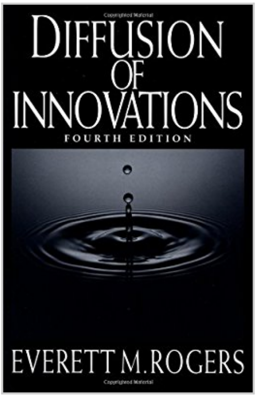

Diffusion of Innovations, Fourth Edition

By Everett M. Rogers

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Since the first edition of this landmark book was published in 1962, Everett Rogers's name has become "virtually synonymous with the study of diffusion of innovations", according to Choice. The second and third editions of Diffusion of Innovations became the standard textbook and reference on diffusion studies. Now, in the fourth edition, Rogers presents the culmination of more than thirty years of research that will set a new standard for analysis and inquiry.

The fourth edition is (1) a revision of the theoretical framework and the research evidence supporting this model of diffusion, and (2) a new intellectual venture, in that new concepts and new theoretical viewpoints are introduced. This edition differs from its predecessors in that it takes a much more critical stance in its review and synthesis of 5,000 diffusion publications. During the past thirty years or so, diffusion research has grown to be widely recognized, applied and admired, but it has also been subjected to both constructive and destructive criticism. This criticism is due in large part to the stereotyped and limited ways in which many diffusion scholars have defined the scope and method of their field of study. Rogers analyzes the limitations of previous diffusion studies, showing, for example, that the convergence model, by which participants create and share information to reach a mutual understanding, more accurately describes diffusion in most cases than the linear model.

Rogers provides an entirely new set of case examples, from the Balinese Water Temple to Nintendo videogames, that beautifully illustrate his expansive research, as well as a completely revised bibliography covering all relevant diffusion scholarship in the past decade. Most important, he discusses recent research and current topics, including social marketing, forecasting the rate of adoption, technology transfer, and more. This all-inclusive work will be essential reading for scholars and students in the fields of communications, marketing, geography, economic development, political science, sociology, and other related fields for generations to come.

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Editorial Review

Review
Technovation Will remain a classic on innovation for the next decade. -- *Review*

About the Author
Everett M. Rogers is professor and chair of the Department of Communication & Journalism at the University of New Mexico. A past president of the International Communications Association, he is the author of *A History of Communication Study* (Free Press, 1994), *Communication Technology* (Free Press, 1986), and several other widely acclaimed books and articles on communication and innovation.

Chapter 1

ELEMENTS OF DIFFUSION

There is nothing more difficult to plan, more doubtful of success, nor more dangerous to manage than the creation of a new order of things....Whenever his enemies have the ability to attack the innovator they do so with the passion of partisans, while the others defend him sluggishly, so that the innovator and his party alike are vulnerable.
Niccolò Machiavelli, *The Prince*

Getting a new idea adopted, even when it has obvious advantages, is often very difficult. Many innovations require a lengthy period, often of many years, from the time they become available to the time they are widely adopted. Therefore, a common problem for many individuals and organizations is how to speed up the rate of diffusion of an innovation.

The following case illustration provides insight into some common difficulties facing diffusion campaigns.

Water Boiling in a Peruvian Village: Diffusion That Failed

The public health service in Peru attempts to introduce innovations to villagers to improve their health and lengthen their lives. This change agency encourages people to install latrines, to burn garbage daily, to control house flies, to report cases of infectious diseases, and to boil drinking water. These innovations involve major changes in thinking and behavior for Peruvian villagers, who do not understand the relationship of sanitation to illness. Water boiling is an especially important health practice for villagers in Peru. Unless they boil their drinking water, patients who are cured of infectious diseases in village medical clinics often return within a month to be treated again for the same disease.

A two-year water boiling campaign conducted in Los Molinas, a peasant village of 200 families in the coastal region of Peru, persuaded only eleven housewives to boil water. From the viewpoint of the public health agency, the local health worker, Nelida, had a simple task: to persuade the housewives of Los Molinas to add water boiling to their pattern of daily behavior. Even with the aid of a medical doctor, who gave public talks on water boiling, and fifteen village housewives who were already boiling water before the campaign, Nelida's diffusion campaign failed. To understand why, we need to take a closer look at the culture, the local environment, and the individuals in Los Molinas.

Most residents of Los Molinas are peasants who work as field hands on local plantations. Water is carried by can, pail, gourd, or cask. The three sources of water in Los Molinas include a seasonal irrigation ditch dose to the village, a spring more than a mile away from the village, and a public well whose water most villagers dislike. All three sources are subject to pollution at all times and show contamination whenever tested. Of the three sources, the irrigation ditch is the most commonly used. It is closer to most homes, and the villagers like its taste.

Although it is not feasible for the village to install a sanitary water system, the incidence of typhoid and other water-borne diseases could be greatly reduced by boiling the water before it is consumed. During her two-year campaign in Los Molinas, Nelida made several visits to every home in the village but devoted especially intensive efforts to twenty-one families. She visited each of these selected families between fifteen and twenty-five times; eleven of these families now boil their water regularly.

What kinds of persons do these numbers represent? We describe three village housewives -- one who boils water to obey custom, one who was persuaded to boil water by the health worker, and one of the many who rejected the innovation -- in order to add further insight into the process of diffusion.

Mrs. A: Custom-Oriented Adopter. Mrs. A is about forty and suffers from a sinus infection. The Los Molinas villagers call her a "sickly one." Each morning, Mrs. A boils a potful of water and uses it throughout the day. She has no understanding of germ theory, as explained by Nelida; her motivation for water boiling is a complex local custom of "hot" and "cold" distinctions. The basic principle of this belief system is that all foods, liquids, medicines, and other objects are inherently hot or cold, quite apart from their actual temperature. In essence, hot-cold distinctions serve as a series of avoidances and approaches in such behavior as pregnancy, child-rearing, and the health-illness system.

Boiled water and illness are closely linked in the norms of Los Molinas; by custom, only the ill use cooked, or "hot" water. Once an individual becomes ill, it is unthinkable to eat pork (very cold) or drink brandy (very hot). Extremes of hot and cold must be avoided by the sick; therefore, raw water, which is perceived to be very cold, must be boiled to make it appropriate to consume.

Villagers learn from early childhood to dislike boiled water. Most can tolerate cooked water only if a flavoring, such as sugar, cinnamon, lemon, or herbs, is added. Mrs. A likes a dash of cinnamon in her drinking water. The village belief system involves no notion of bacteriorological contamination of water. By tradition, boiling is aimed at eliminating the "cold" quality of unboiled water, not the harmful bacteria. Mrs. A drinks boiled water in obedience to local norms, because she perceives herself as ill.

Mrs. B: Persuaded Adopter. The B family came to Los Molinas a generation ago, but they are still strongly oriented toward their birthplace in the Andes Mountains. Mrs. B worries about lowland diseases that she feels infest the village. It is partly because of this anxiety that the change agent, Nelida, was able to convince Mrs. B to boil water.

Nelida is a friendly authority to Mrs. B (rather than a "dirt inspector" as she is seen by other housewives), who imparts useful knowledge and brings protection. Mrs. B not only boils water but also has installed a latrine and has sent her youngest child to the health center for a checkup.

Mrs. B is marked as an outsider in the community of Los Molinas by her highland hairdo and stumbling Spanish. She will never achieve more than marginal social acceptance in the village. Because the community is not an important reference group to her, Mrs. B deviates from village norms on health innovations. With nothing to lose socially, Mrs. B gains in personal security by heeding Nelida's advice. Mrs. B's practice of boiling water has no effect on her marginal status. She is grateful to Nelida for teaching her how to neutralize the danger of contaminated water, which she perceives as a lowland peril.

Mrs. C: Rejector. This housewife represents the majority of Los Molinas families who were not persuaded by the efforts of the change agents during their two-year water-boiling campaign. In spite of Nelida's repeated explanations, Mrs. C does not understand germ theory. How, she argues, can microbes survive in water that would drown people? Are they fish? If germs are so small that they cannot be seen or felt, how can they hurt a grown person? There are enough real threats in the world to worry about -- poverty and hunger -- without bothering about tiny animals one cannot see, hear, touch, or smell. Mrs. C's allegiance to traditional village norms is at odds with the boiling of water. A firm believer in the hot-cold superstition, she feels that only the sick must drink boiled water.

Why Did the Diffusion of Water Boiling Fail?

This intensive two-year campaign by a public health worker in a Peruvian village of 200 families, aimed at persuading housewives to boil drinking water, was largely unsuccessful. Nelida was able to encourage only about 5 percent of the population, eleven families, to adopt the innovation. The diffusion campaign in Los Molinas failed because of the cultural beliefs of the villagers. Local tradition links hot foods with illness. Boiling water makes water less "cold" and hence, appropriate only for the sick. But if a person is not ill, the individual is prohibited by village norms from drinking boiled water. Only individuals who are unintegrated into local networks risk defying community norms on water boiling. An important factor regarding the adoption rate of an innovation is its compatibility with the values, beliefs, and past experiences of individuals in the social system. Nelida and her superiors in the public health agency should have understood the hot-cold belief system, as it is found throughout Peru (and in most nations of Latin America, Africa, and Asia). Here is an example of an indigenous knowledge system that caused the failure of a development program.

Nelida's failure demonstrates the importance of interpersonal networks in the adoption and rejection of an innovation. Socially an outsider, Mrs. B was marginal to the Los Molinas community, although she had lived there for several years. Nelida was a more important referent for Mrs. B than were her neighbors, who shunned her. Anxious to secure social prestige from the higher-status Nelida, Mrs. B adopted water boiling, not because she understood the correct health reasons, but because she wanted to obtain Nelida's approval. Thus we see that the diffusion of innovations is a social process, as well as a technical matter.

Nelida worked with the wrong housewives if she wanted to launch a selfgenerating diffusion process in Los Molinas. She concentrated her efforts on village women like Mrs. A and Mrs. B. Unfortunately, they were perceived as a sickly one and a social outsider, and were not respected as social models of appropriate water-boiling behavior by the other women. The village opinion leaders, who could have activated local networks to spread the innovation, were ignored by Nelida.

How potential adopters view the change agent affects their willingness to adopt new ideas. In Los Molinas, Nelida was perceived differently by lowerand middle-status housewives. Most poor families saw the health worker as a "snooper" sent to Los Molinas to pry for dirt and to press already harassed housewives into keeping cleaner homes. Because the lower-status housewives had less free time, they were unlikely to talk with Nelida about water boiling. Their contacts outside the community were limited, and as a result, they saw the technically proficient Nelida with eyes bound by the social horizons and traditional beliefs of Los Molinas. They distrusted this outsider, whom they perceived as a social stranger. Nelida, who was middle class by Los Molinas standards, was able to secure more positive results from housewives whose socioeconomic level and cultural background were more similar to hers. This tendency for more effective communication to occur with those who are more similar to a change agent occurs in most diffusion campaigns.

Nelida was too "innovation-oriented" and not "client-oriented" enough. Unable to put herself in the role of the village housewives, her attempts at persuasion failed to reach her clients because the message was not suited to their needs. Nelida did not begin where the villagers were; instead she talked to them about germ theory, which they could not (and probably did not need to) understand. These are only some of the factors that produced the diffusion failure in Los Molinas. Once the remainder of the book has been read, it will be easier to understand the water-boiling case.

This ease illustration is based on Wellin (1955).

What Is Diffusion?

Diffusion is the process by which an innovation is communicated through certain channels over time among the members of a social system. It is a special type of communication, in that the messages are concerned with new ideas. *Communication* is a process in which participants create and share information with one another in order to reach a mutual understanding. This definition implies that communication is a process of convergence (or divergence) as two or more individuals exchange information in order to move toward each other (or apart) in the meanings that they give to certain events. We think of communication as a two-way process of convergence, rather than as a one-way, linear act in which one individual seeks to transfer a message to another in order to achieve certain effects (Rogers and Kincaid, 1981). A linear conception of human communication may accurately describe certain communication acts or events involved in diffusion, such as when a change agent seeks to persuade a client to adopt an innovation. But when we look at what came before such an event, and at what follows, we often realize that the event is only one part of a total process in which information is exchanged between the two individuals. For example, the client may come to the change agent with a problem, and the innovation is recommended as a possible solution to this need. The change agent-client interaction may continue through several cycles, as a process of information exchange.

So diffusion is a special type of communication, in which the messages are about a new idea. This newness of the idea in the message content gives diffusion its special character. The newness means that some degree of uncertainty is involved in diffusion.

Uncertainty is the degree to which a number of alternatives are perceived with respect to the occurrence of an event and the relative probability of these alternatives. Uncertainty implies a lack of predictability, of structure, of information. In fact, information is a means of reducing uncertainty. *Information* is a difference in matter-energy that affects uncertainty in a situation where a choice exists among a set of alternatives (Rogers and Kincaid, 1981, p. 64). By differences in matter-energy we mean inked letters on paper, sound waves traveling through the air, or an electrical current in a copper wire. Information can thus take many forms, as matter or energy. A technological innovation embodies information and thus reduces uncertainty about cause-effect relationships in problem-solving. For instance, adoption of residential solar panels for water heating reduces uncertainty about future increases in the cost of fuel.

Diffusion is a kind of *social change,* defined as the process by which alteration occurs in the structure and function of a social system. When new ideas are invented, diffused, and are adopted or rejected, leading to certain consequences, social change occurs. Of course, such change can happen in other ways, too, for example, through a political revolution, through a natural event like a drought or an earthquake, or by means of a government regulation.

Some authors restrict the term "diffusion" to the spontaneous, unplanned spread of new ideas, and use the concept of "dissemination" for diffusion that is directed and managed. In this book we use the word "diffusion" to include both the planned and the spontaneous spread of new ideas.

Controlling Scurvy in the British Navy: Innovations Do Not Sell Themselves

Many technologists believe that advantageous innovations will sell themselves, that the obvious benefits of a new idea will be widely realized by potential adopters, and that the innovation will therefore diffuse rapidly. Seldom is this the case. Most innovations, in fact, diffuse at a disappointingly slow rate.

Scurvy control illustrates how slowly an obviously beneficial innovation spreads (Mosteller, 1981). In the early days of long sea voyages, scurvy was a worse killer of sailors than warfare, accidents, and all other causes of death. For instance, of Vasco de Gama's crew of 160 men who sailed with him around the Cape of Good Hope in 1497, 100 died of scurvy. In 1601, an English sea captain, James Lancaster, conducted an experiment to evaluate the effectiveness of lemon juice in preventing scurvy. Captain Lancaster commanded four ships that sailed from England on a voyage to India; he served three teaspoonfuls of lemon juice every day to the sailors in one of his four ships. Most of these men stayed healthy. But on the other three ships, by the halfway point in the journey, 110 out of 278 sailors had died from scurvy. The three ships constituted Lancaster's "control group"; they were not given any lemon juice. So many of these sailors became sick that Lancaster had to transfer men from his "treatment" ship in order to staff the three other ships.

The results were so clear that one would expect the British Navy to adopt citrus juice for scurvy prevention on all its ships. But it was not until 1747, *about 150 years later,* that James Lind, a British Navy physician who knew of Lancaster's results, carried out another experiment on the *HMS Salisbury.* To each scurvy patient on this ship, Lind prescribed either two oranges and one lemon, or one of five other diets: A half-pint of sea water, six spoonfuls of vinegar, a quart of cider, nutmeg, or seventy-five drops of vitriol elixir. The scurvy patients who got the citrus fruits were cured in a few days, and were able to help Dr. Lind care for the other patients. Unfortunately, the supply of oranges and lemons was exhausted in six days.

Certainly, with this further solid evidence of the ability of citrus fruits to combat scurvy, one would expect the British Navy to adopt this technological innovation for all ship's crews on long sea voyages, and in fact, it did so. *But not until 1795, forty-eight years later.* Scurvy was immediately wiped out. And after only *seventy more years,* in 1865, the British Board of Trade adopted a similar policy, and eradicated scurvy in the merchant marine.

Why were the authorities so slow to adopt the idea of citrus for scurvy prevention? A clear explanation is not available, but other, competing remedies for scurvy were also being proposed, and each such cure had its champions. For example, Captain Cook's reports from his voyages in the Pacific did not provide support for curing scurvy with citrus fruits. Further, Dr. Lind was not a prominent figure in the field of naval medicine, and so his experimental findings did not get much attention in the British Navy. While scurvy prevention was generally resisted for years by the British Navy, other innovations like new ships and new guns were accepted readily. So the Admiralty did not resist all innovations.

This case illustration is based on Mosteller (1981).

Obviously more than just a beneficial innovation is necessary for its diffusion and adoption to occur. The reader may think that such slow diffusion could happen only in the distant past, before a scientific and experimental approach to evaluating innovations. We answer by calling the reader's attention to the contemporary case of the nondiffusion of the Dvorak typewriter keyboard.

Nondiffusion of the Dvorak Keyboard

Most of us who use a typewriter or who do word processing on a computer do not realize that our fingers tap out words on a keyboard that is called "QWERTY," named after the first six keys on the upper row of letters. The QWERTY keyboard is inefficient and awkward. This typewriter keyboard takes twice as long to learn as it should, and makes us work about twenty times harder than is necessary. But QWERTY has persisted since 1873, and today unsuspecting individuals are being taught to use the QWERTY keyboard, unaware that a much more efficient typewriter keyboard is available.

Where did QWERTY come from? Why does it continue to be used, instead of much more efficient alternative keyboard designs? QWERTY was invented by Christopher Latham Sholes, who designed this keyboard to slow down typists. In that day, the type-bars on a typewriter hung down in a sort of basket, and pivoted up to strike the paper; then they fell back in place by gravity. When two adjoining keys were struck rapidly in succession, they jammed. Sholes rearranged the keys on a typewriter keyboard to minimize such jamming; he "anti-engineered" the arrangement to make the most commonly used letter sequences awkward. By thus making it difficult for a typist to operate the machine, and slowing down typing speed, Sholes' QWERTY keyboard allowed these early typewriters to operate satisfactorily. His design was used in the manufacture of all typewriters. Early typewriter salesmen could impress customers by pecking out "TYPEWRITER" as all of the letters necessary to spell this word were found in one row of the QWERTYUIOP machine.

Prior to about 1900, most typists used the two-finger, hunt-and-peek system. Later, as touch typing became popular, dissatisfaction with the QWERTY typewriter began to grow. Typewriters became mechanically more efficient, and the QWERTY keyboard design was no longer necessary to prevent key jamming. The search for an improved design was led by Professor August Dvorak at the University of Washington, who in 1932 used time-and-motion studies to create a much more efficient keyboard arrangement. The Dvorak keyboard has the letters A,O,E,U,I,D,H,T,N, and S across the home row of the typewriter. Less frequently used letters were placed on the upper and lower rows of keys. About 70 percent of typing is done on the home row, 22 percent on the upper row, and 8 percent on the lower row. On the Dvorak keyboard, the amount of work assigned to each finger is proportionate to its skill and strength. Further, Professor Dvorak engineered his keyboard so that successive keystrokes fell on alternative hands; thus, while a finger on one hand is stroking a key, a finger on the other hand can be moving into position to hit the next key. Typing rhythm is thus facilitated; this hand alternation was achieved by putting the vowels (which represent 40 percent of all letters typed) on the left-hand side, and placing the major consonants that usually accompany these vowels on the right-hand side of the keyboard.

Professor Dvorak was thus able to avoid the typing inefficiencies of the QWERTY keyboard. For instance, QWERTY overloads the left hand, which must type 57 percent of ordinary copy. The Dvorak keyboard shifts this emphasis to 56 percent on the stronger fight hand and 44 percent on the weaker left hand. Only 32 percent of typing is done on the home row with the QWERTY system, compared to 70 percent with the Dvorak keyboard. The newer arrangement requires less jumping back and forth from row to row; with the QWERTY keyboard, a good typists' fingertips travel more than twelve miles a day, jumping from row to row. These unnecessary intricate movements cause mental tension, typist fatigue, and lead to more typographical errors.

One might expect, on the basis of its overwhelming advantages, that the Dvorak keyboard would have completely replaced the inferior QWERTY keyboard. On the contrary, after more than 50 years, almost all typists are still using the inefficient QWERTY keyboard. Even though the American National Standards Institute and the Equipment Manufacturers Association have approved the Dvorak keyboard as an alternate design, it is still almost impossible to find a typewriter or a computer keyboard that is arranged in the more efficient layout. Vested interests are involved in hewing to the old design: Manufacturers, sales outlets, typing teachers, and typists themselves.

No, technological innovations are not always diffused and adopted rapidly. Even when the innovation has obvious, proven advantages.

As the reader may have guessed by now, the present pages were typed on a QWERTY keyboard.

Details on resistance to the Dvorak keyboard may be found in Dvorak and others (1936), Parkinson (1972), Lessley (1980), and David (1986a).

Four Main Elements in the Diffusion of Innovations

Previously we defined *diffusion* as the process by which an *innovation* is *communicated* through certain *channels* over *time* among the members of a *social system.* The four main elements are the innovation, communication channels, time, and the social system (Figure 1-1). These elements are identifiable in every diffusion research study, and in every diffusion campaign or program (like the diffusion of water-boiling in a Peruvian village).

The following description of these four elements in diffusion constitutes an overview of the main concepts that will be detailed in Chapters 2 through 11.

1. The Innovation

An *innovation* is an idea, practice, or object that is perceived as new by an individual or other unit of adoption. It matters little, so far as human behavior is concerned, whether or not an idea is objectively new as measured by the lapse of time since its first use or discovery. The perceived newness of the idea for the individual determines his or her reaction to it. If the idea seems new to the individual, it is an innovation.

Newness in an innovation need not just involve new knowledge. Someone may have known about an innovation for some time but not yet developed a favorable or unfavorable attitude toward it, nor have adopted or rejected it. "Newness" of an innovation may be expressed in terms of knowledge, persuasion, or a decision to adopt.

Among the important research questions addressed by diffusion scholars are (1) how the earlier adopters differ from the later adopters of an innovation (Chapter 7), (2) how the perceived attributes of an innovation, such as its relative advantage or compatibility affect its rate of adoption, whether relatively rapidly (as for Innovation I in Figure 1-1) or more slowly (Innovation III), as is detailed in Chapter 6, and (3) why the S-shaped diffusion curve "takes off" at about 10- to 25-percent adoption, when interpersonal networks become activated so that a critical mass of adopters begins using an innovation (Chapter 8). It should not be assumed that the diffusion and adoption of all innovations are necessarily desirable. Some harmful and uneconomical innovations are not desirable for either the individual or the social system. Further, the same innovation may be desirable for one adopter in one situation, but undesirable for another potential adopter in a different situation. For example, mechanical tomato-pickers have been adopted rapidly by large commercial farmers in California, but these machines were too expensive for small tomato growers, and thousands of farmers have thus been forced out of tomato production.

TECHNOLOGICAL INNOVATIONS, INFORMATION, AND UNCERTAINTY. Most of the new ideas analyzed in this book are technological innovations, and we often use the word "innovation" and "technology" as synonyms. A

technology is a design for instrumental action that reduces the uncertainty in the cause-effect relationships involved in achieving a desired outcome. A technology usually has two components: (1) a *hardware* aspect, consisting of the tool that embodies the technology as a material or physical object, and (2) a *software* aspect, consisting of the information base for the tool. For example, we often speak of (1) "computer hardware" consisting of semiconductors, transistors, electrical connections, and the metal frame to protect these electronic components, and (2) "computer software" consisting of the coded commands, instructions, and other information aspects of this tool that allow us to use it to extend human capabilities in solving certain problems. Here we see an illustration of the close relationship between a tool and the way it is used.

The social embedding of the hardware aspects of a technology is usually less visible than its machinery or equipment, and so we often think of technology mainly in hardware terms. Indeed, sometimes the hardware side of a technology is dominant. But in other cases, a technology may be almost entirely composed of information; examples are a political philosophy like Marxism, a religious idea, a news event, a rumor, assembly-line production, and quality circles. The diffusion of such software innovations has been investigated, although a methodological problem in such studies is that their adoption cannot be so easily traced or observed in a physical sense.

A number of new products involve a hardware component and a software component, with the hardware purchased first so that the software component can then be utilized. Examples are VCRs and videotapes, cameras and film, and compact disc players and CDs. Often a company will sell the hardware product at a relatively low price in order to capture market share, and then sell the software at a relatively high price in order to recover profits (Bayus, 1987). An example is the Nintendo game-player, which is sold at a fairly low price (about $100), but with each Nintendo video game sold at a relatively high price (about $60). This is sometimes called a shaver-and-blades strategy.

Some innovations only have a software component, which means they have a relatively lower degree of observability and thus a slower rate of innovation. Such idea-only innovations have seldom been studied by diffusion scholars, perhaps because their spread is relatively difficult to trace.

Even though the software component of a technology is often not so easy to observe, we should not forget that technology almost always represents a mixture of hardware and software aspects. According to our definition, technology is a means of uncertainty reduction that is made possible by information about the cause-effect relationships on which the technology is based. This information often results from scientific R&D activities when the technology is being developed. A technological innovation usually has at least some degree of benefit for its potential adopters. This advantage is not always very clear-cut, at least not to the intended adopters. They are seldom certain that an innovation represents a superior alternative to the previous practice that it might replace.

So a technological innovation creates one kind of uncertainty (about its expected consequences) in the mind of potential adopters, as well as representing an opportunity for reduced uncertainty in another sense (reduced by the information base of the technology). The latter type of potential uncertainty reduction (from the information embodied in the technological innovation itself) represents the possible efficacy of the innovation in solving an individual's perceived problem; this advantage provides the motivation that impels an individual to exert effort in order to learn about the innovation. Once such information-seeking activities have reduced the uncertainty about the innovation's expected consequences to a tolerable level for the individual, a decision concerning adoption or rejection will be made. If a new idea is used by an individual, further evaluative information about its effects is obtained. Thus, the innovation-decision process is essentially an information-seeking and information-processing activity in which the individual is motivated to reduce uncertainty about the advantages and disadvantages of the innovation (see Chapter 5).

We distinguish two kinds of information in respect to a technological innovation.

1. *Software information,* which is embodied in a technology and serves to reduce uncertainty about the cause-effect relationships in achieving a desired outcome.
2. *Innovation-evaluation information*, which is the reduction in uncertainty about an innovation's expected consequences.

The main questions that an individual typically asks in regard to software information are, "What is the innovation?....How does it work?" and "Why does it work?" In contrast, an individual usually wants to know such innovation-evaluation information as, "What are an innovation's consequences?" and "What will its advantages and disadvantages be in my situation?"

TECHNOLOGY CLUSTERS. An important conceptual and methodological issue is to determine the boundaries around a technological innovation. The practical problem is how to determine where one innovation stops and another begins. If an innovation is an idea that is perceived as new, this boundary between innovations ought to be determined by the potential adopters who do the perceiving. In fact, this approach is used by diffusion scholars and by market researchers in positioning studies (described in Chapter 6). For example, a California study of the diffusion of recycling found that households that recycled paper were also likely to recycle bottles and cans, although many families only recycled paper (Leonard-Barton and Rogers, 1980); presumably the two recycling behaviors represented two innovations that were part of an interrelated cluster of recycling ideas. A *technology cluster* consists of one or more distinguishable elements of technology that are perceived as being closely interrelated. Some change agencies promote a package of innovations because they find that the innovations are thus adopted more rapidly. An example of technology cluster was the package of rice- or wheat-growing innovations that led to the Green Revolution in the Third World countries of Latin America, Africa, and Asia. In addition to the so-called miracle varieties of rice or wheat, the cluster included chemical fertilizers, pesticides, and thicker planting of the seeds.

Past diffusion research has generally investigated each innovation as if it were independent from other innovations. This is a dubious assumption, in that an adopter's experience with one innovation obviously influences that individual's perception of the next innovation to diffuse through the individual's system. In reality, a set of innovations diffusing at about the same time in a system are interdependent. It is much simpler for diffusion scholars to investigate the spread of each innovation as an independent event, but this is a distortion of reality.

CHARACTERISTICS OF INNOVATIONS. It should not be assumed, as it sometimes has in the past, that all innovations are equivalent units of analysis. This assumption is a gross oversimplification. While consumer innovations like mobile telephones or VCRs may require only a few years to reach widespread adoption in the United States, other new ideas such as the metric system or using seat belts in cars require decades to reach complete use. The characteristics of innovations, as perceived by individuals, help to explain their different rate of adoption.

1. *Relative advantage* is the degree to which an innovation is perceived as better than the idea it supersedes. The degree of relative advantage may be measured in economic terms, but social prestige, convenience, and satisfaction are also important factors. It does not matter so much if an innovation has a great deal of objective advae the spread of each innovation as an independent event, but this is a distortion of reality.

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1. *Relative advantage* is the degree to which an innovation is perceived as better than the idea it supersedes. The degree of relative advantage may be measured in economic terms, but social prestige, convenience, and satisfaction are also important factors. It does not matter so much if an innovation has a great deal of objective advantage. What does matter is whether an individual perceives the innovation as advantageous. The greater the perceived relative advantage of an innovation, the more rapid its rate of adoption will be.

2. *Compatibility* is the degree to which an innovation is perceived as being consistent with the existing values, past experiences, and needs of potential adopters. An idea that is incompatible with the values and norms of a social system will not be adopted as rapidly as an innovation that is compatible. The adoption of an incompatible innovation often requires the prior adoption of a new value system which is a relatively slow process. An example of an incompatible innovation is the use of contraceptive methods in countries where religious beliefs discourage use of family planning, as in Moslem and Catholic nations. Previously in this chapter we saw how the innovation of water boiling was incompatible with the hot-cold complex in the Peruvian village of Los Molinas.

3. *Complexity* is the degree to which an innovation is perceived as difficult to understand and use. Some innovations are readily understood by most members of a social system; others are more complicated and will be adopted more slowly. For example, the villagers in Los Molinas did not understand germ theory, which the health worker tried to explain to them as a reason for boiling their drinking water. New ideas that are simpler to understand are adopted more rapidly than innovations that require the adopter to develop new skills and understandings.

4. *Trialability* is the degree to which an innovation may be experimented with on a limited basis. New ideas that can be tried on the installment plan will generally be adopted more quickly than innovations that are not divisible. Ryan and Gross (1943) found that every one of their Iowa farmer respondents adopted hybrid seed corn by first trying it on a partial basis. If the new seed could not have been sampled experimentally, its rate of adoption would have been much slower. An innovation that is trialable represents less uncertainty to the individual who is considering it for adoption, as it is possible to learn by doing.

5. *Observability* is the degree to which the results of an innovation are visible to others. The easier it is for individuals to see the results of an innovation, the more likely they are to adopt it. Such visibility stimulates peer discussion of a new idea, as friends and neighbors of an adopter often request innovation-evaluation information about it. Solar adopters often are found in neighborhood dusters in California, with three or four adopters located on the same block. Other consumer innovations like home computers are relatively less observable, and thus diffuse more slowly.

Innovations that are perceived by individuals as having greater relative advantage, compatibility, trialability, observability, and less complexity will be adopted more rapidly than other innovations. Past research indicates that these five qualities are the most important characteristics of innovations in explaining the rate of adoption.

RE-INVENTION. or the first several decades of diffusion research, it was assumed that an innovation was an invariant quality that did not change as it diffused. I remember interviewing an Iowa farmer years ago about his adoption of 2,4-D weed spray. In answer to my question about whether or not he had adopted this innovation, the farmer described in some detail the particular and unusual ways in which he used the weed spray on his farm. At the end of his remarks, I simply checked "adopter" on my questionnaire. The concept of re-invention was not yet in my theoretical repertoire, so I condensed the farmer's experience into one of my existing categories.

In the 1970s, diffusion scholars began to study the concept of *re-invention,* defined as the degree to which an innovation is changed or modified by a user in the process of its adoption and implementation. Some researchers measure re-invention as the degree to which an individual's use of a new idea departs from the mainline version of the innovation that was originally promoted by a change agency (Eveland and others, 1977). Once scholars became aware of the concept of re-invention and began to measure it, they began to find that a considerable degree of re-invention occurred for many innovations. Some innovations are difficult or impossible to re-invent; for example, hybrid seed corn does not allow a farmer much freedom to re-invent, as the hybrid vigor is genetically locked into the seed for the first generation in ways that are too complicated for a farmer to change. Certain other innovations are more flexible in nature, and they are re-invented by many adopters who implement them in a wide variety of different ways. An innovation is not necessarily invariant during the process of its diffusion. And adopting an innovation is not necessarily the passive role of just implementing a standard template of the new idea.

Given that an innovation exists, communication must take place if the innovation is to spread. Now we turn our attention to this second element in the diffusion process.

2. Communication Channels

Previously we defined *communication* as the process by which participants create and share information with one another in order to reach a mutual understanding. Diffusion is a particular type of communication in which the message content that is exchanged is concerned with a new idea. The essence of the diffusion process is the information exchange through which one individual communicates a new idea to one or several others. At its most elementary form, the process involves (1) an innovation, (2) an individual or other unit of adoption that has knowledge of the innovation or experience with using it, (3) another individual or other unit that does not yet have experience with the innovation, and (4) a communication channel connecting the two units. A *communication channel* is the means by which messages get from one individual to another. The nature of the information-exchange relationship between a pair of individuals determines the conditions under which a source will or will not transmit the innovation to the receiver, and the effect of the transfer.

Mass media channels are often the most rapid and efficient means to inform an audience of potential adopters about the existence of an innovation, that is, to create awareness-knowledge. *Mass media channels* are all those means of transmitting messages that involve a mass medium, such as radio, television, newspapers, and so on, which enable a source of one or a few individuals to reach an audience of many. On the other hand, interpersonal channels are more effective in persuading an individual to accept a new idea, especially if the interpersonal channel links two or more individuals who are similar in socioeconomic status, education, or other important ways. *Interpersonal channels* involve a face-to-face exchange between two or more individuals.

Diffusion investigations show that most individuals do not evaluate an innovation on the basis of scientific studies of its consequences, although such objective evaluations are not entirely irrelevant, especially to the very first individuals who adopt. Instead, most people depend mainly upon a subjective evaluation of an innovation that is conveyed to them from other individuals like themselves who have previously adopted the innovation. This dependence on the experience of near peers suggests that the heart of the diffusion process consists of the modeling and imitation by potential adopters of their network partners who have adopted previously. So diffusion is a very social process (see Chapter 8).

HETEROPHILY AND DIFFUSION. An obvious principle of human communication is that the transfer of ideas occurs most frequently between two individuals who are similar, or homophilous. *Homophily* is the degree to which two or more individuals who interact are similar in certain attributes, such as beliefs, education, social status, and the like. In a freechoice situation, when an individual can interact with any one of a number of other individuals, there is a strong tendency to select someone who is very similar.

Homophily occurs because similar individuals belong to the same groups, live or work near each other, and share the same interests. This physical and social propinquity makes homophilous communication more likely. Such communication is also more likely to be effective, and thus to be rewarding. *More effective communication occurs when two or more individuals are homophilous.* When they share common meanings, a mutual subcultural language, and are alike in personal and social characteristics, the communication of new ideas is likely to have greater effects in terms of knowledge gain, attitude formation and change, and overt behavior change. When homophily is present, communication is therefore likely to be rewarding to both participants in the process.

One of the most distinctive problems in the diffusion of innovations is that the participants are usually quite heterophilous. A change agent, for instance, is more technically competent than his or her clients. This difference frequently leads to ineffective communication as the participants do not talk the same language. In fact, when two individuals are identical regarding their technical grasp of an innovation, no diffusion can occur as there is no new information to exchange. The very nature of diffusion demands that at least some degree of heterophily be present between the two participants. Ideally, they would be homophilous on all other variables (education and social status, for example) even though they are heterophilous regarding the innovation. Usually, however, the two individuals are heterophilous on all of these variables because knowledge and experience with an innovation are highly related to social status, education, and the like.

3. Time

Time is a third element in the diffusion process. Much other behavioral science research is timeless in the sense that the time dimension is simply ignored. The inclusion of time as a variable in diffusion research is one of its strengths, but the measurement of the time dimension (often by means of the respondents' recall) can be criticized (Chapter 3). The time dimension is involved in diffusion (1) in the innovation-decision process by which an individual passes from first knowledge of an innovation through its adoption or rejection, (2) in the innovativeness of an individual or other unit of adoption -- that is, the relative earliness/lateness with which an innovation is adopted -- compared with other members of a system, and (3) in an innovation's rate of adoption in a system, usually measured as the number of members of the system that adopt the innovation in a given time period.

THE INNOVATION-DECISION PROCESS. The *innovation-decision process* is the process through which an individual (or other decision-making unit) passes from first knowledge of an innovation to forming an attitude toward the innovation, to a decision to adopt or reject, to implementation and use of the new idea, and to confirmation of this decision. We conceptualize five main steps in the innovation-decision process: (1) knowledge, (2) persuasion, (3) decision, (4) implementation, and (5) confirmation. *Knowledge* occurs when an individual (or other decision-making unit) learns of the innovation's existence and gains some understanding of how it functions. *Persuasion* occurs when an individual (or other decision-making unit) forms a favorable or unfavorable attitude toward the innovation. *Decision* occurs when an individual (or other decision-making unit) engages in activities that lead to a choice to adopt or reject the innovation. *Implementation* occurs when an individual (or other decision-making unit) puts an innovation into use. Re-invention is especially likely to occur at the implementation stage. *Confirmation* occurs when an individual (or other decision-making unit) seeks reinforcement of an innovation-decision that has already been made, but the individual may reverse this previous decision if exposed to conflicting messages about the innovation.

Previously we stated that the innovation-decision process is an information-seeking and information-processing activity in which an individual obtains information in order to decrease uncertainty about the innovation. At the knowledge stage, an individual mainly seeks software information that is embodied in the technological innovation, information that reduces uncertainty about the cause-effect relationships involved in the innovation's capacity to solve an individual's problem. At this stage the individual wants to know what the innovation is and how and why it works. Mass media channels can effectively transmit such software information.

But increasingly at the persuasion stage, and especially at the decision stage, an individual seeks innovation-evaluation information in order to reduce uncertainty about an innovation's expected consequences. Here an individual wants to know the innovation's advantages and disadvantages in his or her own situation. Interpersonal networks with near-peers are particularly likely to convey such evaluative information about an innovation. Subjective evaluations of a new idea from other individuals are especially likely to influence an individual at the decision stage, and perhaps at the confirmation stage.

The innovation-decision process can lead to either *adoption,* a decision to make full use of an innovation as the best course of action available, or to *rejection,* a decision not to adopt an innovation. Such decisions can be reversed at a later point; for example, *discontinuance* is a decision to reject an innovation after it has previously been adopted. Discontinuance may occur because an individual becomes dissatisfied with an innovation, or because the innovation is replaced with an improved idea. It is also possible for an individual to adopt an innovation after a previous decision to reject it. Such later adoption and discontinuance occur during the confirmation stage of the innovation-decision process.

The innovation-decision process involved time in the sense that the five steps usually occur in a time-ordered sequence of knowledge, persuasion, decision, implementation, and confirmation. Exceptions to the usual sequence of the five stages may occur, such as when the decision stage precedes the persuasion stage. The *innovation-decision* period is the length of time required to pass through the innovation-decision process.

The present discussion of the innovation-decision process is mainly at the level of a single individual, and thus to the case of individual-optional innovation-decisions. But many innovation-decisions are made by organizations or other types of adopting units, rather than by individuals. For example, an organization may decide to implement an electronic mail system on the basis of a staff decision or an official's authority decision; the individual office worker in the organization may have little or no say in the innovation-decision. When an innovation-decision is made by a system, rather than by an individual, the decision process is more complicated because a number of individuals are involved (see Chapter 10).

So time is an important dimension in the innovation-decision process.

INNOVATIVENESS AND ADOPTER CATEGORIES. *Innovativeness* is the degree to which an individual or other unit of adoption is relatively earlier in adopting new ideas than the other members of a system. Rather than describing an individual as "less innovative than the average member of a social system," it is handier and more efficient to refer to the individual as being in the "late majority" or in some other adopter category. This short-hand notation saves words and contributes to dearer understanding. Diffusion research shows that members of each of the adopter categories have a good deal in common. If the individual is like most others in the late majority category, he or she is of low social status, makes little use of mass media channels, and learns about most new ideas from peers via interpersonal channels. In a similar manner, we shall present a concise word picture of each of the other four adopter categories (in Chapter 7). *Adopter categories,* the classifications of members of a social system on the basis of innovativeness, include: (1) innovators, (2) early adopters, (3) early majority, (4) late majority, and (5) laggards.

Innovators are active information-seekers about new ideas. They have a high degree of mass media exposure and their interpersonal networks extend over a wide area, reaching outside of their local system. Innovators are able to cope with higher levels of uncertainty about an innovation than are other adopter categories. As the first to adopt a new idea in their system, they cannot depend upon the subjective evaluations of the innovation from other members of their system.

The measure of innovativeness and the classification of a system's members into adopter categories are based upon the relative time at which an innovation is adopted.

RATE OF ADOPTION. There is a third specific way in which the time dimension is involved in the diffusion of innovations. The *rate of adoption* is the relative speed with which an innovation is adopted by members of a social system. When the number of individuals adopting a new idea is plotted on a cumulative frequency basis over time, the resulting distribution is an S-shaped curve. At first, only a few individuals adopt the innovation in each time period (such as a year or a month, for example); these are the innovators. But soon the diffusion curve begins to climb, as more and more individuals adopt in each succeeding time period. Eventually, the trajectory of adoption begins to level off, as fewer and fewer individuals remain who have not yet adopted the innovation. Finally, the S-shaped curve reaches its asymptote, and the diffusion process is finished.

Most innovations have an S-shaped rate of adoption. But there is variation in the slope of the "S" from innovation to innovation; some new ideas diffuse relatively rapidly and the S-curve is quite steep. Other innovations have a slower rate of adoption, and the S-curve is more gradual, with a slope that is relatively lazy. One issue addressed by diffusion research is why some innovations have a rapid rate of adoption, while others are adopted more slowly (see Figure 1-1).

The rate of adoption is usually measured by the length of time required for a certain percentage of the members of a system to adopt an innovation. Therefore, we see that the rate of adoption is measured using an innovation in a system, rather than an individual, as the unit of analysis. Innovations that are perceived by individuals as possessing greater relative advantage, compatibility, and the like, have a more rapid rate of adoption (as discussed previously).

There are also differences in the rate of adoption for the same innovation in different social systems. Many aspects of diffusion cannot be explained by just individual behavior. The system has a direct effect on diffusion through its norms and other system-level qualities, and also has an indirect influence through its individual members.

4. A Social System

A *social system* is defined as a set of interrelated units that are engaged in joint problem-solving to accomplish a common goal. The members or units of a social system may be individuals, informal groups, organizations, and/or subsystems. The system analyzed in a

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