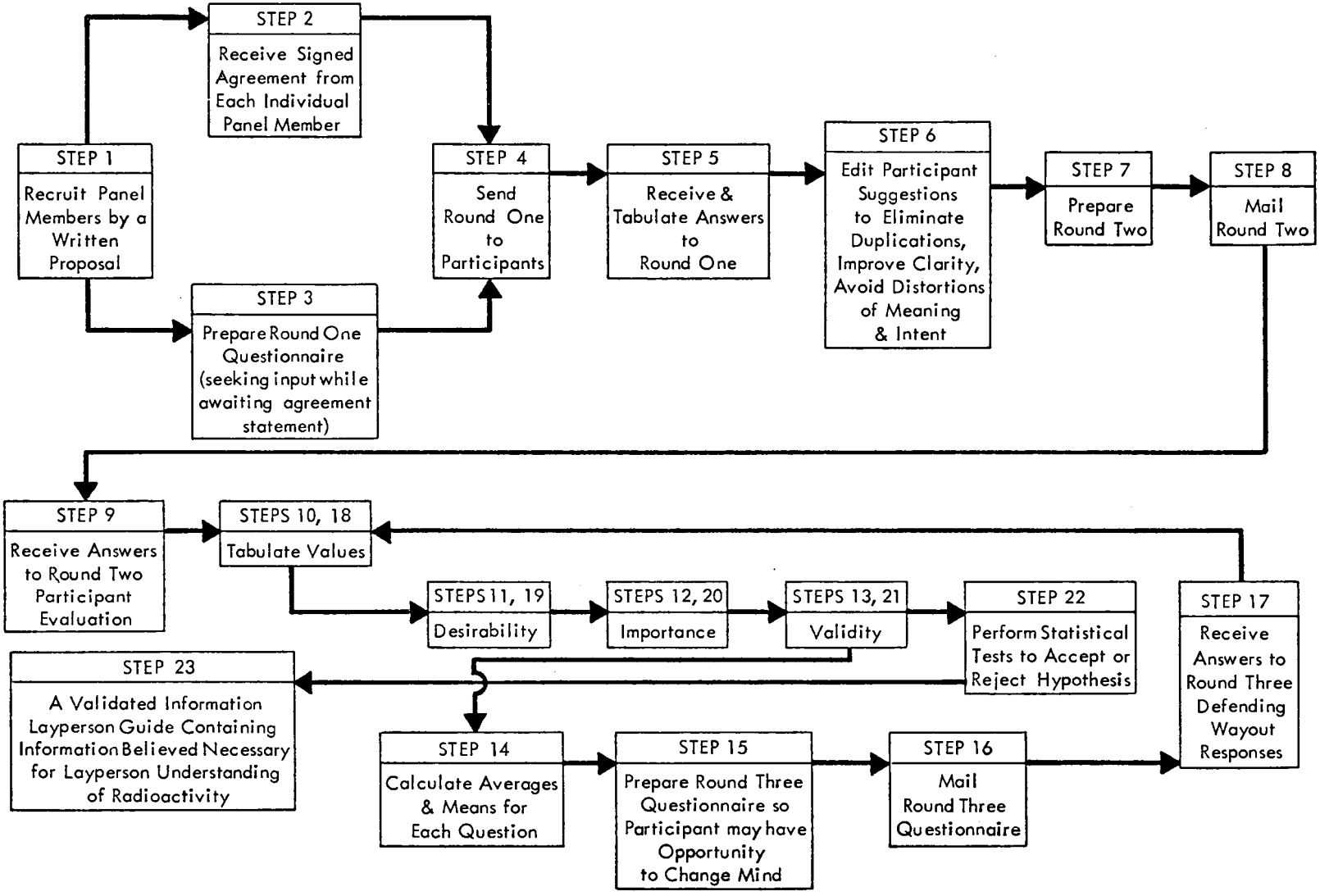


Figure III-1. Methodology Flow Chart.

TABLE III-1

SCALE VALUE FOR ROUND TWO

Desirability*	Importance*	Confidence*
(Effectiveness or Benefits to be gained by having laypersons know this information)	(Priority or Relevance of having a layperson understanding this information)	My confidence in validity of the information in the statement
Desirable: will have a positive effect and little or no negative effect; justifiable on its own merit—7	Important: a most relevant point; first order priority; has direct bearing on major; should be resolved, dealt with, or treated—7	Certain: low risk of being wrong; decision based upon this will not be wrong because of this "fact"; most inferences drawn from this will be true—7
Undesirable: will have a major effect; not justifiable—1	Unimportant: no priority; no relevance; no measurable effect; should be dropped as an item to consider—1	Unreliable: substantial risk of being wrong; not willing to make a decision based on this alone; many incorrect inferences can be drawn—1
*On a declining scale of 7 to 1: 7 = desirable 1 - undesirable	*On a declining scale of 7 to 1: 7 = important 1 = unimportant	*On a declining scale of 7 to 1: 7 = certain 1 = unreliable

IV. AN OPPORTUNITY TO CHANGE—ROUND THREE

This Round focused on giving panel members an opportunity to change their responses to Round Two should they desire to do so. A summary of the Mean scores for all statements was submitted to each panel member along with his or her own Round Two questionnaire. While the questionnaire did not contain the words, the title of this Round was "An Opportunity to Change."

Each panel member was asked to compare the Mean of each response to his or her own Round Two responses. If the response varied by +1 or -1, a panel member was offered the opportunity to change. There was no criterion demanding change nor did a panel member have to give the reason for not changing an answer, as is the customary practice in a Delphi study.

V. DATA ANALYSIS

There were a variety of data analytic methods available to assist the researcher to design, implement, analyze, and write up the results of meaningful research. Statistical analysis is fundamental to research of any kind because whenever a problem can be defined, its resolution is better obtained if there is some way to quantitatively solve it. The data analysis portion of this study began with the idea that there were two major reasons for these data analyses. The first, exploration, involved a preliminary examination of the data for purposes of formulating hypotheses and of understanding the potential role of variables, types, or design; and the establishment of hypotheses made it necessary to

confirm whether the hypotheses were indeed plausible or whether they should be rejected. The Round One questionnaire used in this study was exploratory for two purposes: (1) It generated data from the panel that were used to develop the second questionnaire; (2) thus making it necessary to validate the assumption that independent groups of judges had been selected by the study planner. The establishment of the criteria of independent groups of judges answering questions was crucial as it is in any Delphi study, and involved more than studying the existence of an association in the judge population. It required a descriptive measure of the degree of association or the strength of relationship between the variables in the sample data. It would be redundant to elaborate on the procedures used to develop the first questionnaire and how it was handled, as these details have been discussed in Chapter I and in the first part of this chapter. However, little has been said concerning the structure of the questionnaires, themselves. Common to all three questionnaires was the idea that there were some fundamental concepts underlying the theme of radiation. These concepts were labeled A, B, C, D and E in the first questionnaire and I, II, III and IV in the second and third. It was deemed inappropriate to describe these here; however, if the reader is interested now, he or she may go to Chapter IV. There were four concepts in the last two questionnaires and five in the first because the information in E was more appropriate when combined with the other four concepts.

All questionnaires had behavioral objectives and some examples were laypersons should be able to summarize, laypersons should be able to recognize, or laypersons should be able to compute. Objectives such

as these were grouped under the appropriate concept with the beginning rationale that such procedures would better organize the questionnaires. All such material was labeled A, B, C, D thru R in the latter questionnaire and 1, 2, 3, 4 to 67 on the first.

Only questionnaires two and three contained cognitive information about radiation. All cognitive material was labeled 1, 2, 3 thru 10 or 12. This cognitive material was fundamental to the study. If facts correct or incorrect could not be exchanged between the judging group, the study would have been a failure. As will be seen in subsequent chapters, it was not.

Six hypotheses were postulated regarding the opinions or differences of opinions of the judges; relationships between certain ideas; and changes between questionnaires. In Chapter IV the reader will observe that certain groups of judges were viewing things differently but that when other groups were combined it made it seem that there was consensus. In other words, one will find that some sub-hypotheses evolved.

The study planner had available two basic statistical methodologies with which to test the hypotheses—parametric and nonparametric. The nonparametric methodology was chosen because the planner believed that:

1. the data obtained were such that the assumptions required for parametric tests were unlikely to be satisfied;
2. a general feeling existed that there were too many unverifiable assumptions for sound inference projections, and
3. the population sample size dictated nonparametric techniques.

Some of the tests available for nonparametric methods are contained in Table III-2.

TABLE III-2

COMPARISON OF NONPARAMETRIC AND PARAMETRIC METHODS

Type Hypothesis	Name of Nonparametric Test	Name of Parametric Test
Association Analysis		
Two related samples	Spearman Rank Correlation or Kendall Tau	Pearson product moment correlation
K related samples	Kendall Coefficient of Concordance	F test (randomized blocks analysis of variance)
Inferences Concerning Location of Central Tendency		
K independent samples	Kruskal-Wallis one-way analysis of variance	F test (one-way analysis of variance

Source: J. D. Gibbons, Non Parametric Methods for Quantitative Analysis (New York: Holt, Rinehart and Winston, 1976), p. 30.

The tests used to accept or reject the various hypotheses are in Table III-3. The criteria established for the region of rejection of a null hypothesis was 0.05 level of significance. The various nonparametric tests listed in Table III-2 and again in Table III-3 were not described in this chapter. The formulas used are contained in Chapter IV and located on the various tables for data presentation and calculations. If the reader needs complete descriptions of these tests, they can be

TABLE III-3

SUMMARY OF HYPOTHESES AND STATISTICAL TESTS

Hypothesis	Test[a]
Hypothesis A	Kendall Coefficient of Concordance
Hypothesis B	Kendall Coefficient of Concordance
Hypothesis C	Kruskal-Wallis one-way analysis of variance
Hypothesis D	Kendall Correlation Coefficient Tau
Hypothesis E	Kruskal-Wallis one-way analysis of variance
Hypothesis F	Kruskal-Wallis one-way analysis of variance

[a]Region of rejection alpha = 0.05 level of significance.

found in practically any good text on nonparametric techniques, such as Gibbons[5] and Siegel.[6]

VI. SUMMARY OF CHAPTER III

This chapter has presented a discussion of the steps required to implement this study. Sound advance preparation is required to conduct a Delphi study with a great deal of preparation, in a sense, being unrelated to the goals and objectives of the study. This advance or preliminary work involves contacting the individuals to solicit their participation. Only after completion of this preliminary work can a Delphi study planner mail the first questionnaire.

The variety of data analyses techniques available to a researcher have been summarized and the rationale for the use of nonparametric statistics has been presented. Chapter IV presents the results of the study and a more detailed discussion of the statistical design.

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[5]J. D. Gibbons, Non Parametric Methods for Quantitative Analysis (New York: Holt, Rinehart and Winston, 1976), p. 30.

[6]Sidney Siegel, Nonparametric Statistics for the Behavioral Sciences (New York: McGraw-Hill, 1956), pp. 195-245 and pp. 184-195.

CHAPTER IV

PRESENTATION AND DISCUSSION OF RESULTS

A critical evaluation of the Delphi process was prepared by Sachman of the Rand Corporation in 1974. Sackman, the principal researcher for the evaluation study, believed that the major failings of most Delphi studies were the lack of a stated hypotheses and the accompanying lack of statistical testing.[1] This study, in part, paid heed to Sackman's evaluations and this chapter presents the results and findings of these concerns, as related to the hypotheses presented in Chapter I.

I. ROUND ONE—SEEKING INPUT

The first question asked in the study design was: Can specialists and nonspecialists, exploring a technical field of endeavor, interface well enough to exchange meaningful and understandable knowledge? Originally 90 persons agreed to participate in the study; however, only 72 returned the Round One Questionnaire. After the questionnaires were returned, the panel was divided into three groups for purposes of testing the hypotheses.

Group I: Health Science Educator/Practitioners. This group consisted of nurses, physicians, health/safety educators, and engineering educators. The number of persons returning questionnaires at the end of

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[1] H. Sackman, "Delphi Assessment: Expert Opinion, Forecasting and Group Process," Rand Report R-1283-PR (Santa Monica, CA: The Rand Corporation, April 1974), pp. 12-16.

Round One was 19; at the end of Round Two, 14; and by the end of Round Three, 11 remained—a 42 percent decline from Round One to Round Three.

Group II: Laypersons with Energy Concerns. With 41 members, this group was the largest of the three. Secretaries, association executives, engineers, retirees, typists, chemists, insurance executives, housewives, ministers, economists, and educators (nonhealth/safety) comprised the membership. This group sustained a 51 percent decline with 30 members at the finish of Round Two, and 20 at the finish of Round Three.

Group III: Nuclear Specialists. These members (the smallest group) were selected and classified as nuclear experts simply because they were known to be working in the fields of radiology, nuclear medicine, or nuclear power generation. This segment of the panel had originally numbered 12 persons. The membership declined by Round Three to only five—a 58 percent decline. This figure does not include one member whose final questionnaire arrived too late to be included in the study. If he had been included, this group would have sustained only a 50 percent decline.

It is to be noted that the ages of the panel members ranged from 21 to 72 years and that they lived in 21 different states.

For an explanation of the rationale and methodology used in both panel selection and Round One Questionnaire concept, the reader's attention is directed to Chapters I and III. The initial questionnaire seemingly contained questions that were guaranteed to antagonize everyone at least once. The planner of this study received statements such as: "About half of your questions are anti-nuclear. How can you work in the industry and be so anti?" On the opposite end of the compendium: "Your

questions lead me to believe that no matter what answer you receive from us, you are so pro-nuclear that you will not pay any attention to us." The sources of these Round One statements are documented in Chapter III; and one can safely say that they accomplished their purpose, namely, they generated 650 brand new statements for use in the subsequent rounds. However, something more important seemed to be developing—a true adversary relationship. Here was a group of citizens willing to exchange differences of opinion, and even the study planner sustained some "bruises" in the process.

A summary of the raw data for each item of this initial material may be found in the July 15, 1977 Interim Report located in Appendix D, though the Appendix does not include the written comments. Table IV-1 contains a summary of the aforementioned responses in percentages. They were grouped according to concept and judging group.

It is pertinent at this point to explain the content of Concepts A through E, and to reiterate the number of behavioral objectives that support the concepts.

Concept A: Radiation may affect the human body in such a way as to be harmful or helpful. (12 behavioral objectives)

Concept B: Radiation effects depend upon the amount and type of radiation. (12 behavioral objectives)

Concept C: There are methods by which harmful radiation effects may be prevented or treated. (12 behavioral objectives)

Concept D: Radiation influences the lives of man through its interaction with the environment. (17 behavioral objectives)

TABLE IV-1

SUMMARY OF ROUND ONE RESPONSES (IN PERCENT) CLASSIFIED ACCORDING TO CONCEPT AND JUDGING GROUP

		Opinion Regarding Statement					Feasibility of Teaching Information			
	Concept[a]	Agree	Tend to Agree	No Opinion	Tend to Disagree	Disagree	Highly Feasible	Likely	Unlikely but Possible	Not Feasible
Health Science Educator/ Practitioners	A	34.70	21.90	9.60	14.90	18.90	33.33	37.72	17.54	11.40
Laypersons	A	29.82	21.71	6.14	18.86	23.46	27.48	37.84	20.50	14.19
Nuclear Specialists	A	24.20	17.40	3.00	9.90	45.50	25.00	34.85	17.42	22.73
Health Science Educator/ Practitioners	B	20.61	27.63	7.89	17.98	25.88	18.86	39.47	22.80	18.86
Laypersons	B	17.10	22.37	10.08	19.08	31.36	13.51	34.68	29.73	22.07
Nuclear Specialists	B	13.64	24.24	3.03	12.88	46.21	6.06	34.85	26.52	32.58
Health Science Educator/ Practitioners	C	34.21	34.21	7.46	12.28	11.84	27.19	42.11	24.12	6.58
Laypersons	C	29.17	30.70	7.89	13.38	18.86	16.89	46.62	24.32	12.16
Nuclear Specialists	C	26.52	27.27	9.09	12.88	24.24	13.64	45.45	26.52	14.39
Health Science Educator/ Practitioners	D	20.43	34.99	16.72	15.79	12.07	22.29	42.41	25.08	10.22
Laypersons	D	15.17	23.06	11.92	22.29	27.55	7.31	36.72	35.14	20.83
Nuclear Specialists	D	15.51	23.53	5.88	20.86	34.22	4.81	37.43	34.76	22.99
Health Science Educator/ Practitioners	E	21.05	25.94	15.41	20.68	16.92	20.30	51.50	17.67	10.53
Laypersons	E	21.80	21.05	9.77	19.55	27.82	20.08	47.88	25.29	6.76
Nuclear Specialists	E	26.62	16.23	3.25	13.64	40.26	14.29	52.60	22.73	10.39
Health Science Educator/ Practitioners	(All Concepts Combined)	26.20	28.92	11.42	16.33	17.32	25.39	42.64	21.44	11.52
Laypersons		22.61	23.80	9.16	18.64	25.81	17.05	40.75	27.00	15.20
Nuclear Specialists		21.30	21.73	4.85	14.03	38.09	12.76	41.04	25.59	20.62

(a) Concept A—Radiation may affect the human body in such a way as to be harmful or helpful.

Concept B—Radiation effects depend upon the amount and type of radiation.

Concept C—There are methods by which harmful radiation effects may be prevented or treated.

Concept D—Radiation influences the lives of man through its interaction with the environment.

Concept E—Regulatory agencies do everything practical to prevent radiation from harming the public.

Concept E: Regulatory agencies do everything practical to prevent radiation from harming the public. (14 behavioral objectives)

Kendall's Coefficient of Concordance W, a nonparametric statistical technique, was used to measure the relationship among the opinions expressed by the three groups of judges and the five concepts. Tables IV-2, IV-3, IV-4, IV-5, IV-6, and IV-7 summarize both data and calculation results. Table IV-2 presents all the concepts combined while the other tables summarize individual concepts. The entities (N), agree through disagree, were ranked (1 through 5) based on the opinions of the three groups (K) by utilizing the response information in Table IV-1. Table IV-8 summarizes the data derived from the individual calculations.

Kendall's Coefficient of Concordance W, which was the statistical method used to accept or reject the Null Hypothesis A, considered a measure of the relationship among the several opinions that had been transformed into ranks and the derived coefficient W, represents the association among these opinion variables as expressed by the judging groups. Null Hypothesis A stated that there were no differences of opinion among the three groups of judges concerning the five sets of behavioral objectives grouped by concepts.

Siegel has stated that "a high or significant value of W may be interpreted as meaning that the observers or judges are applying essentially the same standard in ranking the N objects under study."[2] In the above case, the W values (Tables IV-2 through IV-7) ranged from

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[2]Sidney Siegel, Nonparametric Statistics for the Behavioral Sciences, (New York: McGraw Hill, 1956), p. 237.

TABLE IV-2

RANKS ASSIGNED TO THE DEGREE OF OPINION ABOUT RADIATION CONCEPTS BASED ON RESPONSES FROM THREE GROUPS OF JUDGES*

Group	Agree	Tend to Agree	No Opinion	Tend to Disagree	Disagree
Health Science Educator/ Practitioners	4	5	1	2	3
Laypersons	4	5	1	2	3
Nuclear Specialists	3	4	1	2	5
Σ Rj	11	14	3	6	11

*All concepts—A, B, C, D, E combined.

The higher the rank number, the greater the percentage of panel members expressing a particular opinion.

Formula for calculation of coefficient of concordance: $W = \frac{12S}{K^2(N^3-N)} = \frac{(12)(78)}{(3^2)(5^3-5)} = 0.867.$

Calculated value of S = 78.

Tabled coefficient of concordance value $S_{.05} = 64.4.$

Formula for calculation of F statistic: $F = \frac{(K-1)(W)}{1-W} = 13.$

TABLE IV-3

RANKS ASSIGNED TO THE DEGREE OF OPINION ABOUT RADIATION CONCEPT A BASED ON RESPONSES FROM THREE GROUPS OF JUDGES*

Group	Agree	Tend to Agree	No Opinion	Tend to Disagree	Disagree
Health Science Educator/ Practitioners	5	4	1	2	3
Laypersons	5	3	1	2	4
Nuclear Specialists	4	3	1	2	5
Σ Rj	14	10	3	6	12

*Round One Concept A—Radiation may affect the human body in such a way as to be harmful or helpful.

Formula for calculation of coefficient of concordance: $W = \frac{12S}{K^2(N^3-N)} = \frac{(12)(80)}{(3^2)(5^3-5)} = 0.889.$

Calculated value of S = 80.

Tabled coefficient of concordance value $S_{.05} = 64.4.$

Formula for calculation of F statistic: $F = \frac{(K-1)(W)}{1-W} = 16.02.$

TABLE IV-4

RANKS ASSIGNED TO THE DEGREE OF OPINION ABOUT RADIATION CONCEPT B BASED ON RESPONSES FROM THREE GROUPS OF JUDGES*

Group	Agree	Tend to Agree	No Opinion	Tend to Disagree	Disagree
Health Science Educator/ Practitioners	3	5	1	2	4
Laypersons	2	4	1	3	5
Nuclear Specialists	2	4	1	3	5
Σ Rj	7	13	3	8	14

*Round One Concept B—Radiation effects depend upon the amount and type of radiation.

The higher the rank number, the greater the percentage of panel members expressing a particular opinion.

Formula for calculation of coefficient of concordance: $W = \frac{12S}{K^2(N^3-N)} = \frac{(12)(82)}{(3^2)(5^3-5)} = 0.911.$

Calculated value of S = 82.

Tabled coefficient of concordance value of $S_{.05} = 64.4$.

Formula for calculation of F statistic: $F = \frac{(K-1)(W)}{1-W} = 30.70.$

TABLE IV-5

RANKS ASSIGNED TO THE DEGREE OF OPINION ABOUT RADIATION CONCEPT C
BASED ON RESPONSES FROM THREE GROUPS OF JUDGES*

Group	Agree	Tend to Agree	No Opinion	Tend to Disagree	Disagree
Health Science Educator/ Practitioners	4.5	4.5	1	3	2
Laypersons	4	5	1	2	3
Nuclear Specialists	4	5	1	2	3
Σ Rj	12.5	14.5	3	7	8

*Round One Concept C—There are methods by which harmful radiation effects may be prevented or treated.

The higher the rank number, the greater the percentage of panel members expressing a particular opinion.

Formula for calculation of coefficient of concordance: $W = \frac{12S}{K^2(N^3-N)} = \frac{(12)(83.5)}{(3^2)(5^3-5)} = 0.928.$

Calculated value of S = 83.5.

Tabled coefficient of concordance value $S_{.05} = 64.4$.

Formula for calculation of F statistic: $F = \frac{(K-1)(W)}{1-W} = 25.77.$

TABLE IV-6

RANKS ASSIGNED TO THE DEGREE OF OPINION ABOUT RADIATION CONCEPT D
BASED ON RESPONSES FROM THREE GROUPS OF JUDGES*

Group	Agree	Tend to Agree	No Opinion	Tend to Disagree	Disagree
Health Science Educator/ Practitioners	4	5	3	2	1
Laypersons	2	4	1	3	5
Nuclear Specialists	2	4	1	3	5
Σ Rj	8	13	5	8	11

*Round One Concept D—Radiation influences the lives of men through its interaction with the environment.

The higher the rank number, the greater the percentage of panel members expressing a particular opinion.

Formula for calculation of coefficient of concordance: $W = \frac{12S}{K^2(N^3-N)} = \frac{(12)(38)}{(3^2)(5^3-5)} = 0.42.$

Calculated value of S = 38.

Tabled coefficient of concordance value $S_{.05} = 64.4.$

Formula for calculation of F statistic: $F = \frac{(K-1)(W)}{1-W} = 1.45.$

TABLE IV-7

RANKS ASSIGNED TO THE DEGREE OF OPINION ABOUT RADIATION CONCEPT E BASED ON RESPONSES FROM THREE GROUPS OF JUDGES*

Group	Agree	Tend to Agree	No Opinion	Tend to Disagree	Disagree
Health Science Educator/ Practitioners	4	5	1	3	2
Laypersons	4	3	1	2	5
Nuclear Specialists	4	3	1	2	5
Σ Rj	12	11	3	7	12

*Round One Concept E—Regulating agencies do everything practical to prevent radiation from harming the public.

The higher the rank number, the greater the percentage of panel members expressing a particular opinion.

Formula for calculation of coefficient of concordance: $W = \frac{12S}{K^2(N^3-N)} = \frac{(12)(74)}{(3^2)(5^3-5)} = 0.822.$

Calculated value of S = 74.

Tabled coefficient of concordance value $S_{.05} = 64.4.$

Formula for calculation of F statistic: $F = \frac{(K-1)(W)}{1-W} = 9.239.$

TABLE IV-8

HYPOTHESIS A—REJECTION/ACCEPTANCE TABLE

Concepts[a]	Tabled S Value[b]	Calculated S Value[c]	Action
All	75.6	78	Reject @ 0.01 level of significance
A	75.6	80	Reject @ 0.01 level of significance
B	75.6	82	Reject @ 0.01 level of significance
C	75.6	83.5	Reject @ 0.01 level of significance
D	75.6	38	Accept @ 0.01 level of significance
E	75.6	74	Reject @ 0.01 level of significance

[a]Concepts A through E are defined in the individual tables and elsewhere in this chapter.

[b]From Table R—Table of Critical Values of S in the Kendall Coefficient of Concordance W.*

[c]See Tables IV-2 through IV-7.

*Source: Sidney Siegel, Nonparametric Statistics for the Behavioral Sciences (New York: McGraw-Hill, 1956), p. 286.

0.4 to 0.928. Concept D was accepted because its S value was lower than the tabled value.[3] Further, the F test, using the correlation W as part of its calculation, reveals that an F value > 7.01 is significant at the 0.01 level (see Tables IV-2 through IV-7).[4] All calculated F values except Concept D exceeded this value. The F test is, in essence, the same test as the concordance test because both are correlation ratios for a set of ranks.

The Coefficient of Concordance W was also used to measure the relationship of the judges' opinions regarding the feasibility of teaching, to laypersons, the 67 behavioral objectives grouped under the five concepts. As in the "opinion cases" for Hypothesis A, the feasibility categories were ranked utilizing the response information in Table IV-1 (p. 69). The results of the calculations from Tables IV-9 through IV-14 are tabulated in Table IV-15.

Null Hypothesis B stated that there were no differences of opinion among the three groups of judges concerning the teaching of the behavioral objectives grouped under Concepts A-E.

The W values in Tables IV-9 through IV-14 ranged from 0.778 to 0.911 and seemingly indicated that the judges were all applying the same criteria in their judgments. Three of the six Calculated S values in the table were close enough to the Tabled S value to be called marginal even though Siegel has indicated that as long as an S value is equal to

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[3]F. N. Kerlinger, Foundations of Behavioral Research (New York: Holt, Rinehart, and Winston, Inc., 1973), p. 294.

[4]Ibid.

TABLE IV-9

RANKS ASSIGNED TO OPINIONS REGARDING THE FEASIBILITY OF TEACHING RADIATION CONCEPTS A THROUGH E INFORMATION BASED ON RESPONSES FROM THREE GROUPS OF JUDGES[a]

Judging Group	Highly Feasible	Likely	Unlikely but Feasible	Not Feasible
Health Science Educator/Practitioners	3	4	2	1
Laypersons	2	4	3	1
Nuclear Specialists	1	4	3	2
Σ Rj	6	12	8	4

*Round One—All concepts combined.

The higher the rank number, the greater the percentage of panel members expressing a particular opinion.

Formula for calculation of coefficient of concordance: $W = \frac{12S}{K^2(N^3-N)} = \frac{420}{(3^2)(4^3-4)} = 0.778.$

Calculated value of S = 35.

Tabled value of concordance values $S_{.05} = 35.$

Formula for calculation of F statistic: $F = \frac{(K-1)W}{1-W} = \frac{(3-1)(0.778)}{1-0.778} = 7.01.$

TABLE IV-10

RANKS ASSIGNED TO OPINIONS REGARDING THE FEASIBILITY OF TEACHING RADIATION CONCEPT A INFORMATION BASED ON RESPONSES FROM THREE GROUPS OF JUDGES*

Judging Group	Highly Feasible	Likely	Unlikely but Feasible	Not Feasible
Health Science Educator/Practitioners	3	4	2	1
Laypersons	3	4	2	1
Nuclear Specialists	3	4	1	2
Σ Rj	9	12	5	4

*Round One Concept A—Radiation may affect the human body in such a way as to be harmful or helpful.

The higher the rank number, the greater the percentage of panel members expressing a particular opinion.

Formula for calculation of coefficient of concordance: $W = \frac{12S}{K^2(N^3-N)} = \frac{492}{540} = 0.911$.

Calculated value of S = 41.

Tabled coefficient of concordance value $S_{.05} = 35$.

Formula for calculation of F statistic: $F = \frac{(K-1)(W)}{1-W} = \frac{(3-1)(0.911)}{1-0.911} = 20.47$.

TABLE IV-11

RANKS ASSIGNED TO OPINIONS REGARDING THE FEASIBILITY OF TEACHING RADIATION CONCEPT B INFORMATION BASED ON RESPONSES FROM THREE GROUPS OF JUDGES*

Judging Group	Highly Feasible	Likely	Unlikely but Feasible	Not Feasible
Health Science Educator/Practitioners	2	4	3	1
Laypersons	1	4	3	2
Nuclear Specialists	1	4	2	3
Σ Rj	4	12	8	6

*Round One Concept B—Radiation effects depend upon the amount and type of radiation.

The higher the rank number, the greater the percentage of panel members expressing a particular opinion.

Formula for calculation of coefficient of concordance: $W = \frac{12S}{K^2(N^3-N)} = \frac{12(35)}{540} = 0.778.$

Calculated value of S = 35.

Tabled value of concordance value $S_{.05} = 35.$

Formula for calculation of F statistic: $F = \frac{(K-1)(W)}{1-W} = \frac{(3-1)(0.778)}{1-0.778} = 7.01.$

TABLE IV-12

RANKS ASSIGNED TO OPINIONS REGARDING THE FEASIBILITY OF TEACHING RADIATION CONCEPT C INFORMATION BASED ON RESPONSES FROM THREE GROUPS OF JUDGES*

Judging Panel	Highly Feasible	Likely	Unlikely but Feasible	Not Feasible
Health Science Educator/Practitioners	3	4	2	1
Laypersons	2	4	3	1
Nuclear Specialists	1	4	3	2
Σ Rj	6	12	8	4

*Round One Concept C—There are methods by which harmful radiation effects may be prevented or treated.

The higher the rank number, the greater the percentage of panel members expressing a particular opinion.

Formula for calculation of coefficient of concordance: $W = \frac{12S}{K^2(N^3-N)} = \frac{420}{540} = 0.778.$

Calculated coefficient of concordance value S = 35.

Tabled coefficient of concordance value $S_{.05} = 35.$

Formula for calculation of F statistic: $F = \frac{(K-1)(W)}{1-W} = \frac{(3-1)(0.778)}{1-0.778} = 7.01.$

TABLE IV-13

RANKS ASSIGNED TO OPINIONS REGARDING THE FEASIBILITY OF TEACHING RADIATION CONCEPT D INFORMATION BASED ON RESPONSES FROM THREE GROUPS OF JUDGES*

Judging Group	Highly Feasible	Likely	Unlikely but Feasible	Not Feasible
Health Science Educator/Practitioners	2	4	3	1
Laypersons	1	4	3	2
Nuclear Specialists	1	4	3	2
Σ Rj	4	12	9	5

*Round One Concept D—Radiation influences the lives of men through its interaction with the environment.

The higher the rank number, the greater percentage of panel members expressing a particular opinion.

Formula for calculation of coefficient of concordance: $W = \frac{12S}{K^2(N^3-N)} = \frac{492}{540} = 0.911.$

Calculated coefficient of concordance value S = 41.

Tabled coefficient of concordance value $S_{.05} = 35.$

Formula for calculation of F statistic: $F = \frac{(K-1)(W)}{1-W} = \frac{(3-1)(0.911)}{1-0.911} = 20.47.$

TABLE IV-14

RANKS ASSIGNED TO OPINIONS REGARDING THE FEASIBILITY OF TEACHING RADIATION CONCEPT E INFORMATION BASED ON RESPONSES FROM THREE GROUPS OF JUDGES*

Judging Group	Highly Feasible	Likely	Unlikely but Feasible	Not Feasible
Health Science Educator/Practitioners	3	4	2	1
Laypersons	2	4	3	1
Nuclear Specialists	2	4	3	1
Σ Rj	7	12	8	3

*Round One Concept E—Regulatory agencies do everything practical to prevent radiation from harming the public.

The higher the rank number, the greater the percentage of panel members expressing a particular opinion.

Formula for calculation of coefficient of concordance: $W = \frac{12S}{K^2(N^3-N)} = \frac{492}{540} = 0.911.$

Calculated coefficient of concordance value S = 41.

Tabled coefficient of concordance value $S_{.05} = 35.$

Formula for calculation of F statistic: $F = \frac{(K-1)(W)}{1-W} = \frac{(3-1)(0.911)}{1-0.911} = 20.47.$

TABLE IV-15

HYPOTHESIS B—REJECTION/ACCEPTANCE TABLE

Concepts[a]	Tabled S Value[b]	Calculated S Value[c]	Action
All	35	35	Reject @ 0.05 level of significance
A	35	41	Reject @ 0.05 level of significance
B	35	35	Reject @ 0.05 level of significance
C	35	35	Reject @ 0.05 level of significance
D	35	41	Reject @ 0.05 level of significance
E	35	41	Reject @ 0.05 level of significance

[a]Concepts A through E are defined in Tables IV-9 through IV-14 and elsewhere in this chapter.

[b]From Table R—Table of Critical Values of S in the Kendall Coefficient of Concordance W.*

[c]See Tables IV-9 through IV-14.

*Source: Sidney Siegel, Nonparametric Statistics for the Behavioral Sciences (New York: McGraw Hill, 1956), p. 286.

or greater than the tabled value, the null hypothesis can be rejected.[5] A tabled F value of 4.53 was significant at the 0.05 level. All calculated F values utilizing the W value in the calculation exceeded these values and in three of the cases by a significant margin. While indications were that there were some differences of opinion among the judges, Null Hypothesis B was rejected even though the Health Science Educator/Practitioner group showed a tendency to believe that it was highly feasible to teach laypersons (see Tables IV-9 through IV-14) more often than did the Layperson and Nuclear Specialist groups.

Null Hypothesis C stated that there was no relationship between the feasibility of teaching the behavioral objectives and the opinions of the judges regarding these objectives. The Kruskal-Wallis One-Way Analysis of Variance by Ranks was used to test whether these independent opinion samples came from different populations (Group I, II, or III). This test was used to determine whether the K individual samples (Agree, Tend to Agree, No Opinion, Tend to Disagree, Disagree, Highly Feasible, Likely, Unlikely but Possible, and Not Feasible) came from the same groups of judges. The purpose of doing this was to determine whether the differences among the samples signified genuine population differences or whether they represented chance variations as may be expected when samples are taken from the same population. In this case the panel as a whole was considered to be a total population. All of the scores which were percentages of responses (see Table IV-1, p. 69) were ranked in a single series with the smallest score being 1 and the highest

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[5]Op. cit., Siegel, p. 236.

being 27. The sum of the ranks was then calculated and the Kruskal-Wallis test was used to determine whether the ranks are so desparate that they were not likely to have come from the same population.[6]

This test is sometimes referred to as the H test and the calculations are shown in Table IV-16. Reference to this table indicates that the calculated value with two degrees of freedom lies between the tabled H values (which come from a Chi Square table)[7] of $P_{.98} = 0.0404$ and $P_{.99} = 0.0201$. The region of hypothesis rejection in this study was 0.05 level of significance (see Chapter III). A probability of 0.99 or 0.98 is below the criteria standard of 0.05 established for this study; therefore, Null Hypothesis C was accepted and the assumption was made that there were relationships between feasibility of teaching and opinion agreements and/or disagreements. One relationship was the fact that the Health Science Educator/Practitioner group seemed to believe that it was highly feasible to teach an objective a higher percentage of the time than did the other two groups.

II. ROUND TWO—EVALUATION AND ROUND THREE— A CHANCE TO CHANGE

As was discussed in Chapter III, space was provided following each statement on the Round One Questionnaire for comments and the addition of new material. A random sample of comments from the panel members was:

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[6]Op. cit., Siegel, pp. 184-185.

[7]Op. cit., Siegel, pp. 249.

TABLE IV-16

RANKS ASSIGNED TO GROUP RESPONSES (IN PERCENT) ACCORDING TO OPINION AND TEACHING ATTRIBUTES

Attributes	Health Science Educator/ Practitioner		Laypersons		Nuclear Specialists	
	Scores	Rank	Scores[a]	Rank	Scores[a]	Rank
Agree	26.2	7.0	22.6	11.0	21.3	15.0
Tend to Agree	28.9	5.0	24.8	10.0	21.7	12.0
No Opinion	11.4	25.0	9.2	26.0	4.9	27.0
Tend to Disagree	16.3	20.0	18.6	17.0	14.0	22.0
Disagree	17.3	18.0	21.4	13.5	38.1	4.0
Highly Feasible	25.4	9.0	17.1	19.0	12.8	23.0
Likely	42.6	1.0	40.0	3.0	41.0	2.0
Unlikely but Possible	21.4	13.5	27.0	6.0	25.6	8.0
Not Feasible	11.5	24.0	15.2	21.0	20.6	16.0
Ti		122.5		126.5		129
$Ti^2/9$		1667.36		1778.03		1849

[a]Scores are percentage of responses for all concepts (Round One, A through E).

Formula for calculation of H coefficient: $H = \left[\frac{12}{n(n+L)}\right]\left[\sum_i^k \frac{T_i^2}{n_i}\right] - 3(n+1)$

$= \left[\frac{12}{(27)(27+1)}\right](5294.39) - 3(27+1)$

$= 84.038 - 84$

$= 0.038$

Tabled H (X^2) value with 2 df = P.98 = 0.0404; P.99 = 0.0201.

5a. Most laymen will have no need to know how to observe secondary effects of the use of radiation in diagnosis and treatment of disease.

12a. The public has been unnecessarily exposed to X-rays.

32c. Nuclear facilities should be questioned to assure that regulatory agencies provide adequate controls.

34c. A public awareness program is required.

51d. An effort must be made to publicize the benefits as well as the adverse effects of radiation.

64e. Injury frequencies from nuclear facility employees have not been presented to the public.

F. The nuclear industry is always on the defensive because it has failed to present its case to the public.

F. Let's explore the potential for terrorist activity.

F. Are the economic benefits from nuclear power on a par with coal?

F. Do coal-powered electric generating plants produce more radiation than nuclear? Since nuclear plants do not produce other atmospheric pollutants like coal, are not nuclear plants less of a health hazard?

The second questionnaire was developed from the approximately 650 statements similar to the above. In Round Two and Round Three, the panel members were asked to evaluate the concepts and behavioral objectives as to desirability and importance of having laypersons know the information and to evaluate the relevance of having the layperson

understand the information. Cognitive information was presented to support the concepts and objectives. Examples of such information were:

IV.Q. 2: The health hazards of plutonium are special in that very long-lived alpha emitters are involved.

I.A. 4: The symptom known as radiation sickness is a term applied collectively to the symptoms known as the radiation syndrome.

III.E.5: Basic nuclear research is a good investment for the Federal Government as is basic research in all sciences.

IV.I. 5: Population dose rates are extremely small fractions of normal background.

IV.J. 1: Accidents in underground mining result in about 15 deaths per 10,000 miners.

It is to be noted that Concept E in Round One, which stated that "Regulatory agencies do everything practical to prevent radiation from harming the public" was dropped as a Concept in Rounds Two and Three. Several members of the panel pointed out that the expression indicated "goals for those agencies" rather than a Concept. The behavioral objectives listed under this questionable Concept were scattered throughout the remaining four concepts in subsequent rounds. Concept A equals Concept I, B = II, E = III, and D = IV in Rounds Two and Three. (see pages 68 and 70 of this chapter and Tables IV-17 through IV-20 for a definition of the Concepts).

Null Hypothesis D stated that there were no opinion changes among the groups of judges concerning the desirability or importance of having laypersons understand the behavioral objectives developed for the four

TABLE IV-17

A SUMMARY OF ROUND TWO AND ROUND THREE CONCEPT I MEDIAN SCORES RANKED ACCORDING TO DESIRABILITY AND IMPORTANCE AND GROUPED BY BEHAVIORAL OBJECTIVES[a]

	Behavioral Objectives[b]					
	A	B	C	D	E	F
Round Two Desirability	6.4	6.3	5.1	5.9	5.3	4.9
Round Three Desirability	6.5	6.5	5.6	6.1	6.8	4.4
Round Two Importance	6.4	5.5	5.2	5.9	5.0	4.0
Round Three Importance	6.4	6.4	5.5	6.0	5.0	4.4
	F	C	E	D	B	A
Round Two Desirability	1.0	2.0	3.0	4.0	5.0	6.0
Round Three Desirability	1.0	2.0	6.0	3.0	4.5	4.5
	F	E	C	B	D	A
Round Two Importance	1.0	2.0	3.0	4.0	5.0	6.0
Round Three Importance	1.0	2.0	3.0	5.5	4.0	5.5

[a]Round Two and Round Three Concept I—Radiation may affect the human body in such a way as to be harmful or helpful.

[b]See Round Two Questionnaire in Appendix C for the meaning of behavioral objectives A-F.

Desirability S = (5-0)+(4-0)+(0-3)+(2-0)+0-0) = 8.

$$\text{Desirability correlation } r_d = \frac{S}{0.5(N)(N-1)} = \frac{8}{0.5(6)(6-1)} = 0.53.$$

Importance S = (5-0)+(4-0)+(3-0)+(0-1)+(1-0) = 12.

$$\text{Importance correlation } r_i = \frac{S}{0.5(N)(N-1)} = \frac{12}{0.5(6)(6-1)} = 0.80.$$

TABLE IV-18

A SUMMARY OF ROUND TWO AND ROUND THREE CONCEPT II MEDIAN SCORES RANKED ACCORDING TO DESIRABILITY AND IMPORTANCE AND GROUPED BY BEHAVIORAL OBJECTIVES[a]

	Behavioral Objectives[b]								
	A	B	C	D	E	F	G	H	I
Round Two Desirability	5.9	4.7	4.4	4.2	4.5	3.8	4.3	4.0	5.8
Round Desirability	5.9	5.3	4.6	4.7	4.5	4.4	4.4	3.8	5.8
Round Two Importance	5.8	4.8	3.9	4.1	4.2	3.6	4.1	3.8	5.6
Round Three Importance	5.7	5.0	4.0	4.5	4.2	4.0	4.4	3.6	5.6
	F	H	D	G	C	E	B	I	A
Round Two Desirability	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0
Round Three Desirability	2.5	1.0	6.0	2.5	5.0	4.0	7.0	8.0	9.0
	F	H	C	D	G	E	B	I	A
Round Two Importance	1.0	2.0	3.0	4.5	4.5	6.0	7.0	8.0	9.0
Round Three Importance	2.5	1.0	2.5	6.0	5.0	4.0	7.0	8.0	9.0

[a]Round Two and Round Three Concept II—The radiation effect depends upon the amount and type of radiation.

[b]See Round Two Questionnaire in Appendix C for the meaning of behavioral objectives A-I.

Desirability $S = (6-1)+(7-0)+(3-3)+(5-0)+(3-1)+(3-0)+(2-0)+(1-0) = 25.$

Desirability correlation $r_d = \frac{S}{0.5(N)(n-1)} = \frac{25}{0.5(9)(9-1)} = 0.694.$

Importance $S = (6-1)+(7-0)+(6-0)+(3-2)+(3-1)+(3-0)+(2-0)+(8-0) = 34.$

Importance correlation $r_i = \frac{S}{0.5(N)(N-1)} = \frac{34}{0.5(9)(9-1)} = 0.944.$

TABLE IV-19

A SUMMARY OF ROUND TWO AND ROUND THREE CONCEPT III MEDIAN SCORES RANKED ACCORDING TO DESIRABILITY AND IMPORTANCE AND GROUPED BY BEHAVIORAL OBJECTIVES[a]

	Behavioral Objectives[b]					
	A	B	C	D	E	F
Round Two Desirability	5.8	4.9	4.0	5.4	5.1	4.8
Round Three Desirability	6.2	5.2	4.1	5.6	5.1	4.7
Round Two Importance	5.8	4.8	3.7	5.3	5.1	4.8
Round Three Importance	6.2	5.2	3.9	5.2	5.1	4.7
	C	F	B	E	D	A
Round Two Desirability	1.0	2.0	3.0	4.0	5.0	6.0
Round Three Desirability	1.0	2.0	4.0	3.0	5.0	6.0
	C	B	F	E	E	A
Round Two Importance	1.0	2.5	2.5	4.0	5.0	6.0
Round Three Importance	1.0	4.5	2.0	3.0	4.5	6.0

[a]Round Two and Round Three Concept III—There are methods by which harmful radiation effects may be prevented or treated.

[b]See Round Two Questionnaire in Appendix C for the meaning of behavioral objectives A-F.

Desirability $S = (5-0)+(4-0)+(2-1)+(2-0)+(1-0) = 13.$

Desirability correlation $r_d = \frac{S}{0.5(N)(N-1)} = \frac{13}{0.5(6)(6-1)} = 0.867.$

Importance $S = (5-0)+(1-2)+(3-0)+(2-0)+(1-0) = 10.$

Importance correlation $r_i = \frac{S}{0.5(N)(N-1)} = \frac{10}{0.5(6)(6-1)} = 0.667.$

TABLE IV-20

A SUMMARY OF ROUND TWO AND ROUND THREE CONCEPT IV MEDIAN SCORES FOR DESIRABILITY AND IMPORTANCE GROUPED BY BEHAVIORAL OBJECTIVES[a]

	Behavioral Objectives[b]																	
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
Round Two Desirability	5.9	5.2	4.4	4.9	4.9	4.6	4.6	4.7	5.9	4.8	5.0	5.3	5.6	5.1	4.1	5.3	5.4	5.7
Round Three Desirability	5.3	5.5	4.2	4.7	4.4	4.4	4.5	5.6	6.0	4.6	5.1	5.3	5.5	5.0	3.8	5.3	5.5	5.5
Round Two Importance	6.0	4.9	4.4	4.7	4.7	4.6	4.6	4.5	5.8	4.6	4.4	5.1	5.8	5.3	4.0	5.5	5.4	5.7
Round Three Importance	4.7	5.3	4.1	4.7	4.4	4.4	4.6	4.6	5.8	4.4	4.6	5.0	5.6	5.1	3.8	5.5	5.5	5.6
	O	C	F	G	H	J	D	E	K	N	B	L	P	Q	M	R	A	I
Round Two Desirability	1.0	2.0	3.5	3.5	5.0	6.0	7.5	7.5	9.0	10.0	11.0	12.5	12.5	14.0	15.0	16.0	17.5	17.5
Round Three Desirability	1.0	2.0	3.5	5.0	6.5	6.5	8.0	3.5	10.0	9.0	15.5	12.0	12.0	15.5	15.5	15.5	12.0	18.0
	O	C	K	H	F	G	J	D	E	B	L	N	Q	P	R	I	M	A
Round Two Importance	1.0	2.5	2.5	4.0	6.0	6.0	6.0	8.5	8.5	10.0	11.0	12.0	13.0	14.0	15.0	16.5	16.5	18.0
Round Three Importance	1.0	2.0	7.0	7.0	4.0	7.0	4.0	9.5	4.0	13.0	11.0	12.0	14.5	14.5	16.5	17.0	16.5	9.5

[a]Round Two and Round Three Concept IV—Radiation influences the lives of men through its interaction with the environment.

[b]See Round Two Questionnaire in Appendix C for the meaning of behavioral objectives A-R.

Desirability $S = (17-0)+(16-0)+(14-0)+(13-1)+(11-1)+(11-1)+(10-1)+(10-0)+(8-1)+(8-0)+(1-3)+(4-0)+(4-0)+(1-1)+(1-1)+(1-1)+(1-0) = 120.$

Desirability correlation $r_d = \frac{S}{(0.5)(N)(N-1)} = \frac{120}{(0.5)(18)(17)} = 0.784.$

Importance $S = (17-0)+(16-0)+(10-3)+(9-3)+(11-0)+(10-2+(10-1)+(8-1)+(6-2)+(5-3)+(6-1)+(5-1)+(2-1)+(2-1)+(1-1)+(0-2)+(0-1) = 95.$

Importance correlation $r_i = \frac{S}{0.5(N)(N-1)} = \frac{95}{0.5(18)(17)} = 0.621.$

concepts between Rounds Two and Three. The Kendall Rank Correlation Coefficient τ (Tau), was used as a measure of correlation for the two rounds. The data and calculations are presented in Tables IV-17 through IV-20 for Concepts I, II, III, and IV, respectively. Table IV-21 presents a comparison of the various correlation numbers generated by these calculations.

The rationale for this test began by ranking the behavioral objectives (categorized by letters A, B, C, . . . R) according to the three judging groups' opinions of the desirability (d) and the importance (i) of laypersons knowing and performing the objectives grouped according to the four concepts. The judges expressed their opinions by the scaling methods indicated in Table III-1 (p. 59). A seven was very desirable or very important and a one was very undesirable or very unimportant. A number greater than one and less than seven indicated an opinion somewhere in between (see Interim Report II, dated January 3, 1978 in Appendix E for a summary of mean scores for each statement).

The totaling of all of the scores for each objective by participant and by round has been summarized as median scores in Tables IV-17 through IV-20. These scores were then ranked with the lowest median score being the lowest rank. By comparing the ranks in Round Two with the ranks in Round Three and utilizing Kendall Rank Correlation Coefficient (Tau, τ), a suitable measure of correlation was calculated (see Tables IV-17 through IV-20 for the Kendall formula).

The calculated value indicated a moderate to high degree of correlation signifying that little change had occurred between Round

TABLE IV-21

HYPOTHESIS D-REJECTION/ACCEPTANCE TABLE

Concepts	Desirability Correlation r_d	Importance Correlation r_i	P_d [a]	P_i [a]
I	0.53 (m)	0.80 (h)	0.102	0.018
II	0.69 (m)	0.94 (h)	0.0046	0.000025
III	0.87 (h)	0.67 (m)	0.0083	0.048
IV	0.78 (h)	0.62 (m)	> 0.00003	0.00023

[a](m) = moderate correlation $\leq$ 0.8; (h) = high correlation $\geq$ 0.08.

Data compiled from Tables IV-17 through IV-20 (see these tables for concept definitions and calculation methods).

Two and Round Three. Siegel had indicated that when $P \leq a$, the null hypothesis could be rejected. The region of hypothesis rejection in this study was at least 0.05 level of significance. With probability and values so significant in this instance, the null hypothesis was rejected and the assumption was made that there had been few changes between Round Two and Round Three. A review of the median scores in Tables IV-17 through IV-20 revealed few behavioral objectives that the panel failed to recognize as being both desirable and important. This observation was significant in that scale values used for expressing an opinion ranged from seven (very important and/or very desirable), with one representing the opposite.

The validity scores posed a problem in that Round Two was developed from information asked for by the panel and no formal criteria were established to decide what would be placed in the questionnaire other than the fact that three or more panel members expressed the desire to address a specific subject. A summary of total validity scores by participant and group is presented in Tables IV-22 through IV-25. These totals represent a summation of the values on a scale of seven to one (truthful to false) in a manner similar to the scale established for desirability and importance. These scores were transformed into stanine normalized standard scores derived from the original raw scores. The number of validity statements grouped by concepts are as follows

TABLE IV-22

SUMMARY OF ROUND TWO AND ROUND THREE SCORES FOR THE CONCEPT I VALIDITY STATEMENTS

Scores	Health Science Educator/ Practitioners				Laypersons				Nuclear Specialists			
	Round Two Freq./Stanine		Round Three Freq./Stanine		Round Two Freq./Stanine		Round Three Freq./Stanine		Round Two Freq./Stanine		Round Three Freq./Stanine	
214-224	2	(9)	1	(9)	1	(9)	0	(9)	0	(9)	0	(9)
203-213	0	(8)	1	(9)	2	(8)	2	(9)	0	(8)	0	(9)
192-202	4	(8)	2	(8)	2	(8)	1	(8)	0	(8)	0	(8)
181-194	0	(7)	1	(8)	3	(7)	3	(8)	3	(7)	3	(8)
170-180	4	(6)	6	(6)	5	(6)	8	(6)	3	(6)	0	(6)
159-169	2	(5)	0	(4)	6	(5)	0	(4)	0	(5)	1	(4)
148-158	2	(4)	0	(3)	3	(4)	4	(3)	1	(4)	0	(3)
137-147	0	(3)	0	(2)	4	(3)	1	(2)	0	(3)	1	(2)
126-136	0	(3)	0	(1)	4	(3)	1	(1)	1	(3)	0	(1)
115-125	0	(2)	0	(1)	1	(2)	0	(1)	0	(2)	0	(1)
100-114	0	(1)	0	(1)	0	(1)	0	(1)	0	(1)	0	(1)
Totals	14		11		33		20		9		5	

Round Two and Round Three Concept I—Radiation may affect the human body in such a way as to be harmful or helpful.

TABLE IV-23

SUMMARY OF ROUND TWO AND ROUND THREE SCORES FOR THE CONCEPT II VALIDITY STATEMENTS

Scores	Health Science Educator/ Practitioners				Laypersons				Nuclear Specialists			
	Round Two Freq./Stanine		Round Three Freq./Stanine		Round Two Freq./Stanine		Round Three Freq./Stanine		Round Two Freq./Stanine		Round Three Freq./Stanine	
510-532	2	(9)	2	(9)	3	(9)	0	(9)	0	(9)	0	(9)
491-511	0	(8)	0	(8)	2	(8)	3	(8)	1	(8)	0	(8)
470-490	1	(7)	1	(7)	2	(7)	1	(7)	1	(7)	1	(7)
449-469	2	(7)	2	(6)	0	(7)	0	(6)	0	(7)	0	(6)
428-448	0	(6)	0	(6)	1	(6)	1	(6)	1	(6)	1	(6)
407-427	1	(6)	1	(6)	3	(6)	2	(6)	0	(6)	1	(6)
486-406	1	(6)	1	(5)	1	(6)	2	(5)	2	(6)	0	(5)
365-385	0	(5)	1	(5)	2	(5)	4	(5)	2	(5)	1	(5)
344-364	0	(5)	0	(4)	4	(5)	1	(4)	0	(5)	0	(4)
323-343	1	(5)	1	(4)	0	(5)	2	(4)	0	(5)	0	(4)
302-322	2	(4)	1	(3)	1	(4)	0	(3)	0	(4)	0	(3)
281-301	0	(4)	0	(3)	5	(4)	1	(3)	0	(4)	0	(3)
260-280	1	(4)	0	(3)	0	(4)	0	(3)	0	(4)	0	(3)
239-259	0	(3)	0	(3)	1	(3)	0	(3)	0	(3)	0	(3)
218-238	0	(3)	0	(3)	1	(3)	1	(3)	0	(3)	0	(3)
207-217	0	(3)	0	(2)	0	(3)	0	(2)	0	(3)	0	(2)
186-206	0	(3)	0	(2)	0	(3)	0	(2)	0	(3)	0	(2)
165-185	1	(3)	0	(2)	3	(3)	0	(2)	1	(3)	1	(2)
144-164	2	(2)	1	(1)	2	(2)	0	(1)	0	(2)	0	(1)
123-143	0	(1)	0	(1)	1	(1)	0	(1)	0	(1)	0	(1)
92-122	0	(1)	0	(1)	0	(1)	2	(1)	0	(1)	0	(1)
Totals	14		11		32		20		8		5	

Round Two and Round Three Concept II—The radiation effect depends upon the amount of and type of radiation.

TABLE IV-24

SUMMARY OF ROUND TWO AND ROUND THREE SCORES FOR THE CONCEPT III VALIDITY STATEMENTS

Scores	Health Science Educator/ Practitioners				Laypersons				Nuclear Specialists			
	Round Two Freq./Stanine		Round Three Freq./Stanine		Round Two Freq./Stanine		Round Three Freq./Stanine		Round Two Freq./Stanine		Round Three Freq./Stanine	
218-228	3	(9)	3	(8/9)	1	(9)	1	(9)	0	(9)	0	(9)
207-217	0	(8)	0	(7)	4	(8)	1	(8)	0	(8)	0	(8)
196-206	2	(7)	1	(7)	1	(7)	2	(7)	1	(7)	1	(7)
185-195	1	(6)	1	(6)	2	(6)	3	(7)	2	(6)	1	(7)
174-184	1	(6)	1	(6)	1	(6)	2	(6)	2	(6)	2	(6)
163-173	0	(5)	1	(5)	8	(5)	4	(6)	2	(5)	0	(6)
152-162	1	(5)	2	(4)	4	(5)	3	(5)	0	(5)	0	(5)
141-151	1	(4)	1	(4)	3	(4)	2	(4)	0	(4)	0	(4)
130-140	1	(4)	0	(3)	2	(4)	1	(4)	0	(4)	0	(4)
119-129	1	(3)	0	(2)	2	(3)	1	(3)	1	(3)	0	(3)
108-118	1	(2)	0	(2)	2	(2)	0	(2)	0	(2)	1	(2)
90-107	2	(1)	1	(1)	0	(1)	0	(1)	0	(1)	0	(1)
Totals	14		11		30		20		8		5	

Round Two and Round Three Concept III—There are methods by which harmful radiation effects may be prevented or treated.

TABLE IV-25

SUMMARY OF ROUND TWO AND ROUND THREE SCORES FOR THE CONCEPT IV VALIDITY STATEMENTS

Scores	Health Science Educator/ Practitioners				Laypersons				Nuclear Specialists			
	Round Two Freq./Stanine		Round Three Freq./Stanine		Round Two Freq./Stanine		Round Three Freq./Stanine		Round Two Freq./Stanine		Round Three Freq./Stanine	
573-613	2	(9)	2	(9)	1	(9)	0	(9)	0	(9)	0	(9)
532-572	2	(8)	0	(9)	3	(8)	1	(9)	0	(8)	0	(9)
491-531	0	(7)	1	(8)	2	(7)	2	(8)	2	(7)	1	(8)
450-490	3	(6)	3	(7)	3	(6)	4	(7)	4	(6)	2	(7)
409-449	2	(5)	2	(6)	5	(5)	5	(6)	1	(5)	1	(6)
368-408	1	(4)	2	(5)	4	(4)	2	(5)	1	(4)	1	(5)
327-367	1	(4)	0	(4)	1	(4)	0	(4)	0	(4)	0	(4)
286-326	1	(4)	0	(3)	3	(4)	0	(3)	0	(4)	0	(3)
245-285	0	(3)	0	(3)	1	(3)	1	(3)	0	(3)	0	(3)
204-244	0	(3)	1	(3)	3	(3)	2	(3)	0	(3)	0	(3)
163-203	2	(2)	0	(2)	4	(2)	2	(2)	0	(2)	0	(2)
81-162	0	(1)	0	(1)	0	(1)	1	(1)	0	(1)	0	(1)

Round Two and Round Three Concept IV—Radiation influences the lives of men through its interaction with the environment.

Concept I = 32 statements

Concept II = 76 statements

Concept III = 33 statements

Concept IV = 89 statements.

The means for each of these statements were reported in Interim Report II, January 3, 1978 (see Appendix E). A review of this report revealed that in only four instances out of 230 did the calculated mean value fall below 3.5, indicating that the panel as a whole viewed most cognitive statements as being truthful. With the panel believing that 98.2 percent of the statements were true or at least tending to be true, Hypothesis E was rejected. Hypothesis E stated that all three groups of judges believe that the cognitive statements presented to support the behavioral objectives in Concepts I, II, III, and IV have a substantial risk of being incorrect.

Null Hypothesis F stated that there were no changes in the validity rating of statements between Rounds Two and Three. Tables IV-22 through IV-25 entitled "A Summary of the Round Two and Round Three Scores for the Concept I or II, or III or IV Validity Statements," present the frequency of occurrence, and derived stanine scores for each group of judges. These data were utilized to calculate median scores for all groups for both rounds. The median scores are ranked in Table IV-26.

The Kruskal-Wallis One-Way Analysis of Variance (as was used for Hypothesis C) was performed utilizing the data in Table IV-25, producing an H value of 0.69. This calculated value with two degrees of freedom lies between probability values of 0.70 and 0.80 levels of

TABLE IV-26

MEDIAN VALIDITY SCORES RANKED ACCORDING TO ROUNDS AND CONCEPTS BY THREE GROUPS OF JUDGES*

Concept	Round	Health Science Educator/ Practitioner		Laypersons		Nuclear Specialists		All Groups
		Scores	Rank	Scores	Rank	Scores	Rank	Scores
I	Two	183.5	12	173	6	182	10.0	182.5
I	Three	175	8	168.5	3	170	4	179.5
II	Two	343	13	366	14	407.5	18	388.5
II	Three	407	17	368.5	15	387	16	387.5
III	Two	162	1	164.5	2	174.5	7	179.5
III	Three	182	10.0	172.5	5	182	10.0	181.1
IV	Two	449	19	451.5	21	451.5	21	491.5
IV	Three	491	23.5	451.5	21	491	23.5	455.5
Ti			103.5		87		109.5	
$Ti^2/9$			1339		946		1499	

*These median scores were compiled from Tables IV-22 through IV-24, and these tables should be referred to for definitions of Concepts I, II, III and IV.

Formula:

$$H = \frac{12}{N(N+1)} \sum_{j<1}^{K} \frac{Ti^2}{ni} - 3(n+1)$$

$$= \frac{(12)}{(24)(24+1)} (3784) - 3(24+1)$$

$$= 0.68.$$

Tabled value = P.80 = .451; P.70 = 71.

significance in a Chi Square Table. According to Siegel, one could reject the null hypothesis at this level. However, the level of rejection for items in this study was established in Chapter III, a minimum of 0.05. A review of Table IV-26 indicates that Null Hypothesis F should be accepted and assume that there were changes by panel members between Round Two and Round Three.

Based on the calculations summarized in Table IV-26, Null Hyposhesis F was accepted and the assumption was made that there were changes made by panel members between Round Two and Round Three.

The last page of the Round Two Questionnaire contained an exercise entitled "Compute Your Own Radiation Dose" developed by the San Diego Section of the American Nuclear Society and the Pennsylvania Department of Education. The purpose of the exercise was to show the panel members the amount of radiation they were exposed to during the year that this study was conducted. The questionnaire indicated that our national average was 200 mrem/year without X-rays. The average for the 55 members of the panel who returned the Round Two Questionnaire was 574 mrem/year. The averages for Round Three are summarized in Table IV-27. The average of this panel, less X-rays, was 198 mrem.

TABLE IV-27

RESULTS OF "CALCULATE YOUR OWN DOSE" EXERCISE

Participant		Total Dose	X-ray Only	Total Minus X-ray
2	2	208	0	208
6	6	184	0	184
7	7	210	20	190
9	9	234	20	214
12	12	2,529	2,320	209
13	13	327	170	157
15	15	375	196	179
16	16	591	420	171
23	23	280	20	260
24	24	1,857	1,680	177
26	26	542	320	222
30	30	240	20	220
32	32	233	20	213
39	39	538	310	228
40	40	356	170	186
41	41	478	200	278
42	42	1,286	1,100	186
47	47	750	570	180
49	49	380	170	210
50	50	248	50	198
53	53	384	150	234
55	55	341	170	171
57	57	264	10	254
58	58	1,236	1,050	186
60	60	233	20	213
63	63	372	190	182
67	67	186	20	166
68	68	170	20	150
72	72	229	20	209
75	75	188	20	168
78	78	339	170	169
83	83	195	20	175
85	85	495	320	175
86	86	174	20	154
88	88	185	20	165
89	89	3,379	3,140	239
90	90	401	170	231
Totals	37	20,617	13,306	7,311
Average	1	558	360	198*

*Note: National average = 200.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

I. SUMMARY

Public concern about potential safety and health issues related to energy production, especially nuclear powered, had converted the subject into a political problem in several states of our country. This concern was manifested in the formation of ad hoc public interest groups. This study planner believed that the activists who headed these organizations had turned the "Public Interest" movement into an expression of aberration and disenfranchisement from the political and regulatory process rather than a real concern about the true issues of public safety.

The literature search presented in Chapter II confirmed that safety and health concerns as major issues have fluctuated throughout the history of the United States, as indeed it has since antiquity. This search further revealed that while radiation had the potential of being a hazard to the health and safety of the citizens, the history of radiation safety in the United States had been good. However, the United States Government, while spending large sums of money to sponsor the education of nuclear specialists, had spent little to assist the layperson in understanding nuclear science. This literature search revealed that the Delphi Technique (which was developed about 20 years ago for the purpose of estimating the probable effects of massive

atomic bombing attacks on the United States) might have application as a pedagogical tool. Chapter III presented the methods and types of analyses that would be required to utilize this technique to its fullest potential.

Specifically, the purpose of this study was to ascertain if this Delphi Technique, a methodology developed for forecasting future technological events, could be used as a pedagogical tool to help the nuclear specialists communicate with persons less knowledgeable about the subject of radiation. Similarly, it was hoped that the process would be reversible, i.e., letting the nonspecialist communicate his or her concerns so that they might secure answers. Radiation was chosen as the subject because in the mid-seventies nuclear fueled electric generating stations appeared to be one of the more viable options available to provide environmentally clean power to the nation. The problem was that nuclear specialists had difficulty explaining in simple terms this complex subject. It was believed that the Delphi Technique might be used to help with this communication problem. Six null hypotheses were postulated to test the three ideas for which the study was designed. Namely, would there be communication between expert and nonexpert; what was desirable and important for the layperson to know; and would a change occur in cognitive knowledge in this exchange of information?

Null Hypotheses A, B and C presented the ideas that there were no differences of opinion in Round One among the three groups of judges regarding:

1. The behavioral objectives grouped under five concepts;
2. The feasibility of teaching the information; and,
3. The relationship between teaching the objectives and the judges' opinions regarding the objectives.

Null Hypothesis D expressed the idea that there would be no changes in the desirability and importance of having laypersons be able to perform the objectives between Round Two and Round Three.

Null Hypothesis E dealt with the issue of whether or not the judges would believe that the cognitive information was untrue. Null Hypothesis F explored the likelihood of no change on the part of the judges between Round Two and Round Three.

II. CONCLUSIONS

The following conclusions sum up the evaluation of this nonconventional Delphi study of ionizing radiation.

1. Persons with little knowledge about ionizing radiation can share their viewpoints with persons having a great deal of knowledge about the subject and this exchange of information can be done in a meaningful way.

2. This panel indicated that it was feasible to teach laypersons the information they shared during the study.

3. The panel held the opinion that it was both desirable and important for laypersons to have general knowledge about:

   A. the paradox that radiation may be both harmful and beneficial;
   B. the concept that the effects of radiation depend upon the amount and type of radiation;

C. the idea that there are methods by which harmful effects of radiation may be prevented and/or treated;

D. the belief that regulatory agency requirements mitigate the possibilities of radiation releases which could do harm to the layperson; and

E. the explanation of how radiation influences mankind through its interaction with the environment.

4. During 1967 a summer workshop of health educators developed information stressing the advantages of ionizing radiation while recognizing the potential hazards. These positive aspects were presented in the initial questionnaire along with information that presented the negative side of the subject. This panel requested that this study stress the advantages of ionizing radiation rather than the disadvantages.

5. The educator group of panel members believed that it was more feasible to teach laypersons than did the layperson or nuclear specialist group.

6. The second questionnaire presented 234 cognitive statements about ionizing radiation. These statements were presented to support the behavioral objectives that laypersons should be able to list, know, compare, understand, apply, recognize, react, suggest, be aware of, compute, or respond to. The panel indicated that they believed that 98.3 percent of these statements were truthful or tended to be truthful.

7. The panel changed its opinion about the validity of the cognitive statements after being provided with information about how all panel members answered statements contained in the second questionnaire.

8. Two hundred and twenty-five persons were asked by letter to participate in this study. Two hundred and twenty responsed even though initially only 90 agreed that they had the time to participate. Approximately 100 who could not participate offered suggestions. The only conclusion that can be reached from this response was that there are a substantial number of citizens concerned with our country's energy problems and that they wanted to know more about the nuclear aspects of electric power generation.

9. It has been estimated that the average American receives a 200 mrem radiation dose per year from background, television viewing, airplane flights, and nuclear power plants. This panel from 21 states averaged 198 mrem from these sources. However, they averaged an additional 360 mrem from various types of dental and/or medical X-rays.

10. The Delphi Technique requires

    A. a guarantee of anonymity to panel members;

    B. diligence on the part of a Delphi study planner to encourage the adversary process and exploratory thinking in a pedagogical study such as this one, and

    C. a substantial span of time to allow panel members to take time from their daily routines to answer the questionnaires.

III. RECOMMENDATIONS

Two hundred and twenty-five letters soliciting help on this study resulted in a final panel membership of 72 persons—radiation specialists and nonspecialists. Approximately 100 who did not feel they had the time or knowledge to participate offered suggestions. This study has tapped

a resource of persons concerned about their country's and their own future regarding energy and its potential health and safety hazards.

The American Philosopher, Ralph Barton Perry, stated that "ignorance deprives men of freedom because they do not know what alternatives there are. It is impossible to choose to do what one has never heard of."[1] This Delphi Panel has presented their opinions about a very important subject. It would be irresponsible to let the subject drop at this point. To preclude such an event the following recommendation is made:

1. Prepare a grant proposal for consideration by the nuclear industry and/or Department of Energy to complete the development of valid and reliable survey questionnaires grouped according to concepts and behavioral objectives contained in Round Two, so that valid instruments will be able to judge a community's concerns toward the possible construction of nuclear facilities in a community. This should also include an evaluation of the costs versus benefits of diagnostic medical X-rays (see Chapter II).

It is believed that under the leadership of the University of Tennessee Safety Center, with assistance from other organizations at the University such as nuclear engineering, environmental engineering, public health education, safety education, and the radiation biology programs, material could be developed that could give the public that information it needs to make value judgments. It is further proposed

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[1]Tryon Edwards et al., The New Dictionary of Thoughts (New York: Standard Book Company, 1964), p. 290.

that should such a program be developed and funded, the Delphi Panel members and others who gave generously of their time and of themselves without financial compensation should be included to complete the work they and we have started.

2. Prepare interdisciplinary programs regarding the health and safety aspects of other forms of energy production and use, under the leadership of the Safety Center, Division of Health and Safety, University of Tennessee College of Education. It is believed that representatives of the Graduate School of Biomedical Science, the Center for Business and Economic Research, the Bureau of Educational Research and Service, the Office of the Dean of the College of Engineering, the Bureau of Public Administration, the Graduate School of Planning, the Office of the Vice President of Continuing Education, the Space Institute, the Institute of Energy Analysis of Oak Ridge Associated Universities, and the Office of the Tennessee State Energy Authority would be the minimum required to develop such an interdisciplinary program. The literature review for this study indicates that our country has energy problems that portend serious consequences in the not too distant future. The University of Tennessee is ideally located in an area that utilizes all forms of fuels. We do not know the health and safety consequences of such fuels, nor the most efficient ways to utilize such fuels.

CHAPTER VI

RADIATION STUDY LIMITATIONS

I. INTRODUCTION

Linstone, in his Eight Basic Pitfalls: A Checklist, begins his article with a quotation by J. A. Coates, "New technological knowledge creates new ignorance."[1] With this introduction, Linstone then proceeds to emphasize a well known concept, namely, that any significant new approach inevitably spawns criticism and when criticism serves a constructive purpose such criticism is healthy and can even be entertaining. It was in this article that the planner, for this radiation study, first heard of the Sackman Report—a very extensive critique of the relatively new Delphi Technique.[2] Linstone's basic pitfalls article was obviously in answer to Sackman's criticisms. It is the opinion of this study planner that in retrospect, most studies will highlight a number of things which should have been done differently, given enough time, money and fortitude. Sackman's critique should cause a researcher in the Delphi area to do more than just be concerned with "what ifs."

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[1]H. A. Linstone, "Eight Basic Pitfalls: A Checklist," The Delphi Method-Techniques and Applications (Reading, MA: Addison Wesley Publishing Company, 1975), p. 573.

[2]H. Sackman, Delphi Assessment, Expert Opinion, Forecasting and Group Process, R-1283-PR (Santa Monica, CA: Rand Corporation, 1974) pp. 1-118.

Sackman has examined and questioned the entire conceptual design of the technique. While there are those like Linstone,[3] Goldschmidt,[4] Coates,[5] and Scheele[6] who seem to believe that Sackman has somehow missed the point in his assessment, this planner found that to ignore Sackman's comments would be irresponsible. In retrospect, it would have been extremely helpful if this critique and analysis had been found early in this study rather than near its completion.

II. LIMITATIONS

The highlighting of the after-the-fact limitations for this study will be presented in the form of answers to Sackman's criticisms of the technique as a forecasting tool—even though this study was never intended to be a forecasting instrument. The comparison of this radiation study, with Sackman's findings, is contained in Table VI-1.

III. LIMITATION SUMMARY

It seemed appropriate after reading Sackman's critique and the resulting responses to Sackman that this dissertation should have a

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[3]Op cit., Linstone, p. 574.

[4]P. G. Goldschmidt, "Scientific Inquiry or Political Critique?" Technological Forecasting and Social Change (New York: American Elsevier Publishing Co., Inc., 1975), pp. 195-213.

[5]J. F. Coates, "In Defense of Delphi," Technological Forecasting and Social Change (New York: American Elsevier Publishing Co., Inc., 1975), pp. 193-194.

[6]D. S. Scheele, "Consumerism Comes to Delphi," Technological Forecasting and Social Change (New York: American Elsevier Publishing Co., Inc., 1975), pp. 215-219.

TABLE VI-1

SACKMAN CRITIQUE OF THE DELPHI TECHNIQUE COMPARED WITH BLACKMON CRITIQUE OF RADIATION DELPHI STUDY

Sackman's Concerns and Findings	Blackmon's Comments
Sackman Concern 1. Is the Delphi concept of the expert and its claim to represent valid expert opinion scientifically tenable or is it overstated: Sackman Finding 1. The Delphi concept of the expert, and its claim to represent valid expert opinion, is scientifically untenable and overstated. As summarized by Professor Haythorn, ". . . the procedure by which the selection of subjects occurs is not properly explicated, the exact nature of the panel of experts is often left unspecified, and the implicit assumption that results obtained using conventional Delphi with a panel of experts is better than or different from results that would be obtained using another population has not been empirically established."	1. This panel was chosen because they were known (a) to be laypersons concerned about our country's energy problems, (b) to be safety/health occupational nurses, physicians and engineering educators, and (c) medical specialists, radiologists or scientists and engineers in the nuclear power generation field. This selection might not have been as scientific as some would like to see, but these panel members were willing to work without compensation and they were interested enough to volunteer. Sackman's comments are valid regarding expert opinion versus general population. A review of Table IV-9 (p. 69) reveals that the nuclear specialists in Round One were diametrically opposite the Health Science Educator/Practitioner Group in both opinions about the objectives and feasibility except on one area. Further, the second and third round questionnaires were developed from what all members of the panel wanted not just the experts and the panel then turned around and judged most of the cognitive statements to be true and had no opinion changes between Rounds Two and Three after having many opinions concerning the feasibility of teaching some of these same objectives. Thus, it seems that in the area of opinions, one may not need "experts."
Sackman Concern 2. Are Delphi claims of the superiority of group over individual opinion, and of the superiority of remote and private opinion over face-to-face encounter, meanful and valid generalizations? Sackman Finding 2. Delphi claims of the superiority of group over individual opinion, and of the superiority of remote and private opinion over face-to-face encounter, as well as their counterstatements, are unproven generalizations.	2. This question cannot be answered except to say that it is doubtful whether this researcher could have had as large and diverse group to communicate with each other except through this technique. Two hundred and twenty-five persons were asked to become members, 220 responded with 90 agreeing to serve. Admittedly, the final totals turned out to be 72; however, all of these persons responded at least once, 54 twice, and 39 three times. The claims of the Delphi proponents may be as Sackman has stated, however the fact that this radiation study group communicated is borne out by the acceptance and rejection of stated hypotheses.

TABLE VI-1 (continued)

Sackman's Concerns and Findings	Blackmon's Comments
Sackman Concern 3. Is Delphi consensus authentic or specious consensus? Sackman Finding 3. Delphi consensus is specious consensus. As succinctly stated by Professor Haythorn, ". . . the group process used in Delphi rounds is quite similar to the techniques used in social psychological research to study group conformity, rejection of deviant opinion, and deindividualization, all of which have been shown to be counterproductive with regard to the quality of group decisions."	3. The radiation study began by the use of opinion questions from previous studies for the purpose of stimulating thought. The fact that a panel of 72 persons submitted 650 comments and then answered a second and third questionnaire of ~300 statements that utilized the 650 statements which were statistically tested was neither specious consensus nor rejection. The purpose of this study was group communication in the beginning with consensus toward the end. In the measuring of the validity of the cognitive statement, there is concern. Comments from the nuclear specialist group in Round Three saying I will not change that which is true or false just because the consensus says so. In the area of facts when one has a general knowledge panel as opposed to experts it is quite possible to get consensus that is not authentic. This is a very strong limitation in this study because I believe there is consensus about some false statements by calling them true.
Sackman Concern 4. Are Delphi questions, particularly forecasting questions, precise and meaningful? Sackman Finding 4. Delphi questions are likely to be vague.	4. The statements in Round One were for the purpose of stimulating thinking on the part of the panel. They were taken from other studies and designed for the purpose of measuring attitudes toward radiation. The second questionnaire, as stated above, asked what the panel members wanted to find out and were quite specific. The problem some panel members complained about was the fact that they were given no place to state that they did not know on cognitive questions. No one complained about lack of form.
Sackman Concern 5. Are Delphi responses precise and unambiguous? Sackman Finding 5. Delphi responses are likely to be ambiguous.	5. If other Delphi studies are likely to contain ambiguous statements, this one is no different (see Appendices B and C), however it is believed they were kept to a minimum.
Sackman Concern 6. Are Delphi results meaningful and unambiguous? Sackman Finding 6. Delphi results probably represent compounded ambiguity.	6. This panel did not have major disagreements on the desirability or importance of having laypersons know and understand the concepts and behavioral objectives (all opinion questions), however, the statements that represent facts with 98.2 percent stated as being true or tending to be true, is in this researcher's mind an incorrect finding. This is particularly disturbing in light of the fact that the nuclear specialists group had scores as widely dispersed from the median as some of the nonspecialist groups (see Tables IV-22 through IV-25, pp. 98-101). It appears that in some areas, the fortune tellers that Sackman speaks of could be producing equivocal results instead of ambiguous.

TABLE VI-1 (continued)

Sackman's Concerns and Findings	Blackmon's Comments
Sackman Concern 7. Is Delphi primarily concerned with collections of snap judgment opinions of polled individuals from unknown samples, or is it concerned with coherent predictions, analyses, or forecasts of operationally defined and systematically studies behaviors or events? Sackman Finding 7. Delphi is primarily concerned with transient collections of snap judgment opinions of polled individuals from unknown samples, which should not be confused or equated with coherent predictions, analyses, or forecasts of operationally defined and systematically studied behaviors or events.	7. As stated in 3. above, the first part of this study could not have been snap judgment. About 650 comments were received; however, when one reads 3. and 6. above that the panel has overwhelmingly agreed that statements of fact in Round One are practically all truthful one could agree Sackman may have a point in this area. Round Three indicates a movement away from this idea of consensus. However, the hypothesis being explored in the study was whether answers were being changed between rounds, and they were.
Sackman Concern 8. Does Delphi anonymity reinforce scientific accountability or unaccountability in method and findings? Sackman Finding 8. Delphi anonymity reinforces unaccountability in method and findings	8. This panel was guaranteed anonymity, still has it and as far as I am concerned, will keep it. To me, it is the essence of the technique, unaccountability not withstanding. When Round Three was mailed to all 72 panel members asking if their names might be revealed to other panel members, only 39 questionnaires were returned and 10 of these refused permission. I have to believe the reason for failure to return was because of this question.
Sackman Concern 9. Does Delphi systematically encourage or discourage the adversary process and exploratory thinking? Sackman Finding 9. Delphi systematically discourages adversary process and inhibits exploratory thinking.	9. In this study the findings are contrary to Sackman. Again refer to 3. and 6. above. We explored and the adversary process was maintained with diligence on the part of the study director and conscientious panel members.

TABLE VI-1 (continued)

Sackman's Concerns and Findings	
Sackman Concern	
10. Does Delphi represent a critical tradition, or is it uncritically isolated from the mainstream of scientific questionnaire development and behavioral experimentation, and does Delphi set a desirable or an undesirable precedent for interdisciplinary science in the professional planning and policy studies community?	10. Delphi in this study has brought persons together from 31 states, with an age span of 21 to 70 and many different walks and stations in life. They (and this may sound presumptuous) wanted an opportunity to learn and share something about what might be the true safety and health concerns associated with radiation, thereby becoming better able to make judgments concerning future energy policy. In this sense, I wholly reject Sackman's statement that an undesirable precedent has been for interdisciplinary science in the planning and policy studies community. However, one must agree that no evidence appears forthcoming regarding scientific questionnaire development.
Sackman Finding	
10. Delphi has been characterized by isolation from the mainstream of scientific questionnaire development and behavioral experimentation, and has set an undesirable precedent for interdisciplinary science in the professional planning and policy studies community.	

chapter directed toward providing a summary of the study limitations even though study "Limitations" are to be found in Chapter I. A review of the statements in Chapter I are not inconsistent with those listed below. The reader of this report should look upon the statements below as a continuation of the list in Chapter I.

1. The Nuclear Specialist group as compared to the other two groups (17 percent) is small. This fact was not of great importance in opinion areas such as the opinion about the Round One attitude statements, the Round One feasibility of teaching statements, Round Two and Round Three desirability and importance statements. However, when statements involving the validity of knowledge such as how a radiation particle penetrates, or the amount of radiation the body can stand, and similar cognitive statements, the ability to change an opinion as to the truthfulness or falseness of a fact is of concern. This may be the most important limitation of this study and indeed of all Delphi studies.

2. In the cognitive area, no method was given whereby a person could declare that he or she did not know an answer. Several panel members in Round Two informed the planner that when they did not know something they put down a "four" or "one" or didn't answer. As a result, in calculating the means as feedback for Round Three, these answers were omitted. A major question remains: How many others chose a number and did not say anything? A review of Table IV-26 (p. 103) indicates quite a bit of change between Rounds Two and Three and the statistical tests applied indicated a great deal of change. No conclusion should be drawn other than the fact that there was movement—

whether the movement was toward truthfulness or falseness is anyone's guess.

3. The question of anonymity raised by Sackman is of concern because in this study, this planner is convinced by the lack of returned questionnaires at the end of Round Three that he almost "blew" the study by asking to reveal the names of the panel members to other panel members (see Appendix F for the listings by known and assumed profession and geographical location by participant number). Due to the lack of response to the request to reveal, both by not returning the questionnaire or forgetting to sign the release, the identity of the panel members will remain in a safety deposit box until June 1981, at which time they will be destroyed. Therefore, due to small sample size the data indicating movement around the means reported in Interim Report II (Appendix E) may be "soft" even though statistically valid.

4. All statements in Round One had either been tested for validity and reliability (to determine an attitude for or against radiation) or had been developed in a university workshop. Round Two statements were simply a record of what the panel said they wanted to know. The raw scores obtained from the Round Two and Round Three Questionnaires were transformed into "stanine" normalized standard scores for purposes of comparing groups. The major recommendation in Chapter V pertains to this subject.

5. "Perhaps the greatest of all human rights is the right to help shape and determine one's own and society's future. We need to know far more about human attitudes toward future developments."[7]

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[7]Op. cit., Sackman, p. 71.

BIBLIOGRAPHY

BIBLIOGRAPHY

Bugnard, L. Risk Evaluation for Protection of the Public in Radiation Accidents. Safety Series, No. 21. Vienna, Austria: International Atomic Energy Agency and World Health Organization, 1967.

Bureau of National Affairs. "Clean Air Act," Environmental Reporter. Washington: 1973.

Bureau of National Affairs. "Federal Water Pollution Control Act," Environmental Reporter. Washington: 1972.

Bureau of National Affairs. "The National Environmental Policy Act," Environmental Reporter. Washington: 1970.

Bureau of National Affairs. "Solid Waste Disposal Act," Environmental Reporter. Washington: 1970.

Campana, R. J., and S. Langer. Nuclear Power and the Environment—Questions and Answers. Hinsdale, Illinois: American Nuclear Society, 1976.

Chambers, J. C., S. K. Mullick, and D. D. Smith. How to Choose the Right Forecasting Technique. Boston: Harvard Business Review, July/August, 1971.

Chanlett, E. T. Environmental Protection. New York: McGraw Hill, 1973.

Clayton, G. D. The Industrial Environment-Its Evaluation and Control. Washington: U.S. Department of Health, Education and Welfare, Public Health Service, Center for Disease Control and National Institute for Occupational Safety and Health, 1973.

Corn, J. K. and Morton. "Setting Standards for the Public: An Historical Perspective," Impact of Energy Production on Human Health. Oak Ridge: ERDA Technical Information Center, 1976.

Costner, R. C. and C. M. Lytle. Modern Constitutional Law. New York: Free Press, 1971.

Crater, H. L. "The Identification of Factors Influencing College Students' Attitudes Toward Radioactivity." Unpublished Doctor's dissertation, University Microfilms, 1972.

Cyphert, F. R. and W. L. Gant. "The Delphi Technique: A Case Study," Phi Delta Kappa. Bloomington, Ind.: Phi Delta Kappa Inc., 1971.

Educational Resource Information Center. Dialog Search File 1. Knoxville: University of Tennessee, 1976.

Eisenbud, Merril. "Radiation Standards and Public Health," Nuclear Power and Radiation in Perspective. Oak Ridge: Nuclear Safety Information Center, 1974.

Epstein, S. S. Impact of Energy Production on Human Health—An Evaluation of Means for Assessment. Oak Ridge: ERDA Technical Information Center, 1976.

ERDA Technical Information Center. ERDA Technical Information Center—Its Functions and Services. Oak Ridge: 1975.

Findlay, Esther and Bruce. Your Rugged Constitution. Palo Alto, California: Stanford University Press, 1950.

Fri, R. W. "An Overview of our National Energy Needs, Resources and Future Developments," Impact of Energy Production on Human Health—An Evaluation of Means for Assessment. Oak Ridge: ERDA Technical Information Center, 1976.

Fuller, J. G. We Almost Lost Detroit. New York: Ballentine Books, 1976.

Gordon, Theodore and Olaf Helmer. Report on a Long Range Forecasting Study. New York: New York's Basic Books, Inc., 1963.

Guilford, J. P. Fundamental Statistics in Psychology and Education. New York: McGraw Hill Book Company, Inc., 1956.

Gwynne, P., James Bishop, Jr., and S. G. Michaud. "How Safe is Nuclear Power?" Newsweek. Washington: Newsweek, Inc. 1976.

Haddon, W., E. A. Suchman, and David Klein. Accident Research-Methods and Approaches. New York: Harper and Row Publishers, 1974.

Helmer, Olaf. The Use of the Delphi Technique in Problems of Education Innovations. Santa Monica, California: The Rand Corporation, 1966.

Hogerton, J. F. The Atomic Energy Deskbook. New York: Reinhold Publishing Company, 1963.

Hull, A. P. "Radiation in Perspective: Some Comparisons of the Environmental Risks from Nuclear and Fossil-Fueled Power Plants," Nuclear Power and Radiation in Perspective. Oak Ridge: Nuclear Safety Information Center, 1974.

Jones, K. L., L. W. Shanberg, and C. O. Byer. Health Science. New York: Harper and Row, 1974.

Katz, Milton. "Decision Making in the Production of Power," Energy and Power. San Francisco: Scientific American, 1971.

LeRoy, G. V. "Exposure to Radiation in an Emergency," NCRP Report No. 29. Washington: National Council on Radiation Protection and Measurement, 1962.

Lien, A. J. Measurement and Education of Learning, Third Edition. Dubuque, Iowa: Wm. C. Brown Company Publishers, 1975.

Linstone, H. A. The Delphi Technique. Reading, MA: Addison-Wesley Publishing Co., 1975.

Lyman, James D. Nuclear Terms—A Glossary. Oak Ridge: ERDA Technical Information Center, 1974.

Martino, J. P. The Precision of Delphi Estimates. New York: Elsevier Publishing Co., Inc., 1970.

Maslow, A. H. "A Theory on Human Motivation," Organization Theories. Columbus, Ohio: C. E. Merril Publishing Co., 1970.

McKee, William D. (ed.) Environmental Problems in Medicine. Springfield, Ill.: Charles C. Thomas, Publisher, 1976.

Moatman, G. L. "With the Society," Fire Technology. Boston: Society of Fire Protection Engineers, 1973.

Mostromatteo, Ernest. "From Ramazzini to Occupational Health Today from an International Perspective," Journal of Occupational Medicine, No. 5. Research Triangle Park, N.C.: Burroughs Wellcome Co., 1975.

National Commission on Fire Protection and Control. American Burning: The Report of the National Commission on Fire Prevention and Control. Washington: Government Printing Office, 1973.

Oak Ridge Associated Universities. Educational Programs and Facilities in Nuclear Science and Engineering. Oak Ridge: 1975.

Oak Ridge Associated Universities. Scientists and Engineers for the Nuclear Age. Oak Ridge: 1974.

Page, J. A. and Mary-Win O'Brien. Bitter Wages. New York: Grossman Publishers, 1973.

Parker, H. M. "Basic Radiation Protection Criteria," NCRP Report No. 39. Washington: National Council on Radiation Protection and Measurements, 1971.

Pennsylvania Department of Education. The Environmental Impact of Electrical Power Generation: Nuclear and Fossil. Washington: U.S. Government Printing Office, 1975.

Purdom, P. W. "Environment and Health," Environmental Health. New York: Academic Press, 1971.

Ramazzini, Bernardo. De Morbis Artificum: Diseases of Workers. New York: New York Academy of Medicine, 1964.

Rosen, George. The History of Public Health. New York: M. D. Publications, 1958.

Sackman, H. "Delphi Assessment: Expert Opinion, Forecasting, and Group Process," Rand Report R-1283-PR. Santa Monica, California: Rand Corporation, 1974.

Seaborg, G. T. and D. M. Wilkes. Education and the Atom. New York: McGraw Hill Book Company, 1964.

Siegel, Sidney. Nonparametric Statistics for the Behavioral Sciences. New York: McGraw-Hill, 1956.

"Special Bicentennial Issue," Occupation Hazards. Cleveland, Ohio: Industrial Publishing Company, 1975.

Starr, Chauncey. "International Realities of the Energy Crisis," The Environmental Impact of Electrical Power Generation: Nuclear and Fossil. Washington: Government Printing Office, 1975.

Thoreen, Donald R. "Product Liability: The Arms Grow Longer," Chemical Engineering. New York: McGraw Hill Publishing Co., 1973.

Tichaue, E. R. "Chapter 32—Ergonomic Aspects of Biomechanics," The Industrial Environment—Its Evaluation and Control. Washington: Government Printing Office, 1960.

Vollmer, H. M. and L. H. Towle. Radiation Safety Training in a Naval Shipyard. Washington: Government Printing Office, 1960.

Wallace, B. C. (ed.) Health Aspects of Radiation—Draft. Oak Ridge: AEC Technical Information Center, 1967.

Weaver, W. T. "The Delphi Forecasting Method," Phi Delta Kappan. Bloomington, Ind.: Phi Delta Kappa, Inc., 1971.

APPENDIXES

APPENDIX A

PANEL RECRUITING LETTER

This appendix contains a copy of the letter used to recruit members to participate in this project.

118 West Lincoln Road
Oak Ridge, TN 37830
February 1, 1977

Dear

The purpose of this letter is to solicit your participation in a piece of research being undertaken by the undersigned in partial fulfillment of requirements for the Degree of Doctor of Education in Health Education from the University of Tennessee. Members of a panel and I will be attempting to utilize a variation of the "Delphi Technique" to develop information useful to the general public in expanding their understanding of radiation. It is believed that several hours of your valuable time will be needed to answer a series of questionnaires and to write your opinions. The anticipated time span will be from mid-February, 1977 through November, 1977. I sincerely hope that you will join me and approximately 75 others from the fields of business, education, clergy, manufacturing, engineering, medicine, and farming in an attempt to catalogue what we, the panel, perceive that the public should know about the subject of ionizing radiation, particularly that associated with nuclear-fueled electrical power generation. Hopefully, this group will have a fairly even distribution of proponents and critics of nuclear energy. The proposed size of the panel is smaller than I would like; however, economic considerations are a factor as this is a personally funded study.

Note: This space contained information of interest to a specific individual or group of individuals.

Major choices must be made about our country's energy future and each citizen—as a voter, a consumer, a home owner—has a stake in and some influence over future energy policy. The production and use of energy is considered by some to be the single most important cause of environmental degradation—all the way from devastation of lands by surface mining and the hazards of deep mining to oil spills and sulfur emissions. Similarly, the country needs power to keep its economy going although our country can ill afford to trade an energy crisis for a health crisis brought on by environmental problems. While nuclear power may not be a panacea for solving the energy problems of the country, environmentally and economically it is conceivable that it is the major choice available until breakthroughs occur in other forms. Therefore, the general public needs to consider radioactivity—how it is generated, how it is moved in the environment, its effects on people and the magnitude of the problems of contamination over the coming years.

A review of the literature indicates that nuclear specialists have had difficulty explaining to the public in simple terms these complex subjects. When proponents can only respond with lengthy technical discourses, the public finds the critics' cry that nuclear power is unsafe, uneconomical, unreliable, and unnecessary forceful rhetoric. Some have found that effectively answering the critic to be analogous to having first rebuttal to the cry of "fire" in a crowded theatre. I believe that it is important for those individuals who have factual information to present it in terms that the general public can understand. Both proponents and critics have a responsibility to separate real experience from conjecture, imagined fears, and the "what ifs" that are frequently brought to the public's attention as "newsworthy."

The "Delphi Technique" was originally developed by Gordon & Helmer at the Rand Corporation in the early 1960's. It is an intuitive methodology for organizing and sharing concerns about future events. Its original use was to establish a chronology of scientific and technological events and to judge when the events might occur through the speculations of several experts. Delphi operates on the principle that several heads are better than one in making subjective conjectures based upon rational judgment and shared information rather than merely guessing. The process can usually separate hope from likelihood. An important characteristic of the technique is that participants do not know who the other participants might be. The panel, that hopefully you will consent to join, will be composed of nuclear specialists who through Delphi Technique can respond to the concerns of other members of the panel who will come from nonnuclear fields of endeavor.

To sum up, the "Delphi Technique" seems to offer (a) a method of studying the process of thinking about the future, (b) a pedagogical tool that can cause people to think about the future in a more complex way than they ordinarily would and (c) a planning tool which may aid in probing priorities held by persons with different concerns and ideas.

In closing, I feel that you should know that this graduate student is 50 years old, (2) has been employed by a prime contractor of both AEC and ERDA for 25 years in a nonnuclear engineering capacity, and (3) it is my belief that those of us who have the ability to present a complex subject in factual understandable language have a responsibility to do so.

If you decide to participate, please return the attached acknowledgment by February 1, 1977. You will receive the first questionnaire by February 15, 1977. If you decide not to participate, I would still appreciate the return of the acknowledgment. If you are so inclined, a statement of why not would also be appreciated. Thank you very much for considering this request and I look forward to hearing from you.

Very truly yours,

J. T. Blackmon, Jr., P.E.

JTBJr:njc

Attachment

STATEMENT OF ACKNOWLEDGMENT

1. I, _____, will participate in the Blackmon Delphi Probe to help determine what laypersons should know about radioactivity.

2. I, _____, do not wish to participate in the Blackmon Delphi Probe.

3. Remarks:

_____
Signature

_____
Date

☐ Please check if you desire a copy of the summary of the study.

APPENDIX B

ROUND ONE QUESTIONNAIRE—SEEKING INPUT

This appendix contains the instructions and the first questionnaire submitted to the panel.

Each statement was paraphrased and coded from published studies. The code may be read as follows:

60-No. = 1960 study by Stanford Research Institute, Menlo Park, California (H. M. Vollmer and L. H. Towle).

67-No. = 1967 Health Education Workshop at the University of Tennessee at Knoxville, Tennessee, directed by Bill C. Wallace.

72-No. = 1972 Unpublished Doctoral dissertation by H. L. Crater, University of Texas at Austin, Texas.

Sheet 1 of Initial Questionnaire

ROUND ONE—SEEKING INPUT

OPINION ABOUT STATEMENTS					CONCEPTUAL STATEMENTS	FEASIBILITY OF TEACHING			
Agree	Tend to Agree	No Opinion	Tend to Disagree	Disagree		Highly Feasible	Likely	Unlikely But Possible	Not Feasible
					A. Radiation may affect the human body in such a way as to be harmful or helpful. Laypersons should:				
					1. realize that radiation acts upon the human body to cause sickness and to treat diseases. (67-1)				
					1a.				
					2. learn to respect the consequences of human exposure to acute irradiation from external sources. (67-2)				
					2a.				
					3. be able to list the diseases that can be treated by radiotherapy. (67-3)				
					3a.				
					4. know the methods in using radiation to diagnose diseases. (67-4)				
					4a.				
					5. know how to observe secondary effects of the use of radiation in diagnosis and treatment of disease. (67-5)				
					5a.				

Sheet 2 of Initial Questionnaire

ROUND ONE—SEEKING INPUT

OPINION ABOUT STATEMENTS				CONCEPTUAL STATEMENTS	FEASIBILITY OF TEACHING			
Agree	Tend to Agree	No Opinion	Tend to Disagree	Disagree		Highly Feasible	Likely	Unlikely But Possible	Not Feasible
				6.				
				6a.				
				7. recognize that, although radiation can be helpful or harmful, it is safe to say that to date more lives have been saved by radiotherapy than lost by accidental overexposure. (72-10)				
				7a.				
				8. support banning radionuclides in hospitals because of the danger of leakage or contamination. (72-13)				
				8a.				
				9. worry about the effects of radiation on the human body. (60-1)				
				9a.				

Sheet 3 of Initial Questionnaire

ROUND ONE—SEEKING INPUT

OPINION ABOUT STATEMENTS				CONCEPTUAL STATEMENTS	FEASIBILITY OF TEACHING			
Agree	Tend to Agree	No Opinion	Tend to Disagree / Disagree		Highly Feasible	Likely	Unlikely But Possible	Not Feasible
				10. recognize that exposure to radiation is usually harmful. (60-4)				
				10a.				
				11. recognize that people are more afraid of radiation than they need to be. (60-7)				
				11a.				
				12. insist that x-rays, which are a form of radiation, be restricted to emergencies. (60-16)				
				12a.				
				B. Radiation effects depend upon the amount and type of radiation. Laypersons should:				
				13. be able to identify types of radiation. (67-7)				
				13b.				

Sheet 4 of Initial Questionnaire

ROUND ONE—SEEKING INPUT

OPINION ABOUT STATEMENTS				CONCEPTUAL STATEMENTS	FEASIBILITY OF TEACHING			
Agree	Tend to Agree	No Opinion	Tend to Disagree	Disagree		Highly Feasible	Likely	Unlikely But Possible	Not Feasible
				14. be able to classify sources of radiation. (67-8)				
				14b.				
				15. recognize differences in the radiation effect produced by different types of radiation. (67-9)				
				15b.				
				16. learn the techniques for measuring radiation. (67-10)				
				16b.				
				17. be able to interpret the relationship between kinds of radiation and dose rates. (67-11)				
				17b.				
				18. be able to apply their knowledge of radiation effects to determine what happens at the primary site of interaction. (67-12)				
				18b.				

Sheet 5 of Initial Questionnaire

ROUND ONE—SEEKING INPUT

OPINION ABOUT STATEMENTS					CONCEPTUAL STATEMENTS	FEASIBILITY OF TEACHING			
Agree	Tend to Agree	No Opinion	Tend to Disagree	Disagree		Highly Feasible	Likely	Unlikely But Possible	Not Feasible
					19. be able to recognize that the research on radiation effects and on radioactivity lead to the advancement of human knowledge. (67-13)				
					19b.				
					20. fear an increasing genetic load for mutations among humans through the increased use of ionizing radiation. (72-19)				
					20b.				
					21. not worry until the scientists can agree on the biological effects of radiation. (60-5)				
					21b.				
					22. recognize that the use of radiation in medical treatment is likely to do more harm than good. (60-9)				
					22b.				

Sheet 6 of Initial Questionnaire

ROUND ONE—SEEKING INPUT

OPINION ABOUT STATEMENTS					CONCEPTUAL STATEMENTS	FEASIBILITY OF TEACHING			
Agree	Tend to Agree	No Opinion	Tend to Disagree	Disagree		Highly Feasible	Likely	Unlikely But Possible	Not Feasible
					23. realize that all forms of radiation are potentially dangerous. (60-12)				
					23b.				
					24. recognize that the "dangers" of radiation have been highly overrated. (60-15)				
					24b.				
					C. There are methods by which harmful radiation effects may be prevented or treated. Laypersons should:				
					25. be able to appreciate methods for preventing exposure to radiation. (67-14)				
					25c.				
					26. understand the emotional and social aspects of confinement in fallout shelters. (67-15)				
					26c.				

Sheet 7 of Initial Questionnaire

ROUND ONE—SEEKING INPUT

OPINION ABOUT STATEMENTS					CONCEPTUAL STATEMENTS	FEASIBILITY OF TEACHING			
Agree	Tend to Agree	No Opinion	Tend to Disagree	Disagree		Highly Feasible	Likely	Unlikely But Possible	Not Feasible
					27. understand the methods used in treating persons exposed to radiation. (67-16)				
					27c.				
					28. be able to select from a list of occupations those in which exposure to radiation is a hazard. (67-17)				
					28c.				
					29. be able to evaluate legislation that protects them from radiation hazards. (67-18)				
					29c.				
					30. be able to recognize drugs that may be able to protect man from radiation. (67-19)				
					30c.				
					31. oppose the spending of large sums of money for basic nuclear research because it would be a poor investment by the federal government. (72-4)				
					31c.				

Sheet 8 of Initial Questionnaire

ROUND ONE—SEEKING INPUT

OPINION ABOUT STATEMENTS					CONCEPTUAL STATEMENTS	FEASIBILITY OF TEACHING			
Agree	Tend to Agree	No Opinion	Tend to Disagree	Disagree		Highly Feasible	Likely	Unlikely But Possible	Not Feasible
					32. question the construction of all nuclear facilities because of the harmful products they produce. (72-7)				
					32c.				
					33. recognize that people living near a nuclear reactor can have confidence in the ability of health physicists to prevent major radiation accidents. (72-8)				
					33c.				
					34. be optimistic that scientists will soon develop ways of utilizing the high temperature water released from nuclear power plants for some useful purpose. (72-15)				
					34c.				
					35. recognize that it is reasonable for people to be exposed to some radiation in order to accomplish necessary work. (60-2)				
					35c.				

Sheet 9 of Initial Questionnaire

ROUND ONE—SEEKING INPUT

OPINION ABOUT STATEMENTS					CONCEPTUAL STATEMENTS	FEASIBILITY OF TEACHING			
Agree	Tend to Agree	No Opinion	Tend to Disagree	Disagree		Highly Feasible	Likely	Unlikely But Possible	Not Feasible
					36. recognize that with simple precautions, radioactive materials can be handled safely. (60-10)				
					36c.				
					D. Radiation influences the lives of man through its interaction with the environment. Laypersons should:				
					37. be able to suggest ways in which radiation affects the environment in which man lives. (67-20)				
					37d.				
					38. know how to recognize contamination on food-stuffs from fall-out. (67-21)				
					38d.				
					39. be able to suggest ways of controlling fallout contamination of food-stuffs. (67-22)				
					39d.				

ROUND ONE—SEEKING INPUT

OPINION ABOUT STATEMENTS					CONCEPTUAL STATEMENTS	FEASIBILITY OF TEACHING			
Agree	Tend to Agree	No Opinion	Tend to Disagree	Disagree		Highly Feasible	Likely	Unlikely But Possible	Not Feasible
					40. be able to compare the relative distributions of various sources to radioactive contamination in/to the atmosphere. (67-23)				
					40d.				
					41. be able to propose legislation for controlling radio-active pollution of the atmosphere and for controlling the distribution of irradiated food-stuffs. (67-24)				
					41d.				
					42. be able to integrate information on the effects of radiation on living tissues with the use of radiation to sterilize and preserve food and drugs. (67-25)				
					42d.				
					43. know how to apply their knowledge of radiation effects in order to control environmental pests. (67-26)				
					43d.				

Sheet 11 of Initial Questionnaire

ROUND ONE—SEEKING INPUT

OPINION ABOUT STATEMENTS					CONCEPTUAL STATEMENTS	FEASIBILITY OF TEACHING			
Agree	Tend to Agree	No Opinion	Tend to Disagree	Disagree		Highly Feasible	Likely	Unlikely But Possible	Not Feasible
					44. be able to summarize the impact of radiation on the health of man. (67-27)				
					44d.				
					45. recognize that it would be desirable for all large cities to replace their coal-burning power plants with plants that generate electricity from nuclear energy. (72-2)				
					45d.				
					46. be suspicious of nuclear powered submarines as major polluters of the world's oceans. (72-3)				
					46d.				
					47. recognize that the job crisis currently confronting many highly trained nuclear scientists was inevitable because the "product" they produced was worth the high costs. (72-5)				
					47d.				

Sheet 12 of Initial Questionnaire

ROUND ONE—SEEKING INPUT

OPINION ABOUT STATEMENTS					CONCEPTUAL STATEMENTS	FEASIBILITY OF TEACHING			
Agree	Tend to Agree	No Opinion	Tend to Disagree	Disagree		Highly Feasible	Likely	Unlikely But Possible	Not Feasible
					48. recognize that people living near a harbor have no cause to be apprehensive when a nuclear powered ship is in port for any length of time. (72-11)				
					48d.				
					49. recognize that as an increasing number of nuclear power reactors are brought into operation in the United States, significantly higher levels of radioactive contaminants in our streams and lakes will be detected. (72-14)				
					49d.				
					50. assume that scientists can be depended upon to study nearby fracture zones very carefully before detonating nuclear test explosives underground. (72-18)				
					50d.				
					51. be optimistic that in the future the benefits derived from radioactivity will exceed any possible misuses of nuclear power. (72-20)				
					51d.				

ROUND ONE—SEEKING INPUT

OPINION ABOUT STATEMENTS					CONCEPTUAL STATEMENTS	FEASIBILITY OF TEACHING			
Agree	Tend to Agree	No Opinion	Tend to Disagree	Disagree		Highly Feasible	Likely	Unlikely But Possible	Not Feasible
					52. recognize that workers are actually safer in atomic plants than in most conventional plants. (60-3)				
					52d.				
					53. recognize that an atomic power plant is a serious hazard to the surrounding community. (60-6)				
					53d.				
					E. Regulatory agencies do everything practical to prevent radiation from harming the public. Laypersons should:				
					54. recognize that to date the development of nuclear energy has proceeded in an orderly and responsible manner which promises to carry over into future development. (72-1)				
					54e.				
					55. recognize that in general the national news media tend to present information about nuclear power and radioactivity in an unfavorable light. (72-6)				
					55e.				

Sheet 14 of Initial Questionnaire

ROUND ONE—SEEKING INPUT

OPINION ABOUT STATEMENTS					CONCEPTUAL STATEMENTS	FEASIBILITY OF TEACHING			
Agree	Tend to Agree	No Opinion	Tend to Disagree	Disagree		Highly Feasible	Likely	Unlikely But Possible	Not Feasible
					56. recognize that if forced to make a choice between continuing their research and taking a stand for the public good, most nuclear scientists would give priority to their research. (72-9)				
					56e.				
					57. recognize that over the next decade the United States should commit itself to developing a network of nuclear reactors in order to meet its future energy demands. (72-12)				
					57e.				
					58. recognize that nuclear physicists working today have "sold their souls" to the military-industrial complex in order to obtain their research grants. (72-16)				
					58e.				
					59. believe that the appropriate adjective to describe the activities of the former United States Atomic Energy Commission is "militaristic". (72-17)				
					59e.				

OPINION ABOUT STATEMENTS					CONCEPTUAL STATEMENTS	FEASIBILITY OF TEACHING			
Agree	Tend to Agree	No Opinion	Tend to Disagree	Disagree		Highly Feasible	Likely	Unlikely But Possible	Not Feasible
					60. recognize that chances for recovery from radiation injury are slight. (60-8)				
					60e.				
					61. recognize that if radiation leakage occurs in an atomic energy plant, the best thing to do is to evacuate the plant immediately. (60-11)				
					61e.				
					62. recognize that a trained worker is as safe around radioactive materials as a worker in a nonnuclear industrial plant. (60-13)				
					62e.				
					63. recognize that after several years, homes located near an atomic power plant are likely to become unsafe places to live. (60-14)				
					63e.				

Sheet 16 of Initial Questionnaire

ROUND ONE—SEEKING INPUT

OPINION ABOUT STATEMENTS					CONCEPTUAL STATEMENTS	FEASIBILITY OF TEACHING			
Agree	Tend to Agree	No Opinion	Tend to Disagree	Disagree		Highly Feasible	Likely	Unlikely But Possible	Not Feasible
					64. recognize that accidents involving atomic energy have been extremely rare. (60-17)				
					64e.				
					65. recognize that one can't be too cautious around radioactive materials. (60-18)				
					65e.				
					66. recognize that atomic energy plants are dangerous places to work. (60-19)				
					66e.				
					67. let the hazards of radiation stand in the way of continued atomic energy development. (60-20)				
					67e.				

Sheet 17 of Initial Questionnaire

ROUND ONE—SEEKING INPUT

OPINION ABOUT STATEMENTS					CONCEPTUAL STATEMENTS	FEASIBILITY OF TEACHING			
Agree	Tend to Agree	No Opinion	Tend to Disagree	Disagree		Highly Feasible	Likely	Unlikely But Possible	Not Feasible
					F. This category is for any concept or idea in the field of radioactivity that a participant would like for the panel to explore that was not covered in A through E.				

APPENDIX C

ROUND TWO QUESTIONNAIRE—EVALUATION

This appendix contains a copy of the Round Two Questionnaire. This questionnaire was also used for Round Three; therefore, included in this appendix are the instruction sheets for both rounds, and the Scaling Table used for both rounds.

ROUND TWO—EVALUATION

INSTRUCTIONS

This questionnaire asks that you evaluate the desirability and importance of the four suggested concepts relative to the health aspects of radiation as well as the suggested behavioral objectives expected of a layperson after he or she learns the content of the material presented for the development of the concepts.

CONCEPTS are labeled I, II, III and IV. Suggested BEHAVIOR OBJECTIVES are labeled A, B, C, etc.

The scale values to be used in making your judgments are explained in the attached table entitled SCALE VALUE TABLE.

You will be expressing your judgments with two separate numbers for each of the four concepts and 39 behavioral objectives.

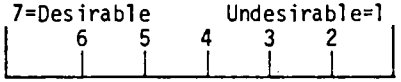
In addition, please provide a number that expresses your opinion as to the validity of the statement of fact being used to support the behavioral objectives.

CONTENT statements are labeled 1, 2, 3, 4, etc.

BE SURE TO READ THE SCALING TABLE BEFORE MARKING THE QUESTIONNAIRE AND PLEASE RETURN BY SEPTEMBER 1, 1977.

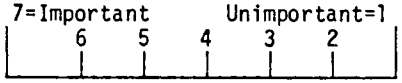
SCALE VALUE TABLE FOR ROUND TWO

THE FOLLOWING VALUES TO BE USED IN RATING STATEMENTS IN QUESTIONNAIRE



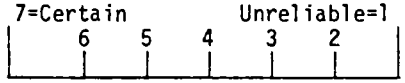
Desirability (Effectiveness or Benefits to be Gained by Having Laypersons Know This Information)

Desirable	Will have a positive effect and little or no negative effect
7	justifiable on its own merit
Undesirable	Will have a major effect
1	not justifiable



Importance (Priority or Relevance of Having a Layperson Understanding This Information

Important	a most relevant point
	first order priority
	has direct bearing on major
7	should be resolved, dealt with, or treated
Unimportant	no priority
1	no relevance
	no measurable effect
	should be dropped as an item to consider



My Confidence in Validity of the Information in the Statement

Certain	low risk of being wrong
	decision based upon this will not be wrong because of this "fact"
7	
	most influences drawn from this will be true
Unreliable	substantial risk of being wrong
1	not willing to make a decision based on this alone
	many incorrect inferences can be drawn

ROUND THREE—A CHANCE TO CHANGE

INSTRUCTIONS

Attached is your original copy of Round Two entitled Evaluation and a summary of the mean scores of all participants. Note: Some participants without any knowledge concerning a specific statement scored with a specific number. These numbers as well as the unanswered statement were not included in the computed averages.

Please compare each of the answers with your answer. If your answer varies by +1 or -1 you may wish to change your answer (i.e., The mean for statement II.D.2 = 4.5. If your answer was 3.5 or less or if your answer was 5.5 or greater, you may wish to change. There is no criteria that says you have to, nor will you have to state why you do not wish to change as is the usual practice in a Delphi Study).

Return your questionnaire by February 15, 1978. Those of you who did not return Round II should do so now if you still have your copy.

A copy of the scaling table is printed on the back of these instructions to refresh your memory.

Please note a new page 25 has been added to your questionnaire.

Sheet 1 of Second Questionnaire

Round Two—Evaluation

Concepts—Behavioral Objectives—Content	Scales*		
	Desirability 7-6-5-4-3-2-1	Importance 7-6-5-4-3-2-1	Validity 7-6-5-4-3-2-1

I. Radiation may affect the human body in such a way as to be harmful or helpful.

A. A layperson should realize that radiation is a physical agent like sunlight, heat, and pressure that has effects on living tissue that can cause damage or when properly channelled become beneficial.

1. When the human body is exposed to radiation, the results may be harmful or beneficial.

2. Radiation injuries are not different from other kinds of injuries that occur after over-exposure to radiant or thermal energy.

3. The sequence of reactions of the human body to large amounts of radiation is unique and forms a recognizable pattern known as the radiation syndrome.

4. The symptoms known as radiation syndrome appear within 30 days of whole-body exposure to doses of 50 rad or more.

5. Radiation sickness is a term applied collectively

Sheet 2 of Second Questionnaire

Round Two—Evaluation

Concepts—Behavioral Objectives—Content	Scales*		
	Desirability 7-6-5-4-3-2-1	Importance 7-6-5-4-3-2-1	Validity 7-6-5-4-3-2-1

I. A. 5. to the symptoms known as the radiation syndrome.

6. Radiation may be used to treat diseases. The treatment of diseases by radiation is known as radiotherapy.

7. Radiation may be used to diagnose diseases. The diagnosis of diseases by radiation is called radiodiagnosis.

B. A layperson should respect the consequences of human exposure to acute irradiation from external sources.

1. Radiation affects tissues of the body shortly after exposure to produce or a combination of the following disorders called somatic effects:

(a) headache or dizziness; (b) loss of hair, appetite and weight; (c) nausea and vomiting; (d) burns of the skin; (e) blindness and/or cataracts; (f) hemorrhage; (g) disturbance of digestion; (h) lowered body resistance to disease and infection by reducing the number of white blood cells (leukocytes); (i) development of anemia as a result of a decrease in the number of red blood cells (erythrocytes); (j) reduced capacity of the bone marrow to produce blood cells; (k) convulsions

Sheet 3 of Second Questionnaire

Round Two—Evaluation

Concepts—Behavioral Objectives—Content	Scales*		
	Desirability 7-6-5-4-3-2-1	Importance 7-6-5-4-3-2-1	Validity 7-6-5-4-3-2-1
I. B. 1. and death, which occur after severe acute doses that damage the nervous system.			
2. The severity of radiation sickness and the prospects for recovery depend upon the amount of radiation or radiation dose to which one is exposed.			
3. Much of what is known about the effects of radiation on the human body has been learned from studies conducted on: (a) atomic bomb survivors in Japan; (b) survivors of nuclear accidents; (c) data from medical exposures.			
4. Radiation damage may appear years after apparent recovery from exposure. These latent effects appear most frequently as: (a) shortening of life span; (b) acceleration of aging; (c) increased incidence of cancer; (d) alteration of patterns of heredity, particularly in increased rates of mutation.			
C. A layperson should be able to list diseases treated by radiotherapy and should know that further information is available.			
1. Successful treatment of cancer by radiation has been reported for many types of malignancies.			

Sheet 4 of Second Questionnaire

Round Two—Evaluation

Concepts—Behavioral Objectives—Content	Scales*		
	Desirability 7-6-5-4-3-2-1	Importance 7-6-5-4-3-2-1	Validity 7-6-5-4-3-2-1

I. C. 2. Radiotherapy can be applied to benign tumors with good results. However, radiation hazards must be weighed against the benefits of this mode of treatment.

3. Other disorders treated by radiation include: (a) hyperthyroidism; (b) warts; (c) Parkinson's disease.

4. Many lives have been prolonged, though not necessarily saved.

D. A layperson can trust the technically qualified persons who use the various radiation methods to diagnose diseases.

1. Electromagnetic radiation (such as x and gamma rays) may be used to "take a picture of organs such as the lungs.

a. This process (radiography) may be used to diagnose diseases such as tuberculosis.

2. Radioisotope "cocktails" are given to patients. Radiation counters and/or scanners make a graphic representation of the diseases tissue.

3. Differential localization of radioisotopes in normal and diseased tissue creates definable patterns. These

Sheet 5 of Second Questionnaire

Round Two—Evaluation

Concepts—Behavioral Objectives—Content	Scales* Desirability 7-6-5-4-3-2-1	Importance 7-6-5-4-3-2-1	Validity 7-6-5-4-3-2-1
I. D. 3. patterns are used to diagnose neoplasms of all types, thyroid diseases, abnormalities in human anatomy, etc.			
4. Radionuclides have been used in hospitals for years without serious leakage or contamination.			
5. All modern hospitals use radiation in some form for diagnosis and treatment.			
6. X-rays used in medical and dental practices should be administered by physicians or by x-ray technicians trained and certified in the use of medical x-rays.			
E. A layperson should learn (when necessary) how to look for the secondary effects of radiation used in the diagnosis and the treatment of diseases.			
1. Injuries may be induced by using radiation in the diagnosis or treatment of diseases.			
2. Development of the injuries may be immediate such as the difficulty in digestion caused by injury to the intestine by using radiotherapy to treat bladder cancer.			

Sheet 6 of Second Questionnaire

Round Two—Evaluation

Concepts—Behavioral Objectives—Content	Scales*		
	Desirability 7-6-5-4-3-2-1	Importance 7-6-5-4-3-2-1	Validity 7-6-5-4-3-2-1
I. E. 3. Latent injuries such as cancer may appear up to twenty years after medical exposure.			
4. Radiotherapy or radiodiagnosis during pregnancy is particularly hazardous to the unborn child and should be avoided except when absolutely necessary. The incidence of leukemia appears to be much higher among children exposed prenatally.			
5. Persons trained specifically for radiotherapy and radiodiagnosis are called radiologists.			
6. The news media and some scientists with axes to grind have caused people to be more fearful of radiation than they need to be. Controlled radiation is not hazardous.			
F. A layperson should recognize the demographic implications of the medical uses of radiation.			
1. Increasing life expectancy rates make greater demands on food supplies and fuel reserves.			
2. Serious social, emotional and economic problems are imposed upon all age groups as an increasing life expectancy multiplies the number of nonproductive members in our society.			

Sheet 7 of Second Questionnaire

Round Two—Evaluation

Concepts—Behavioral Objectives—Content	Scales* Desirability 7-6-5-4-3-2-1	Importance 7-6-5-4-3-2-1	Validity 7-6-5-4-3-2-1

I. F. 3. Early diagnosis and effective treatment of once-incurable diseases affects the age distributions of populations.

4. The quality of medicine practiced in various countries and communities probably varies directly with the proper use of the diagnostic use of radiation.

5. Natural radiation (by the linear hypothesis) plus nuclear bombs have killed more people than have actually been cured by radiotherapy. Diagnostic x-irradiation has been a bigger though indirect lifesaver.

II. The radiation effect depends upon the amount of and type of radiation.

A. The layperson <u>should be able to identify</u> types of radiation.

1. Two types of radiation that may affect man are:

a. electromagnetic (rays)
b. particulate

2. Rays most frequently encountered by man are: gamma rays, x-rays, and cosmic rays. Laser

Sheet 8 of Second Questionnaire

Round Two—Evaluation

Concepts—Behavioral Objectives—Content	Scales* Desirability 7-6-5-4-3-2-1	Importance 7-6-5-4-3-2-1	Validity 7-6-5-4-3-2-1

II. A. 2. beams are becoming a source of radiation exposure to some groups.

3. The kinds of particles most frequently encountered by man are: alpha particles and beta particles. Other ionizing particles to which man may be occasionally exposed include: neutrons, fast electrons, protons and mesons.

4. The difference between radioactivity and radiation is that radioactivity is a property of some materials and radiation is the energy that is emitted at one point and received at another.

B. The layperson <u>should be able to classify</u> the sources of radiation.

1. There are some sources of radiation to which everyone is exposed.

a. fallout
b. natural background radiation

2. The degree of exposure to the ubiquitous types of radiation depends largely upon the geographical location of the individual.

Sheet 9 of Second Questionnaire

Round Two—Evaluation

Concepts—Behavioral Objectives—Content	Scales* Desirability 7-6-5-4-3-2-1	Importance 7-6-5-4-3-2-1	Validity 7-6-5-4-3-2-1
II. B. 3. Radiotherapy and radiodiagnosis may constitute sources of exposure.			
4. Personnel in radiation industries and mining of certain ores are exposed to radiation. Occupational exposure to radiation is carefully controlled and accidents are highly infrequent.			
5. Some common sources of natural radioactivity are:			
a. Radiation from soil-gases such as radon 222, thoron 220 and solids such as coal (which releases radioactivity when burned).			
b. Solar radiation, as does most natural radioactivity, originates as solar particles beams produced by flares on the sun.			
c. Radiation from the stars, which is produced by neutrons or low energy protons, are alpha particles released in nuclear collision of particles of high energy (HEEP-238).			
6. Some common sources of alpha radiation are:			
a. Natural or background radiation that comes from naturally radioactive elements (i.e. -			

Concepts—Behavioral Objectives—Content	Scales* Desirability 7-6-5-4-3-2-1	Importance 7-6-5-4-3-2-1	Validity 7-6-5-4-3-2-1

II. B. 6. a. uranium) in solids, rocks, and minerals.

b. Man-made such as the production of nuclear fuel.

7. Some common sources of beta radiation are:

a. Natural or background (i.e. solids, rocks, and minerals.

b. Man-made such as television and nuclear reactor by-products.

8. Some common sources of gamma radiation are:

a. Natural or background accompanying alpha and beta radiations in solids, rocks, and minerals as well as cosmic.

b. Medical and dental x-rays.

c. Reactor waste.

d. Power sources for satellites.

e. Medical diagnostic aids, disease treatment and therapy.

C. A layperson should be able to visualize how radiation penetrates matter (Glasstone Ch. 7).

Sheet 11 of Second Questionnaire

Round Two—Evaluation

Concepts—Behavioral Objectives—Content	Scales*		
	Desirability 7-6-5-4-3-2-1	Importance 7-6-5-4-3-2-1	Validity 7-6-5-4-3-2-1
II. C. 1. A charged particled (+ or -) hitting an atom with sufficient energy can move an orbital electron further from the atom's nucleus or cause it to escape from the atom completely.			
2. When one or more electrons has escaped, then the atom is said to be ionized.			
3. An atom will then have a net positive charge since it is missing an electron.			
4. The positively charged atom taken with its separated negative electron is called an ion pair.			
5. Ions can react chemically with matter.			
6. Ions can move in electric fields.			
7. Ions can recombine and emit light.			
8. Ions can serve as condensation nuclei.			
9. The differing electrical properties of alpha, beta, and gamma radiation were discovered and reported in 1903.			

Sheet 12 of Second Questionnaire

Round Two—Evaluation

Concepts—Behavioral Objectives—Content	Scales*		
	Desirability 7-6-5-4-3-2-1	Importance 7-6-5-4-3-2-1	Validity 7-6-5-4-3-2-1
II. D. A layperson should be able to suggest how radiation penetration can be physically blocked (PDE/ERDS-69).			
1. Alpha radiation which is the most hazardous type of radiation, when allowed to enter the body (by swallowing or inhaling an alpha emitter) can sometimes penetrate a very thin piece of paper but cannot penetrate a piece of conventional aluminum foil.			
2. Beta radiation is capable of penetrating a piece of aluminum foil or several layers of a person's skin. In air, its range may be as much as a yard.			
3. High energy gamma radiation and x-rays are capable of penetrating a person, a concrete block or a sheet of lead.			
4. Alpha decay radiation has two protons, two neutrons, zero electrons, and two positive charges.			
5. Beta decay negatron radiation has zero protons,zero neutrons, one electron and one negative charge.			
6. Beta decay position radiation has zero protons, zero neutrons, one electron and one positive charge.			

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Concepts—Behavioral Objectives—Content	Scales* Desirability 7-6-5-4-3-2-1	Importance 7-6-5-4-3-2-1	Validity 7-6-5-4-3-2-1
II. D. 7. Gamma radiation has zero protons, zero neutrons, zero electron and zero charge.			
8. X-ray radiation has zero protons, zero neutrons, zero electron and zero charges.			
E. A layperson <u>should be able to recognize</u> differences in the radiation effect produced by different types of radiation.			
1. Different types of radiation produce similar effects on living tissues frequency with which radiation effects occur varies with the type of radiation.			
2. Different types of radiation vary in their potential to damage tissue because of mass (size) and electric charge (positive or negative).			
3. The effectiveness of two types of radiation for inducing a certain effect may be compared. The comparison is termed the relative biological effectiveness (RBE).			
4. Radiations lose energy as they travel through living tissue. This loss of energy is called the <u>linear energy transfer</u> (LET).			

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Concepts—Behavioral Objectives—Content	Scales* Desirability 7-6-5-4-3-2-1	Importance 7-6-5-4-3-2-1	Validity 7-6-5-4-3-2-1
II. E. 5. Radiation effects result from absorption of lost energy by living tissue.			
F. A layperson should be able to evaluate techniques for measuring radiation.			
1. Units of measurement (rad, roentgen, rem, etc.) have been devised especially for the quantification of radiation.			
2. Measurements of radiation are made by special kinds of instruments.			
3. Some instruments measure radiation (radiation dosimeters) in biological materials, while other instruments detect radiation (radiation detectors).			
4. Types of radiation dosimeters include film badges and pocket chambers.			
5. Some types of radiation detectors are: scintillation detectors, Geiger-Mueller counters, proportional counters and ionization chambers.			
6. Radiation in not detectable by the human senses except in massive doses.			

Concepts—Behavioral Objectives—Content	Scales* Desirability 7-6-5-4-3-2-1	Importance 7-6-5-4-3-2-1	Validity 7-6-5-4-3-2-1

II. F. 7. The simplest radiation detection device is ordinary photographic film which darkens on exposure to radiation. It is used routinely in film badges for measuring the cumulative amount of exposure received by people who work with sources of radiation.

8. The photographic reactions with radiations from uranium led to the initial discovery of radioactivity in 1896.

G. A layperson <u>should be able to understand</u> the relationship between the kinds of radiation and the dose.

1. The dose of radiation required to produce a given effect (such as a mutation) depends upon the kind of radiation.

2. Relative biological effectiveness (RBE) is a factor used to compare the ability of different types of radiation to damage biological materials.

3. RBE for radiations are:

X-rays	1
Gamma rays	1
Beta particles	1

Concepts—Behavioral Objectives—Content	Scales* Desirability 7-6-5-4-3-2-1	Importance 7-6-5-4-3-2-1	Validity 7-6-5-4-3-2-1
II. G. 3. Fast neutrons 10 Thermal neutrons 4-5 Alpha particles 10-20			
4. The ability of biological material to absorb radiation is proportional to the effect produced.			
5. A measure of the ability of biological material to absorb ionizing radiation is called linear energy transfer (LET).			
6. LET is defined as the radiation energy lost per unit of path through a biological material.			
7. In general, the higher the LET value, the greater the relative biological effectiveness of the radiation in the material.			
8. The roentgen (R) is the unit of exposure related to the number of ion pairs produced in the air by x-rays and gamma rays.			
9. The rad (radiation absorbed dose) indicated the amount of all energy (not just ion parts) deposited in material by any type of radiation.			

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II. G.	10. The rad is a unit - one rad equals the energy required to raise the body temperature by two-millionths of a degree fahrenheit.			
	11. The rem (roentgen equivalent man) refers to the results of energy deposited tissue.			
	12. The rem is a measurable unit of biological dose that is the product of the amount and type of radiation. These products can be totalled to determine the total dose.			
	13. The most meaningful units for measuring radiation dose to humans are the rem and millirem (1/1000 of a rem, abbreviated mrem).			
	14. Americans receive on the average wholebody radiation dose of 200 rem per year depending on the elevation of our homes, type construction of our home, the amount of time we spend out of doors, what we eat, drink, and breath, how much television we watch, how many jet flights we take, the condition of our health (whether diagnostic therapautic medical or dental treatments are required) and how close we live to a nuclear plant.			

Concepts—Behavioral Objectives—Content	Scales* Desirability 7-6-5-4-3-2-1	Importance 7-6-5-4-3-2-1	Validity 7-6-5-4-3-2-1
II. G. 15. Federal standards require that average population exposures from all man-made non-medical sources be kept below 170 mrem per year and that individuals in the general population not receive more than 500 mrem per year.			
16. Occupational limits are set at 5 rem per year.			
H. A layman <u>should be able to apply</u> the knowledge of radiation effects in order to determine what happens at the primary site of interaction.			
1. The human body is made up of many compounds, which are composed of molecules.			
2. Examples of some of the compounds found in the human body are: water, carbon dioxide, proteins, carbohydrates, fats, and various salts (carbonates, sulfates, phosphates, etc.)			
3. A very large portion of the human body is water.			
4. Ionization is a process in which electrons are added or subtracted to atoms or molecules to change the electrical charge.			

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Concepts—Behavioral Objectives—Content	Scales* Desirability 7-6-5-4-3-2-1	Importance 7-6-5-4-3-2-1	Validity 7-6-5-4-3-2-1
II. H. 5. Ionizing radiation produces ionization and excitation (see No. 13 below).			
6. One of the primary effects of radiation on living tissue is ionization particularly of water.			
7. Water is composed of the elements of hydrogen and oxygen. A molecule of water is composed of two parts of hydrogen and one part of oxygen.			
8. Water is ionized to yield hydrogen (hydrogen atoms with a negative electric charge) and hydroxy radicals (a hydrogen atom coupled with an oxygen atom).			
9. When two hydroxyl radicals interact, a molecule of hydrogen peroxide is formed.			
10. Hydrogen peroxide is poisonous to the body.			
11. Radiation interacts with larger molecules in the body such as proteins to dissociate (break up) or to crossline (joining of parts of two different molecules to form a new molecule) them.			
12. Alteration of body chemistry is usually harmful and results in injuries.			
13. Nonionizing radiation such as some wavelength of			

Concepts—Behavioral Objectives—Content	Scales*		
	Desirability 7-6-5-4-3-2-1	Importance 7-6-5-4-3-2-1	Validity 7-6-5-4-3-2-1
II. H. (13) ultraviolet rays in cosmic radiation excites or makes unstable the molecules in the tissue through which it is passing.			
14. After becoming excited, a molecule will eventually settle back to its normal energy level, but to do this, it must lose the energy gained by excitation.			
15. In returning to stability, some molecules lose energy by giving off light (i.e., fluorescence).			
I. A layperson should support research on radiation effects and on radioactivity in order to advance human knowledge.			
1. Radiation effects studies have contributed significantly to all areas of biology, particularly in the understanding of cells, inheritance, and molecules. Examples are:			
a. immune reactions to tissue transplants			
b. mechanisms of mutation			
c. development of ecosystems			
2. Radioisotope tracers have unlocked many secrets of the body composition and function. Such studies			

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II. I. 2. have included investigation of:

a. quantities of trace elements in tissues.
b. metabolism of elements and compounds

3. A greater understanding of the human body promotes better health.

III. There are methods by which harmful radiation effects may be prevented or treated.

A. A layperson <u>should know the methods</u> used in preventing exposure to radiation.

1. Exposure to radiation may be modified by chemical, physical and biological means.

2. Physical protection against exposure to radiation aims at preventing radiation from reaching man or objects in his environment.

3. Among methods for physical protection against radiation are: shielding with materials such as lead; creams for preventing exposure of the skin; and protective clothing.

Concepts—Behavioral Objectives—Content	Scales* Desirability 7-6-5-4-3-2-1	Importance 7-6-5-4-3-2-1	Validity 7-6-5-4-3-2-1
III. A. 4. Chemical methods of protection against radiation are based primarily on attempts to prevent or correct harmful chemical reactions in the body that are produced by radiation. These include a variety of drugs administered either prior to or following exposure. Among the more effective drugs for preventing radiation sickness in animals are composed of organic sulfur compounds.			
5. Some biological factors that modify the results of radiation exposure include: age, sex, state of nutrition, and general state of health.			
6. Biochemicals such as hormones and vitamins appear to be helpful in protection against radiation.			
B. A layperson should be able to predict the emotional and social aspects of confinement in fallout shelters.			
1. Psychological and sociological aspects of confinement for extended periods of time have been studied under real and simulated conditions.			
2. Civil defense planning has encompassed many areas of human existence in postattack environments, such as: (a) food and water supplies; (b) land usage;			

Concepts—Behavioral Objectives—Content	Scales* Desirability 7-6-5-4-3-2-1	Importance 7-6-5-4-3-2-1	Validity 7-6-5-4-3-2-1
III. B. 2. (c) agriculture; (d) transportation; (e) medical supplies; (f) utilization of medical personnel; (g) government; (h) economics; (i) population dynamics.			
3. Fallout shelters no longer figure in U.S. plans.			
C. A layperson <u>should know the methods</u> used for treating persons exposed to radiation.			
1. Radiation damage in the human body is repaired by medical techniques and by normal body processes.			
2. The treatment of radiation injuries depends upon the dose received.			
3. As specific symptoms develop in a person that has been exposed, appropriate treatment is administered.			
4. There are no special ways for treating radiation sickness.			
5. Treatment often consists of a combination of therapeutic techniques such as bone marrow and blood transfusions, antibiotics, hormones, vitamins, and therapy for conventional burns.			

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	Desirability 7-6-5-4-3-2-1	Importance 7-6-5-4-3-2-1	Validity 7-6-5-4-3-2-1

III. D. A layperson should be able to select from a list of occupations those in which exposure to radiation could be a hazard if safety guidelines are not followed.

1. The following groups may be exposed to radiation as a result of their occupations: (a) radar personnel; (b) microwave personnel; (c) radioisotope processors; (d) producers of radiopharmaceuticals; (e) radiologists; (f) x-ray technicians; (g) nurses and supporting personnel at hospitals; (h) reactor personnel; (i) military personnel associated with nuclear vessels; (j) luminous dial painters; (k) uranium ore miners; (l) personnel in uranium processing.

2. Nuclear industries have excellent safety records.

3. Nuclear industries follow the standards set for maximum permissible dose to personnel.

4. The confidence of people living near reactors in the safety of power reactors would be reinforced if they were involved in some of the planning.

5. Stringent enforcement of the governmental regulations must take place to assure persons living near a nuclear power plant.

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III. D. 6. With appropriate protection features, training of users, and carefully designed equipment, radioactive materials can be handled safely.			
E. A layperson <u>should be able to evaluate</u> legislation and standards for protection against radiation.			
1. The Federal Government (NRC, DOE & EPA) has standards for the use of large quantities of radio-isotopes, including regulations for waste disposal.			
2. A number of states have established regulatory agencies for the control of radiation and radio-activity.			
3. Many states conducted surveys in recent years that have yielded recommendations for the safe operation of x-ray equipment by doctors, dentists, etc.			
4. Standards have been set by the International Council for Radiation Protection to control the radiation dose allowable to persons under various conditions of exposure.			

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	Desirability 7-6-5-4-3-2-1	Importance 7-6-5-4-3-2-1	Validity 7-6-5-4-3-2-1
III. E. 5. Standards and regulations for the control of radiation exposure are regularly revised to reflect new findings on radiation injuries in relation to dose.			
6. More research funds should be allocated for radiation health programs.			
7. Basic nuclear research is a good investment for the Federal Government as is basic research in all sciences.			
8. Nuclear research and development expenditures by the Federal Government are necessary to develop a safe useful nuclear operation for future energy production.			
9. Laypersons should question the construction of nuclear power plants to emphasize that care be used in assuring that harmful products will not be released in excessive quantities and that control be available.			
F. A layperson should be aware that drugs exist which have the potential to protect man against radiation.			

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Concepts—Behavioral Objectives—Content	Scales* Desirability 7-6-5-4-3-2-1	Importance 7-6-5-4-3-2-1	Validity 7-6-5-4-3-2-1
III. F. 1. Drugs have been perfected that increase survival of laboratory animals exposed to lethal doses of radiation.			
2. Other drugs have been developed to remove radioisotope contamination from the bodies of animals.			
3. Drugs protect animals against ionizing radiation by: (a) removing free radicals; (b) reducing the oxygen content of the body; (c) chemical binding with disulfides found outside the cells; (d) increasing basic radioresistance.			
4. Agents such as oxygen may be used to increase the radiosensitivity of cancer cells, thereby increasing the effectiveness of radiotherapy.			
IV. Radiation influences the lives of man through its interaction with the environment.			
A. A layperson understands and suggests ways in which radiation affects the environment in which man lives.			
1. Radioactivity in the environment arises from two sources: artificial sources and background radiation.			

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IV. A. 2. Artificial sources of radioactivity are man-made and include: fallout from nuclear explosions, disposal of radioactive wastes by industry, and dispersion of radioactivity by peaceful application of nuclear energy.			
3. Natural background radiation is that present in the environment as a result of cosmic radiation and/or the presence of radiation materials in a natural form such as sands.			
a. Levels of cosmic radiation are dependent upon geographical location and altitude.			
b. Areas have been found on the earth where igneous formations such as lava flows and monazite sands contribute to unusually high levels of radiation. Two such areas are in Brazil and India.			
B. A layperson should know that the contamination of food can be due to fallout.			
1. The main source of radioactive contamination of foodstuffs is fallout.			

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IV. B. 2.	Radioisotope contamination of food by biologically-important nuclides is hazardous to man.			
3.	Biologically-important radionuclides are those that are accumulated in certain areas of plants and animals as a result of metabolic processes.			
4.	Some of the important radioisotopes contaminating foodstuffs are iodine-131, cesium-137, and strontium-90.			
5.	Radioisotopes are transferred from water, the atmosphere, or soils to items in the human diet via food chains. An example of such a transfer is the transport of cesium-137 from soils and/or water to man via lichens and mosses, which are foods of reindeer and caribou, then to man via meat of these animals.			
6.	Fallout travels thousands of miles while airborne.			
7.	If a major reactor accident were to occur, then foodstuffs will be contaminated, but under certain conditions many can be decontaminated.			

Concepts—Behavioral Objectives—Content	Scales*		
	Desirability 7-6-5-4-3-2-1	Importance 7-6-5-4-3-2-1	Validity 7-6-5-4-3-2-1
IV. C. A layperson should be able to hypothesize ways of controlling fallout contamination of foodstuffs.			
1. Plants become contaminated by fallout via the atmosphere, water, or soil.			
2. Animals are contaminated by fallout internally via ingestion or inhalation.			
3. Owing to variation in metabolic processes, different species of plants and animals will vary in the kind and amount of radioisotopes that will be retained.			
4. Distribution and concentration of the radioactivity from fallout will vary significantly in different tissues of plants and animals. Therefore, it is possible to choose foods with low levels of radioactive contamination.			
5. Crop rotation may be used to control the radioactivity of foodstuffs growing on contaminated soils.			
6. Removal of radioactive contamination from foodstuffs may be achieved by chemical and physical			

Concepts—Behavioral Objectives—Content	Scales* Desirability 7-6-5-4-3-2-1	Importance 7-6-5-4-3-2-1	Validity 7-6-5-4-3-2-1
IV. C. 6. methods. For example, cooking reduces the levels of contamination in some foods. The chemical process of ion exchange may be used to remove strontium-90 from milk, and pilot plants have been designed for the large-scale processing of contaminated milk by such methods.			
7. Packaging offers protection from some fallout components.			
8. Normal radioactive decay of isotopes will reduce contamination levels in foodstuffs.			
9. Weapons fallout control measures can be applied equally successfully to the control of contamination from airborne releases from nuclear power reactor accidents.			
D. A layperson should be able to compare the relative contribution of various sources of radioactive contamination to the atmosphere.			
1. The primary sources of radioactive contamination of the atmosphere is fallout.			
2. Disposal of radioactive materials by radiochemi-			

Concepts—Behavioral Objectives—Content	Scales* Desirability 7-6-5-4-3-2-1	Importance 7-6-5-4-3-2-1	Validity 7-6-5-4-3-2-1

IV. D. 2. cal processing plants and reactors adds small quantities of radioactivity to the atmosphere. Monitoring programs at such sites assure that radioactive contamination of the atmosphere from such sources is within recommended limits, well below that considered hazardous to man.

3. Pollution of the atmosphere by natural background radiation is negligible.

4. In the sense of perspective, this is a very important concept and laypersons should have the information.

E. A layperson should be able to understand legislation for controlling radioactive pollution of the atmosphere and for controlling the distribution of irradiated foodstuffs.

1. State and federal agencies establish and enforce regulation for the control of atmospheric pollution by radioactivity from industrial sources.

2. Regulations for radiation protection are generally based on extrapolation from experimental animal data, and are directed toward providing guidelines for human exposure that will prevent the development of radiation injuries.

Concepts—Behavioral Objectives—Content	Scales*		
	Desirability 7-6-5-4-3-2-1	Importance 7-6-5-4-3-2-1	Validity 7-6-5-4-3-2-1
IV. E. 3. The Federal Drug Administration approves foods for perservation by radiation.			
F. A layperson <u>should be able to integrate</u> information of effects of radiation on living tissue with the use of radiation to sterilize and preserve food and drugs.			
1. Spoilage of foods and drugs is attributed to the activity of microorganisms (chiefly bacteria and fungi).			
2. Microorganisms interact with foods to decompose them, producing obnoxious odors, peculiar flavors, and discoloration.			
3. Radiation in sufficient doses will kill micro-organisms.			
4. Radiosterilization of foods is the process of killing all microorganisms on or in the food. Providing that package is done immediately and under sterile conditions, foods such as bacon may be kept without refrigeration for long periods of time.			
5. Many of the food studies are aimed toward			

	Concepts—Behavioral Objectives—Content	Scales* Desirability 7-6-5-4-3-2-1	Importance 7-6-5-4-3-2-1	Validity 7-6-5-4-3-2-1
IV. F. 5.	extension of shelf-life by treating the foods with radiation doses that will control the harmful populations. This process is known as radio-preservation or radio-sterilization.			
6.	Some foods of plant origin are treated by radiation for the purpose of sprout inhibition (e.g., potatoes and onions).			
7.	Among foods that have been evaluated for the effectiveness of radiation processing are: bacon, clams, shrimp fruits, and a few vegetables.			
8.	Acceptance studies have been carried out among groups of persons that have consumed foods preserved by irradiation.			
9.	Consumption of products that have been radioactively sterilized does not make the use of such materials radioactive. (42046301)			
10.	Some benefits to agriculture from nuclear energy are: (a) tracing fertilizer action; (b) plant growth studies; (c) cattle feeding studies; (d) sterilization of male screwworm flies. (43045701 & ORGDP RIP)			

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IV. G. A layperson should be able to apply knowledge of radiation effects toward the control of environmental pests.			
1. Radiation impairs the reproductive capacity of animals.			
2. The screwworm fly, a pest of domestic animals, was eradicated by the sterile-male technique. The reproductive capacity of male screwworm flies was eliminated by exposure of males to massive, but sublethal doses of gamma radiation. In a short time after the sterilized males were released, the screwworm fly population disappeared.			
3. Radioactive tracers have been placed to elucidate the life cycle of Anopheles mosquitos, a host for the malaria pathogen. Knowledge of the life cycle and behavorial patterns of the Anepheles mosquitos has led to improved techniques for control.			
H. Laymen should be able to recognize that utility choices between coal and nuclear power should be based on market considerations. (NIPC -29)			
1. There presently exists a regulatory framework that deals adequately with social costs external to the industry.			

Concepts—Behavioral Objectives—Content	Scales*		
	Desirability 7-6-5-4-3-2-1	Importance 7-6-5-4-3-2-1	Validity 7-6-5-4-3-2-1
IV. H. 2. Special security implications of nuclear power demand continued close government control.			
3. Special security implications require government participation in the critical stages of the nuclear fuel cycle.			
4. A significant decision yet to be made by government is whether to introduce plutonium into the nuclear fuel cycle.			
5. The United States must greatly improve the management of its rapidly growing accumulation of nuclear wastes and develop a strategy for its disposal.			
I. Laymen should know pertinent facts about the inevitable risks to human health resulting from the use of nuclear power to generate electricity.			
1. The assessment of nuclear power health risks involves analysis of occupational accident rates, radiation exposures for workers and populations under normal operating conditions, and the probabilities or consequences on public health from reactor accidents.			
2. Radioactivity is encountered at most stages of the nuclear fuel cycle.			

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IV. I. 3.	Small quantities of radiation are normally released at each stage.			
4.	Worker exposures may range as high as 50 times normal background levels.			
5.	Population dose rates are extremely small fractions of normal background.			
6.	Such materials may become trapped in body tissues or remain in the environment for centuries, a continuing source of radiaton exposure.			
7.	While the rates of exposure may be small the cumulative effects of contemporary power generation may be larger when summed over many generations.			
8.	Efforts to reduce risks through better treatment of radiation sources such as mill tailings, improved siting policies and other measures should not await resolution of existing uncertainties.			
9.	The exposures of interest in assessing the risks of nuclear power range from fractions of a millirem, well below background in the case of normal emission, to a few rem in the case of occupational exposures			

Concepts—Behavioral Objectives—Content	Scales* Desirability 7-6-5-4-3-2-1	Importance 7-6-5-4-3-2-1	Validity 7-6-5-4-3-2-1
IV. I. 9. and to exposures of a few millirem to hundreds of rem in the event of an accident.			
10. Assessments of health effects from nuclear power are complicated by the fact that there has been relatively little operational experience. The data accumulated thus far have been derived from practices that are changing.			
J. Laymen should recognize that the mining portion is the primary locus of occupational hazard.			
1. Accidents in underground mining result in about 15 deaths per 10,000 miners.			
2. Miners are exposed to external radiation in mines and inhaled dust on which radon daughter decay products are absorbed.			
3. Radon daughters inhaled this way may become trapped in tissue in the lower respiratory tract, where they can be carcinogenic.			
4. Radon emissions during mining may also have a public health impact, however, the remote location of the mines indicate that population exposures are neglible.			

Concepts—Behavioral Objectives—Content	Scales* Desirability 7-6-5-4-3-2-1	Importance 7-6-5-4-3-2-1	Validity 7-6-5-4-3-2-1
IV. K. Laymen <u>should recognize</u> that milling operations are part of the nuclear fuel cycle.			
1. Occupational accidents in the milling of uranium are poorly documented but appear to be relatively low.			
2. Milling operations result in the creation of huge tailings piles near the mills and these piles continue radon-222 for many thousands of years and thereby become a prospective source of long term exposure.			
L. Laypersons <u>should recognize</u> the potential radiation health problems in the transportation, conversion, fabrication and reactor construction phases of the nuclear fuel cycle.			
1. Relatively small volumes of material are involved in nuclear power generation after the initial mining and milling operations.			
2. Levels of radioactivity present at these stages are small for the uranium fuel cycle.			
3. Projections concerning population dose is about 3 man-rem to the base per reactor year (indicating insignificant health effects).			

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IV. M. Laypersons <u>should recognize</u> that normal reactor operation presents no major health problems.			
1. During operation, radioactive gases and volatile radioiostopes migrate out of fuel through small cladding defects into the coolant. These effluent gases include iodine, xenon, and krypton are trapped and treated.			
2. It is estimated that approximately 500 curies of krypton 85 with a half life of 10.7 years is released annually per reactor (emitting beta and gamma rays) and dispersed worldwide. The health effects are radiation exposure to the skin.			
3. Another effluent is carbon 14 with a half-life of 5,730 years. The amount of reactor carbon 14 is minute compared to the 220 million curies in the atmosphere due to cosmic radiation and 6 million curies due to atmospheric weapons testing.			
4. Workers are exposed to these radiations during refueling and repair operations.			
5. The public receives on the order of 100 man-rem per reactor year.			

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IV. N. The layperson's major concern is how to react to major reactor accidents involving core melt and breach of containment.			
1. Should such an event occur, the dose in the immediate environs may be high enough to cause rapidly lethal radiation sickness, while the dose at greater distances diminishes ultimately to background levels as radioactivity is gradually diluted by dispersion, fallout and decay.			
2. The risks of early radiation sickness and death are estimated to be confined to the area with 10-15 miles of the reactor but depend heavily on the plume temperature, weather conditions, population density and speed of evacuation of the area.			
3. A major study estimates that such an accident could conceivably result in 10 latent cancer deaths per year but the estimates could be significantly reduced by a prudent site selection away from population centers.			
O. The public should be able to suggest ways for proper waste management and disposal.			

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IV. O. 1. Public and occupational doses resulting from waste management and disposal are often regarded as insignificant due in part to lack of experience with commercial waste management.			
2. It is possible that mill tailings as presently treated will be found to have longer health effects than other wastes disposed of in geological repositories.			
3. The health risks of waste management in 1977 before disposal are likely to depend on whether reprocessing and recycle occur.			
P. Reprocessing and recycling of waste is not, in 1977, a part of the fuel cycle but laypersons <u>should be aware</u> of the potential health problems.			
1. Reprocessing would involve the dissolution of spent fuels with a consequent liberation of gaseous and volatile radioisotopes and the separation of the uranium and plutonium from the other radioactive waste materials.			
2. Recycle of plutonium would introduce this material into the transportation and fuel fabrication segments of the fuel cycle.			

Sheet 43 of Second Questionnaire

Round Two—Evaluation

Concepts—Behavioral Objectives—Content	Scales* Desirability 7-6-5-4-3-2-1	Importance 7-6-5-4-3-2-1	Validity 7-6-5-4-3-2-1
IV. P. 3. Occupational hazards of reprocessing and recycle would be almost entirely radiological.			
4. Population exposures would be almost entirely due to carbon 14, krypton 85 and other materials presently being released under controlled conditions.			
5. Reprocessing and recycling would reduce the need for uranium mining and milling and thus potentially reduce occupational and public health consequences of these operations.			
6. According to a special report, plutonium plays essentially no role in occupational or public health effects from reprocessing and recycling.			
Q. The public should be able to respond to health risk facts concerning plutonium.			
1. Science knows more about the plutonium behavior in environmental and food chain pathways to men, its mode of uptake and translocation to various organs and its particular radiotoxic effects than the 1977 controversy might suggest.			
2. The health hazards of plutonium are special in that			

	Concepts—Behavioral Objectives—Content	Scales* Desirability 7-6-5-4-3-2-1	Importance 7-6-5-4-3-2-1	Validity 7-6-5-4-3-2-1
IV. Q. 2.	very long-lived energetic alpha emitters are involved.			
3.	The largest risk from plutonium is through inhalation of small particles which become lodged in the lower respiratory tract.			
4.	Plutonium in the lung can induce cancer; it can translocate with the same effects to other tissues through absorption and transport in the lymphatics and blood.			
5.	The translocation health consequences are expected to be largest in liver and bone.			
6.	Plutonium also concentrates to lesser degree in human gonads.			
7.	In the mid 1950's the International Commission on Radiological Protection and the National Counil on Radiation Protection and Measurements set standards for maximum permissible body burdens for plutonium and there is no evidence that these standards for exposures and body burdens of plutonium are grossly in error even though this conclusion rests primarily on animal experiments.			

Sheet 45 of Second Questionnaire

Round Two—Evaluation

Concepts—Behavioral Objectives—Content	Scales*		
	Desirability 7-6-5-4-3-2-1	Importance 7-6-5-4-3-2-1	Validity 7-6-5-4-3-2-1
IV. R. A layperson should be able to summarize the impact of radiation on the health of man.			
1. Radiation plays a dual role in the lives of man. Good influences far outweigh bad influences. Understanding the impact of radiation on man and his environment eliminates fear of the unknown, produces a deeper appreciation of the human organism, and creates a challenge for the future--individually and collectively.			
2. From the attached form entitled "Compute Your Own Radiation Dosage", record your own radiation dosage here _____ mrem.			

Panel Member No._____

Page 24 of 24

COMPUTE YOUR OWN RADIATION DOSAGE

We nave seen that radiation is all about us and is part of our natural environment. In this exercise you will get an idea of the amount you are exposed to every year. The unit of radiation used here is the millirem.

	Common Source of Radiation	Your Annual Inventory (mrem/year)
WHERE YOU LIVE	Location: Cosmic radiation at sea level	40
	Add 1 for every 100 feet of elevation where you live	____
	House construction: Wood 35 Concrete 50 Brick 75 Stone 70	____
	Ground (U.S. Average)	56
WHAT YOU EAT DRINK AND BREATHE	Water and food (U.S. Average)	25
	Air (U.S. Average)	5
HOW YOU LIVE	Jet Airplanes: Number of 6000 mile flights x 4	____
	Radium Dial Wrist Watch: Add 2	____
	Television Viewing:	
	Black and white: Number of hours per day x 1	____
	Color: Number of hours per day x 2	____
	X-ray Diagnosis and Treatment	
	Limb x-ray: 420	
	Chest x-ray: 150	
	Stomach x-ray: 350	
	Colon x-ray: 450	
	Head x-ray: 50	
	Spinal x-ray: 250	
	Gastrointestinal tract x-ray: 2000	
	Dental x-ray: 20	____

		Your Annual Inventory (mrem/year)
HOW CLOSE YOU LIVE TO A NUCLEAR PLANT	At Site Boundary: Number of hours per day x .2	____
	One Mile Away: Number of hours per day x 0.02	____
	Five Miles Away: Number of hours per day x 0.002	____
	TOTAL	____

Compare your dose to the U.S. Average of 200 mrem/year.

Panel Member No._____
New Page 25

DELPHI PARTICIPANT INFORMATION

Name:

Address:

Present Occupation (i.e., nurse, engineer, secretary, educator, industrialist, scientist, physician, student, etc.)

Trained for What Occupation (i.e., nurse, physician, educator, engineer, minister, etc.)

	Please Circle	
High School Graduate	Yes	No
College Graduate	Yes	No
Master's	Yes	No
Doctoral	Yes	No

I give permission to reveal my name to the other participants in this study.

Signed_____

Date_____

APPENDIX D

INTERIM REPORT—JULY 15, 1977

This appendix contains the results of Round One. It was mailed to all panel members, along with Round Two.

TO ALL BLACKMON DELPHI STUDY PARTICIPANTS

Interim Report
July 15, 1977

There are 90 persons serving as members of this panel. In addition to 9648 answers submitted by 72 respondents to Round One, an additional 650 comments were made about the questionnaire or about things members believed had been omitted. As a result of this overwhelming response, I have failed to maintain our proposed schedule—I am approximately six weeks behind. It is hoped that no one is being inconvenienced.

Your Round Two questionnaire is attached to this interim report. Please return Round Two by September 1, 1977. It is believed that the questionnaire and instruction sheet is self-explanatory.

Further, you will find the following items that are not to be returned to me as they are for your information:

1. Your original questionnaire. (For those of you who did not return Round One and if you cannot find your original, let me know as I have a few left.)

2. Table I—A tabular summary of the panels' opinions about each statement.

3. Table II—A tabular summary of the panels' evaluation of whether the content of a statement could be taught or learned by the general public.

4. Table III—Table III is a comparison of this panels' answers to certain questions with the answers of 1,200 students at the University of Texas in 1972.

Approximately one half of the statements coded 72-1 through 72-20 refer to radioactivity favorably and the rest are stated unfavorably. These twenty statements were developed and tested at the University of Texas by H. L. Crater, Jr. as part of his doctoral dissertation. The list of statements about the nuclear power industry, nuclear medicine, industrial applications of radioactivity nuclear scientists and the atom's history and future were believed to elicit one's belief on the topics and yield a quantitative indication of one's attitude.

It would be tempting to interpret the scores of members of this panel in absolute terms. That is, with a possible range of scores from 0 to 80 on the twenty statements, it would seem logical to assign the quality "neutral" to score of 40 and interpret all scores above that figure as indicative of positive attitudes of varying intensity and all scores below 40 as indicative of negative attitudes toward radioactivity. However, as Crater stated "Authorities in the field of attitude scale construction . . . caution that it is impossible to affix a neutral point along a summated rating scale. It was not the purpose of this questionnaire to secure such information, and I

have included Table III for your own review. It is to be noted that certain questions clearly antagonized some of you. It was not my intention to do so and I sincerely apologize for having done so. The same apology includes having created a sense of frustration on the part of some of you.

> One panel member stated that "I cannot understand why anyone would want to teach or have someone learn information as false as some of the information appeared to be." Another person obviously had serious disagreements with some of the statements and did not wish to state whether it was feasible to teach the information even though it was feasible.

One person wanted a restatement of the purpose of this study.

> The purpose of this study is an attempt to see if a panel of nuclear experts and nuclear laymen can exchange ideas through the Delphi Method in order to convert enough of this complex subject into language that laypersons can understand—be he a PhD Mathematician, or a garbage truck driver. At present, the layperson seems to be receiving understandable, though possibly distorted, information from certain public interest groups with very little understandable material from nuclear advocates. As stated in the introduction to Round One, the statements were chosen from documented sources to stimulate you as we approach this subject together—I believe that I have been successful thus far.

Please continue to provide feedback as we move forward, as this is the essence of the Delphi Technique. Thanks in advance for going the second mile. Honestly, your work becomes easier after this round.

Very truly yours,

J. T. Blackmon, Jr.

Attachments:

Round Two—Evaluation—To Be Returned to Blackmon
Round Two—Instruction Sheet—Do Not Return to Blackmon
Round Two—Scaling Table—Do Not Return to Blackmon
Round One—Individual Questionnaire—Do Not Return to Blackmon
Tables I, II, III—Do Not Return to Blackmon

TABLE I

SUMMARY OF OPINION OF ROUND ONE

Question Number	Total Number of Answers				
	A	TTA	No.	TTD	D
1	59	10	0	1	2
2	53	15	3	0	1
3	11	20	5	25	11
4	12	27	3	15	15
5	8	25	6	18	15
6	3	20	8	15	26
7	41	17	9	1	4
8	3	1	18	9	41
9	14	17	4	12	25
10	5	14	5	19	29
11	36	25	4	5	2
12	7	8	1	16	40
13	17	15	6	16	18
14	12	22	8	11	19
15	14	26	10	8	14
16	3	16	9	13	31
17	3	19	8	19	23
18	3	11	14	18	26
19	24	21	7	11	9
20	8	14	12	19	19
21	13	8	7	13	31
22	1	4	5	8	54
23	30	23	3	4	12
24	20	27	5	10	10
25	51	16	2	2	1
26	32	21	10	4	5
27	16	30	9	10	7
28	17	35	7	7	6
29	22	30	4	9	7
30	13	15	13	14	17
31	2	1	4	14	51
32	3	16	6	18	29
33	21	28	8	11	4
34	20	30	16	5	1
35	20	28	9	6	9
36	29	18	6	14	5
37	19	25	9	8	11
38	14	14	7	14	23
39	22	16	6	12	16
40	7	28	8	19	10
41	6	18	8	18	22
42	5	19	11	17	20
43	5	16	11	16	24
44	19	29	6	11	7
45	7	14	10	20	21
46	1	5	12	16	38
47	1	2	42	10	17
48	20	28	12	10	2
49	6	16	13	18	19
50	9	28	11	18	6
51	21	32	6	6	7
52	26	21	16	5	4
53	3	6	2	21	40
54	23	29	6	9	5
55	22	27	9	13	1
56	5	14	12	19	22
57	30	24	8	7	3
58	1	6	13	15	37
59	1	10	11	14	36
60	4	14	15	22	17
61	9	12	24	8	19
62	31	19	8	11	3
63	0	2	5	22	43
64	45	19	5	2	1
65	46	20	2	2	2
66	4	8	6	23	31
67	2	6	3	16	45

TABLE II

SUMMARY OF FEASIBILITY OF TEACHING PORTION OF ROUND ONE

Question Number	Total Number of Answers				
	HF	L	NC	UBP	NF
1	48	18	3	2	1
2	34	24	7	6	1
3	11	15	5	29	12
4	12	20	4	24	12
5	8	17	6	27	14
6	1	15	6	19	31
7	25	34	6	5	2
8	10	32	6	8	16
9	25	27	11	3	6
10	22	29	5	8	8
11	20	34	3	12	3
12	18	25	6	9	14
13	10	21	4	23	14
14	13	15	7	23	14
15	8	22	5	23	14
16	4	16	8	18	26
17	4	13	9	21	25
18	3	11	13	16	29
19	8	31	3	18	12
20	5	29	8	19	11
21	8	28	6	14	16
22	13	24	6	12	17
23	24	34	6	5	3
24	11	38	5	16	2
25	29	30	5	7	1
26	16	28	7	15	6
27	9	27	4	23	9
28	16	34	5	12	5
29	8	16	4	35	9
30	5	14	10	26	17
31	4	32	9	16	11
32	8	36	10	11	7
33	10	38	5	16	3
34	14	35	9	12	2
35	14	33	9	9	7
36	19	34	4	11	4
37	12	27	5	17	11
38	9	14	8	26	15
39	11	25	9	17	10
40	3	25	8	21	15
41	1	15	8	26	22
42	2	15	12	20	23
43	3	21	6	20	22
44	10	25	5	23	9
45	3	21	10	26	12
46	6	27	12	15	12
47	0	9	30	20	13
48	9	40	7	12	4
49	9	29	12	20	2
50	5	31	8	19	9
51	7	34	8	18	5
52	13	28	10	18	3
53	10	32	7	15	8
54	9	41	5	14	3
55	8	26	12	22	4
56	7	20	14	22	9
57	10	39	6	14	3
58	7	22	14	17	12
59	5	26	12	18	11
60	8	31	15	13	5
61	16	26	20	7	3
62	14	36	10	10	2
63	9	31	9	14	9
64	22	41	5	4	0
65	32	33	5	1	1
66	13	33	5	14	7
67	9	29	7	16	11

TABLE III

ATTITUDE TOWARD RADIOACTIVITY SCALE COMPARISON OF DELPHI PANEL TO UNIVERSITY OF TEXAS STUDY

Delphi Statement Number	Texas Statement Number	Cognitive Measure of A Belief Concerning Radioactivity	Affective Measure of A Belief Concerning Radioactivity	Behavioral Measure of A Belief Concerning Radioactivity	Percent Responses to Radioactivity Scale Agree	Tend to Agree	Neutral	Tend to Disagree	Disagree	Year
7	10	Yes	--	--	12	27	30	18	12	1972
					57	24	13	1	6	1977
8	13	--	--	Yes	1	6	45	32	16	1972
					4	1	25	13	57	1977
20	19	Yes	--	Yes	10	38	27	17	8	1972
					11	19	17	26	26	1977
31	4		--	Yes	3	7	11	43	35	1972
					3	1	6	19	71	1977
32	7	--	--	Yes	14	35	15	28	7	1972
					4	22	8	25	40	1977
33	8	Yes	--	--	7	34	24	27	8	1972
					29	39	11	15	6	1977
34	15	--	--	Yes	11	52	25	10	2	1972
					28	42	22	7	1	1977
45	2	--	--	Yes	21	44	19	11	4	1972
					10	10	14	28	29	1977
46	3	Yes	--	--	4	15	29	33	19	1972
					1	7	17	22	53	1977
47	5	--	Yes	--	2	6	25	43	35	1972
					1	3	58	14	24	1977
48	11	Yes	--	--	17	40	25	14	3	1972
					28	39	17	14	3	1977
49	14	Yes	--	--	9	40	27	20	4	1972
					8	22	18	25	26	1977
50	18	Yes	--	--	11	42	22	20	6	1972
					13	39	15	25	8	1977
51	20	--	Yes	--	10	38	27	17	8	1972
					29	44	8	8	10	1977
54	1	--	Yes	--	8	40	13	31	8	1972
					32	40	8	13	7	1977
55	6	Yes	--	--	6	33	32	26	3	1972
					31	38	13	18	1	1977
56	9	--	Yes	--	7	33	29	23	8	1972
					7	19	17	26	31	1977
57	12	--	--	Yes	25	44	21	7	2	1972
					42	33	11	10	4	1977
58	16	--	Yes	--	4	23	38	25	10	1972
					1	8	18	21	51	1977
59	17	--	Yes	--	8	28	29	27	8	1972
					1	14	15	19	50	1977

APPENDIX E

INTERIM REPORT II—JANUARY 3, 1978

This appendix contains the results of Round Two. It was mailed to all panel members along with Round Three.

TO ALL BLACKMON DELPHI PARTICIPANTS

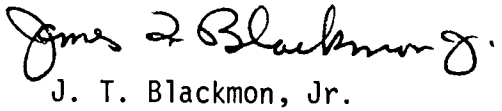
INTERIM REPORT II

January 3, 1978

I wish to take this opportunity to wish each of you a very happy and prosperous New Year, and to thank those of you who have so diligently answered these very lengthy questionnaires. Several of you have critized, and in some cases rightly, such things as sentence construction, the verbs used, the spelling and punctuation. It is to be further noted that those of you who are specialists in some facet of radiation find some of the statements in the questionnaire simplistic. Others of you who are not specialists and have stated that the only thing you know about radiation is what you have read in the papers find the questionnaire statements very difficult. The last two statements above are the rationale for this study. Is it possible through third parties for identified specialists in a specific field to share information in a meaningful way with interested persons who have little knowledge of the details of that specific field? Round II was the result of your expanding the 57 statements in Round One. The scaling system is a modified methodology used in psychometric studies that try to judge beliefs and attitudes.

As you can see we have a rather complex study utilizing an important highly specialized technical subject; however, the end is in sight and I beseech you to please go one more round.

Very truly yours,



J. T. Blackmon, Jr.

JTB,jr./gf

Attachments:

Each participants Round II - to be returned to Blackmon.
Round III Instruction Sheet - not to be returned.
Round II Scores - not to be returned.

ROUND THREE - A CHANCE TO CHANGE

INSTRUCTIONS

Attached is your original copy of Round Two entitled Evaluation and a summary of the mean scores of all participants. Note: Some participants without any knowledge concerning a specific statement scored with a specific number. These numbers as well as the unanswered statement were not included in the computed averages.

Please compare each of the answers with your answer. If your answer varies by +1 or -1 you may wish to change your answer, (i.e., The mean for statement II.D.2 = 4.5. If your answer was 3.5 or less or if your answer was 5.5 or greater, you may wish to change. There is no criteria that says you have to, nor will you have to state why you do not wish to change as is the usual practice in a Dephi Study).

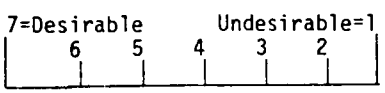
Return your questionnaire by February 15th 1978. Those of you who did not return Round II should do so now if you still have your copy.

A copy of the scaling table is printedon the back of these instructions to refresh your memory.

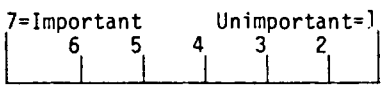
Please note a new page 25 has been added to your questionnaire.

SCALE VALUE TABLE FOR ROUND TWO

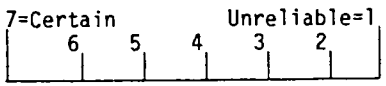
THE FOLLOWING VALUES TO BE USED IN RATING STATEMENTS IN QUESTIONNAIRE



Desirability (Effectiveness or Benefits to be Gained by Having Laypersons Know This Information)	
Desirable	Will have a positive effect and little or no negative effect
7	justifiable on its own merit
Undesirable	Will have a major effect
1	not justifiable



Importance (Priority or Relevance of Having a Layperson Understanding This Information	
Important	a most relevant point
	first order priority
7	has direct bearing on major
	should be resolved, dealt with, or treated
Unimportant	no priority
	no relevance
1	no measurable effect
	should be dropped as an item to consider



My Confidence in Validity of the Information in the Statement	
Certain	low risk of being wrong
	decision based upon this will not be wrong because of this "fact"
7	most influences drawns from this will be true
Unreliable	substantial risk of being wrong
1	not willing to make a decision based on this alone
	many incorrect inferences can be drawn

SUMMARY OF MEAN SCORES

I. Desirability - 6.7
I. Importance - 6.6
I.A. Desirability - 6.7
I.A. Importance - 6.6
I.A.1 - 6.7
I.A.2 - 3.1
I.A.3 - 5.3
I.A.4 - 4.3
I.A.5 - 5.7
I.A.6 - 6.7
I.A.7 - 5.5

I.B. Desirability - 6.2
I.B. Importance - 6.1
I.B.1 - 5.6
I.B.2 - 6.3
I.B.3 - 6.1
I.B.4 - 5.4

I.C. Desirability - 5.4
I.C. Importance - 5.3
I.C.1 - 6.0
I.C.2 - 5.2
I.C.3 - 3.8
I.C.4 - 5.4

I.D. Desirability - 5.8
I.D. Importance - 5.7
I.D.1 - 5.6
I.D.2 - 6.0
I.D.3 - 5.0
I.D.4 - 4.2
I.D.5 - 6.3
I.D.6 - 6.7

I.E. Desirability - 5.1
I.E. Importance - 4.9
I.E.1 - 5.6
I.E.2 - 5.1
I.E.3 - 5.0
I.E.4 - 5.4
I.E.5 - 6.3
I.E.6 - 4.9

I.F. Desirability - 4.8
I.F. Importance - 4.5
I.F.1 - 5.9
I.F.2 - 5.2
I.F.3 - 5.8
I.F.4 - 4.2
I.F.5 - 3.0

II. Desirability - 6.7
II. Importance - 6.1
II.A. Desirability - 5.7
II.A. Importance - 6.7
II.A.1 - 5.1
II.A.2 - 5.4
II.A.3 - 4.9
II.A.4 - 5.3

II.B. Desirability - 4.9
II.B. Importance - 4.8
II.B.1 - 6.3
II.B.2 - 5.4
II.B.3 - 6.0
II.B.4 - 5.3
II.B.5 - 7.2
II.B.6 - 5.2
II.B.7 - 5.1
II.B.8 - 4.8

II.C. Desirability - 4.3
II.C. Importance - 3.9
II.C.1 - 4.9
II.C.2 - 5.2
II.C.3 - 5.0
II.C.4 - 4.6
II.C.5 - 4.4
II.C.6 - 5.5
II.C.7 - 4.2
II.C.8 - 3.9
II.C.9 - 4.0

II.D. Desirability - 4.3
II.D. Importance - 4.6
II.D.1 - 4.3
II.D.2 - 4.5
II.D.3 - 4.4
II.D.4 - 4.0
II.D.5 - 3.8
II.D.6 - 3.4
II.D.7 - 3.7
II.D.8 - 3.8

II.E. Desirability - 4.6
II.E. Importance - 4.2
II.E.1 - 4.2
II.E.2 - 4.8
II.E.3 - 4.8
II.E.4 - 4.7
II.E.5 - 5.8

II.F. Desirability - 4.0
II.F. Importance - 3.7
II.F.1 - 5.8
II.F.2 - 5.9
II.F.3 - 5.5
II.F.4 - 5.6
II.F.5 - 5.7
II.F.6 - 5.2
II.F.7 - 5.7
II.F.8 - 5.2

II.G. Desirability - 4.4
II.G. Importance - 5.8
II.G.1 - 5.6
II.G.2 - 5.3
II.G.3 - 3.9
II.G.4 - 5.4
II.G.5 - 4.5
II.G.6 - 4.7
II.G.7 - 4.6
II.G.8 - 4.9
II.G.9 - 4.4
II.G.10 - 3.5
II.G.11 - 4.5
II.G.12 - 4.4
II.G.13 - 4.7
II.G.14 - 4.5
II.G.15 - 4.3
II.G.16 - 4.4

II.H. Desirability - 3.9
II.H. Importance - 3.7
II.H.1 - 6.2
II.H.2 - 6.3
II.H.3 - 6.6
II.H.4 - 5.1
II.H.5 - 4.4
II.H.6 - 4.5
II.H.7 - 6.5
II.H.8 - 4.7
II.H.9 - 4.7
II.H.10 - 4.4
II.H.11 - 4.4
II.H.12 - 5.0
II.H.13 - 4.6
II.H.14 - 4.8
II.H.15 - 4.7

II.I. Desirability - 5.9
II.I. Importance - 5.6
II.I.1 - 5.4
II.I.2 - 5.6
II.I.3 - 6.1

III. Desirability - 6.6
III. Importance - 6.1
III.A. Desirability - 5.6
III.A. Importance - 6.0
III.A.1 - 5.6
III.A.2 - 6.3
III.A.3 - 6.3
III.A.4 - 4.4
III.A.5 - 3.4
III.A.6 - 3.8

III.B. Desirability - 5.1
III.B. Importance - 5.0
III.B.1 - 5.5
III.B.2 - 5.5
III.B.3 - 4.0

III.C. Desirability - 3.8
III.C. Importance - 3.9
III.C.1 - 5.0
III.C.2 - 5.9
III.C.3 - 4.8
III.C.4 - 3.0
III.C.5 - 5.2

III.D. Desirability - 6.6
III.D. Importance - 5.3
III.D.1 - 6.2
III.D.2 - 5.7
III.D.3 - 5.6
III.D.4 - 5.1
III.D.5 - 6.0
III.D.6 - 6.1

III.E. Desirability - 5.0
III.E. Importance - 5.0
III.E.1 - 6.0
III.E.2 - 5.5
III.E.3 - 5.1
III.E.4 - 5.2
III.E.5 - 5.2
III.E.6 - 5.2
III.E.7 - 5.8
III.E.8 - 6.0
III.E.9 - 5.4

III.F. Desirability - 5.0
III.F. Importance - 5.1
III.F.1 - 4.2
III.F.2 - 4.2
III.F.3 - 3.7
III.F.4 - 3.9

IV. Desirability - 5.7
IV. Importance - 5.9
IV.A. Desirability - 5.3
IV.A. Importance - 4.9
IV.A.1 - 6.2
IV.A.2 - 5.9
IV.A.3 - 5.7

IV.B. Desirability - 5.2
IV.B. Importance - 5.0
IV.B.1 - 4.9
IV.B.2 - 4.3
IV.B.3 - 4.8
IV.B.4 - 5.2
IV.B.5 - 4.9
IV.B.6 - 6.1
IV.B.7 - 3.9

IV.C. Desirability - 4.3
IV.C. Importance - 4.4
IV.C.1 - 6.3
IV.C.2 - 5.9
IV.C.3 - 5.9
IV.C.4 - 4.9
IV.C.5 - 3.9
IV.C.6 - 3.8
IV.C.7 - 5.3
IV.C.8 - 4.6
IV.C.9 - 4.2

IV.D. Desirability - 4.9
IV.D. Importance - 5.0
IV.D.1 - 5.0
IV.D.2 - 5.2
IV.D.3 - 4.9
IV.D.4 - 5.5

IV.E. Desirability - 4.7
IV.E. Importance - 4.7
IV.E.1 - 5.9
IV.E.2 - 5.6
IV.E.3 - 4.5

IV.F. Desirability - 4.5
IV.F. Importance - 4.6
IV.F.1 - 5.9
IV.F.2 - 6.0
IV.F.3 - 5.8
IV.F.4 - 4.8
IV.F.5 - 5.1
IV.F.6 - 4.9
IV.F.7 - 4.4
IV.F.8 - 4.2
IV.F.9 - 4.1
IV.F.10 - 5.2

IV.G. Desirability - 4.3
IV.G. Importance - 4.4
IV.G.1 - 5.6
IV.G.2 - 4.6
IV.G.3 - 4.9

IV.H. Desirability - 4.6
IV.H. Importance - 4.4
IV.H.1 - 3.6
IV.H.2 - 5.8
IV.H.3 - 5.7
IV.H.4 - 5.5
IV.H.5 - 6.1

IV.I. Desirability - 5.8
IV.I. Importance - 5.7
IV.I.1 - 6.2
IV.I.2 - 5.0
IV.I.3 - 4.5
IV.I.4 - 3.9
IV.I.5 - 4.5
IV.I.6 - 4.5
IV.I.7 - 4.9
IV.I.8 - 5.5
IV.I.9 - 4.9
IV.I.10 - 4.8

IV.J. Desirability - 4.8
IV.J. Importance - 4.5
IV.J.1 - 4.2
IV.J.2 - 4.8
IV.J.3 - 5.1
IV.J.4 - 4.9

IV.K. Desirability - 5.1
IV.K. Importance - 4.6

(IV.K. cont'd)

IV.K.1 - 5.0
IV.K.2 - 4.4

IV.L. Desirability - 5.4
IV.L. Importance - 5.1
IV.L.1 - 5.4
IV.L.2 - 5.0
IV.L.3 - 4.3

IV.M. Desirability - 5.6
IV.M. Importance - 5.8
IV.M.1 - 4.7
IV.M.2 - 3.9
IV.M.3 - 4.7
IV.M.4 - 4.2
IV.M.5 - 3.7

IV.N. Desirability - 5.6
IV.N. Importance - 5.8
IV.N.1 - 6.4
IV.N.2 - 5.4
IV.N.3 - 4.7

IV.O. Desirability - 4.1
IV.O. Importance 4.2
IV.O.1 - 4.7
IV.O.2 - 5.7
IV.O.3 - 5.0

IV.P. Desirability - 5.3
IV.P. Importance - 5.7
IV.P.1 - 4.9
IV.P.2 - 5.2
IV.P.3 - 4.6
IV.P.4 - 3.6
IV.P.5 - 5.1
IV.P.6 - 4.1

IV.Q. Desirability - 5.5
IV.Q. Importance - 5.5
IV.Q.1 - 4.6
IV.Q.2 - 5.0
IV.Q.3 - 4.5
IV.Q.4 - 4.6
IV.Q.5 - 4.5
IV.Q.6 - 3.7
IV.Q.7 - 4.6

IV.R. Desirability - 5.6
IV.R. Importance - 5.4
IV.R.1 - 5.7
IV.R.2 - 574.

APPENDIX F

DELPHI PANEL ROSTER

This appendix contains a roster of persons who served on the panel by participant number, known profession, and place of residence.

DELPHI PANEL ROSTER

Participant Number	Known Profession	State
2	Health Educator	Virginia
4	Educator	Washington State
5	Health Educator	Illinois
6	Health Educator	Missouri
7	Health Educator	Virginia
9	Health Educator	Washington State
10	Health Educator	Arizona
11	Nurse	California
12	Nurse	North Carolina
13	Nursing Educator	Massachusetts
15	Nurse	Massachusetts
16	Nurse	Connecticut
18	Physician	Minnesota
20	Unknown	Missouri
21	Unknown	Tennessee
23	Civil Engineer	Montana
24	Parent Teachers Association	Tennessee
25	Unknown	Kentucky
26	Editor	District of Columbia
27	Government Manager	District of Columbia
30	Engineer	Tennessee
31	Engineer	South Carolina
32	Scientist-Educator	Kentucky
33	Administrator	Virginia
36	Economist	District of Columbia
37	Information Director	Tennessee
38	Computer Technology	Massachusetts
39	Association Official	Ohio
40	Engineer/Educator	Michigan

Participant Number	Known Profession	State
41	Engineer	Texas
42	Biologist	Tennessee
43	Unknown	Virgin Islands
44	Trade Association Official	District of Columbia
45	Trade Association Official	Colorado
47	Educator	Tennessee
48	Association Official	New York
49	Association Executive	Massachusetts
50	Engineer	Tennessee
51	Manufacturer	New Jersey
52	Association Executive	Illinois
53	Physician	South Carolina
54	Physician	New Jersey
55	Physician	Connecticut
56	Physician	Texas
57	Physician	New Mexico
58	Minister	North Carolina
60	Minister	Mississippi
61	Christian Education Director	Virginia
62	Physician	Massachusetts
63	Educator	Massachusetts
64	Physician	New York
65	Unknown	New York
67	Educator	Maryland
68	Engineer/Educator	District of Columbia
69	Clerk/Typist	Tennessee
70	Health Educator	North Carolina
71	Psychologist	California
72	Educator	Tennessee
73	Educator	Tennessee
74	Student	Florida

Participant Number	Known Profession	State
75	Engineer	California
76	Industrialist	Ohio
77	Retired Engineer	Florida
78	Chemist	Wisconsin
79	Engineer	New Mexico
81	Engineer	Illinois
82	Engineer	Tennessee
83	Fed. Gov. Administrator	Tennessee
84	Manager Trainee	Massachusetts
85	Secretary	Tennessee
86	Minister	Tennessee
88	Engineer	New Jersey
89	Economist	California
90	Nurse/Educator	New Mexico

VITA

James Thomas Blackmon, Jr., was born in Charlotte, North Carolina, in 1926. He attended elementary schools in Roanoke, Virginia, and graduated from Central High School in Charlotte, North Carolina, in 1943, entering the Navy from high school. He received a Bachelor of Science degree in Business Administration, a Master of Science degree in Safety Education, and Doctor of Education degree in Health Education from the University of Tennessee in 1973, 1975 and 1978, respectively. He has been employed by Union Carbide Corporation in Oak Ridge, Tennessee, since May 1952.

He is a registered professional engineer; Chairman of the National Fire Protection Association Committee on Ovens and Furnaces; a member of National Fire Protection Association Committee on Atomic Energy; a member of the Tennessee Society of Professional Engineers and the National Society of Professional Engineers; and a member of the Society of Fire Protection Engineers. He is also Chairman of the City of Oak Ridge Building Code Appeals Board.

He is married to the former Mary Alexa Brown of Gresham, South Carolina, and is the father of sons Michael Earl and Joseph Peter.