DIMENSIONS OF INNOVATION*

† Donald C. Pelz
† Fred C. Munson
† Linda L. Jenstrom

ABSTRACT

Within a conceptual framework of three dimensions, this paper examines parallels between the process of innovation in shipbuilding and in nursing care. Major conclusions are:

1. A given innovation must include not only technological change but also embedding activities to ensure its fit into the adopting organization.

2. To ensure continuation of the innovating process, it is necessary to build innovative capacity, with leadership vested in some person or group.

3. System-wide innovation requires both an effective diffusion process and diffusion capacity, to disseminate knowledge about specific innovations and also about ways to build innovative capacity.

4. Building both innovative capacity and diffusion capacity must be seen as responsibilities of the entire organization or system.

INTRODUCTION

What are the parallels, if any, between innovation in the building of ships and innovation in provision of hospital nursing care? That question is explored here within a conceptual framework of three broad dimensions:

- Characteristics of the innovation as a product.

- Stages of innovating as a process.

- Key actors in the innovating process.

To the extent that innovation in settings as diverse as shipbuilding and nursing is parallell on conceptual dimensions, common principles are likely to apply. Where conceptual features diverge, principles of innovation are also likely to differ.

Staff of the Center for Research on Utilization of Scientific Knowledge (CRUSK) have collaborated since 1975 with the University of Michigan School of Nursing, the Michigan State University School of Nursing, and the Michigan Nurses Association in carrying out a five-year program on utilization of nursing research, called here the *Michigan Nursing Project*, with Jo Anne Horsley, Ph.D., Professor of Nursing as principal investigator and D. C.

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† *D.C. Pelz, Ph.D., is Director of the Center for Research on Utilization of Scientific Knowledge, Institute for Social Research, University of Michigan, Ann Arbor, MI. Established in 1964 to create new knowledge about how knowledge is used, the Center is currently examining knowledge use in public policy, organizational development, technology assessment, health services, and program evaluation. F. C. Munson, Ph.D. is Professor of Hospital Administration, School of Public Health the University of Michigan. L. L. Jenstrom, Research Associate, Children's Hospital, Washington, DC, wrote for the maritime innovation committee a case study on the National Shipbuilding Research Program of the National Maritime Administration.*

* *This paper grew from a presentation by the senior author to the committee on Innovation and Technology Transfer in the Maritime Industry, Ann Arbor, MI, 7 April 1978. Under authorization of the Maritime Transportation Research Council, National Academy of Sciences, the committee has been examining factors which motivate or inhibit innovation in the building or operation of ships, and suggesting ways to improve the climate for innovation in that industry.*

Pelz as co-investigator (Horsley, Crane, and Bingle, 1978). The objectives are (1) to assist nursing departments in developing an innovating process for incorporating findings from nursing research into the daily practice of registered nurses, and (2) to promote collaboration between nursing researchers and practitioners in designing practice-relevant nursing research. A separate program in the University's School of Public Health has introduced cost-containing innovations in admissions and scheduling systems of Michigan hospitals (Munson and Hancock, 1972).

The invitation to speak to the maritime innovation committee offered Pelz and Munson an opportunity to explore how the general model they had been developing for innovation in health care systems could be extended to the sharply different case of shipbuilding, particularly to the National Shipbuilding Research Program of the Maritime Administration (Jenstrom, 1978). It became apparent that the conceptual framework for health care was relevant for many aspects of maritime innovation.

In this paper, various conceptual distinctions will be drawn and illustrated with examples from the nursing and shipbuilding programs. The first three sections will take up the major dimensions: *The Innovation as a Product, States of Innovating as a Process, and Key Actors in the Innovating Process.* The next three sections will elaborate these dimensions under topics of: *Building Innovative Capacity, Diffusion Process, and Building Diffusion Capacity.*

THE INNOVATION AS A PRODUCT

Innovation is not synonymous with invention. "Invention" generally refers to the creation of a new idea, product, or technique; "innovation" refers to the introduction of something new to a system that has not used it before. The same invention can be used to innovate in different settings.

It is useful to distinguish between innovation as a noun —i.e., the new product or technique, and innovation as a verb — i.e., the sequence of activities by which the new device is introduced. In the first sense, a given innovation can be viewed as having two components: technological content and embedding content. In planning for the implementation of a given innovation, it is critical that both aspects be addressed. Too often an innovation is considered only in terms of its technological content, and too often this leads to failure when the innovation is implemented.

Technological Content and Embedding Content

The technological content of an innovation is a device or a process that represents a change in the current methods of producing goods or services. Technological content includes the hardware, such as a computer or a LASH ship[1], as well as the software that is necessary to use or apply the hardware. An example of the latter is the computer programs needed to use computer hardware. In fact, the technological content may be limited to software, such as a new procedure for scheduling admission of patients to surgical wards of hospitals.

The embedding content of an innovation refers to the arrangements needed for linking the technological content into an operating system. Embedding content is essential to successful innovation. The receiving system must be prepared in many ways. Personnel must be trained in the skills necessary to use the new technology of the innovation. Specialized units within an organization or new roles for its personnel may have to be created. Changes in the organizational hierarchy or in lines of reporting and command may be required, particularly if a new organizational unit is established. New units and new roles will re-

[1] *In this technology (Lighter Aboard Ship), specially designed barges are loaded at a remote site, towed to the LASH ship and hoisted on board, transported, and lifted off for delivery to their destination. See Renehan (1978).*

quire new lines of communication.

Embedding content may be illustrated with the example of automation of operating systems on Swedish ships.[2] When several systems (navigation, collision prevention, propulsion control, fire and flooding control) were automated, the function of the crew was changed radically. They were no longer responsible for human performance of these systems, but instead became responsible for maintenance of the computerized control machinery. A whole new set of job definitions, self-concepts, and motivations had to be introduced. Job roles became more interchangeable, and job assignments more flexible; it was no longer necessary to keep a given individual with a given ship whose idiosyncracies he had learned to manage. It required several months of training to put the new skills in place; for the first two years, sets of technical experts traveled with the crews to aid in correction of difficulties and to reinforce the training.

The "innovation" in this example was not limited to the computer-based hardware and software of the control machinery itself (technological content); it included the entire supporting system of job roles and functions, and the training required to establish this system (embedding content). Implementation of the latter was a prolonged process over nearly five years.

It is difficult to over-estimate the importance of careful consideration of the embedding content of an innovation. An example of failure to address this aspect can be seen in the implementation of the LASH shipping concept.[2] The first time that a LASH ship put into Rotterdam, it was loaded with barges containing tractors which had been manufactured in Germany and then floated down the Rhine. By the time the ship made her trans-Atlantic crossing, most of the tractors were reduced to scrap metal. They had been secured sufficiently for transportation down the Rhine, since that was what the barge men know how to do; however, the barge men had not been trained in the proper methods of securing tractors for an ocean crossing. Clearly, it was not the technological content of the innovation, the LASH ship, which was at fault; the failure lay in the inadequate preparation given the support system.

It is important that planners develop a clear understanding of the impact of the innovation on the personnel involved. When changes are made in the way personnel are expected to function, it is essential that they have the skills and the understanding needed to perform their new roles. Occasionally, new roles resulting from innovations are deflating. They may create feelings of loss of status, of doing something more routine than was done before. There may be fewer opportunities for exercising judgment. If so, real resistance may be created.

Adaptation

During the initial phases of implementing an innovation, two processes of adaptation may occur. The first consists of modifications in the technology, such as minor improvements in the hardware or software — for example, modifications in components of computer programs. Seldom can a given piece of hard or soft technology be taken off a shelf and plugged into an existing organization without undergoing changes in the technical content.

The second process of adaptation is continued design of the embedding features. Although the embedding content should be planned prior to the implementation of the innovation, embedding, when it actually occurs, is an adaptation of the recipient organization. Plans and procedures for carrying out the embedding will usually require modification, as experience with the innovation is acquired and unforeseen problems arise.

STAGES OF INNOVATING AS A PROCESS

The foregoing discussion has examined the concept of innovation as a noun — i.e.,

[2] *Oral report at meeting of maritime innovation committee.*

the sequence of activities that are required when an innovation is implemented. This will be called the innovating process.

This process is typically described as comprising a series of stages. A wealth of literature on the topic is synthesized in state-of-art reviews such as those by Rogers (1962), Havelock (1969), Rogers with Shoemaker (1971), Human Interaction Institute (1976), or Zaltman and others (1973, 1977). The number of stages is somewhat arbitrary, and each stage can be divided into numerous components.[3] Nevertheless, the major stages can be arranged in a rough chronological sequence with the stipulation that portions of adjacent stages may overlap, that whole sections may be omitted, and that stages or components may be recycled. Pelz and Munson propose that the following four major stages will provide a useful framework:

I. Diagnosis (also called theory, analysis, or policy-setting)

II. Design (also called specification, solution-building, or development)

III. Implementation (also called pilot testing or demonstration)

IV. Diffusion (also called multiple implementation or replication)

While there is general recognition that the innovating process occurs in stages, there is a tendency to overlook how protracted this process can be, and how much effort is required at each stage. Further, there is a tendency to overlook the fact that different kinds of activities are needed to nourish each of the stages in the process.

[3]*In a recent review on diffusion of innovation in health care organizations, Greer (1977) finds at least three stages differentiated in the literature: (1) ideas enter the organization and are considered; (2) adoption decisions are made; (3) implementation occurs.*

These omissions may arise from the fact that much of the literature on diffusion of innovations has examined their adoption by individuals (e.g., use of hybrid corn by American farmers). The pivotal decision is whether or not to try the innovation on a small scale. In examining more complex innovations, and particularly those that must be adopted by a system rather than an individual, it becomes clear that many key decisions must be made at a number of points. This sequence of decision points is illustrated in the following discussion of stages in the innovating process.

Stage I: Diagnosis

In the stage of diagnosis, the task is to recognize a difficulty, express it as a perceived problem, analyze the problem, and decide on a general course of action. Ideally, this stage may include development of components such as the following, although many of these components may be skipped in practice:

- A mechanism for conducting diagnosis is established (or responsibility is assigned to an existing mechanism).
- A problem or difficulty is recognized as requiring attention.
- A practice need is felt (performance gap between actual and desired performance).
- Causes or sources of problem are diagnosed.
- Search is undertaken for potential solutions or policy options.
- Several solutions or policy options are generated or retrieved.
- Potential payoffs (benefits) and drawbacks (costs) of each option are assessed, either crudely or elegantly.

- The feasibility of implementing each option is analyzed.

- One solution or option is selected for development and trial.

- Criteria are specified for knowing whether the problem has been resolved.

In the diagnosis stage, there are two key questions:

1. *What is the problem?*

2. *What are the potential solutions for the problem?*

Diagnosis usually begins with an assessment of the organization. It is necessary to look at the operation of the organization and decide whether or not its performance is adequate or acceptable. If not, it is necessary to identify the source of the difficulty — the problem. Once the problem is identified, a decision must be made as to the most likely direction to go in search of a solution. For example, if an organization is having difficulty retaining personnel, it is necessary to decide if the solution is likely to be found by exploring better recruiting procedures, or by increasing pay and benefits, or by improving working conditions. Giving careful thought to the direction of search for solutions is of critical importance and requires considerable creative effort.

The National Shipbuilding Research Program of the Maritime Administration (MarAd) is doing an excellent job of carrying out the requirements of the diagnostic stage. The procedure for identifying new areas of research is based on a pooling of information among shipbuilders. Using a committee structure, shipyard representatives compile and evaluate existing problems, and share their knowledge of resources which potentially bear on solutions. In the process of developing a research proposal for funding by the program, shipyards conduct a thorough survey of the resources of the shipbuilding industry, as well as related or potentially supportive industries. Such surveys have occasionally produced solutions without the need for research. If no ready-made solutions are found, the shipyards participate in the decision on the direction in which a solution is likely to be found through research. In fact, they draw up the research specifications.

Stage II: Design

In the design stage, a set of action guidelines is developed to give concrete shape to the technological and embedding content of the solutions. The guidelines should be sufficiently detailed for practitioner use. Ideally, the design stage includes components such as the following:

- A mechanism for designing the innovation is established (or responsibility is assigned to an existing mechanism).

- Existing documents about the innovation are scrutinized: research literature, manuals, descriptions.

- Experts are consulted; experience of other agencies with this innovation is sought.

- Guidelines for technological content are developed for this agency (original plans may be modified or elaborated).

- The technological hardware and/or software is produced or obtained.

- Guidelines for embedding content (organizational adaptation and support) are developed.

- Procedures for evaluating the innovation are developed.

— A pilot site is selected for trial implementation (unless the innovation is such that it must be implemented system-wide).

In negotiating the design stage, it is sometimes possible to retrieve an existing invention that seems to address the stated problem. It is also sometimes possible to issue a contract to a research and demonstration firm, allied industry, or free-lance inventor for the development of the technological content of the innovation needed to address the problem. However, a great deal more is involved than simply picking out or developing the appropriate hardware and/or software. It is necessary to carry out development activities for adapting the new technology to the organization, and the organization to the technology — that is, to design the embedding content.

It is unlikely that the design for the embedding content can be procured by issuing a contact. Much of it must be done by the organization that is going to adopt the new technology. A contracting firm is unlikely to have sufficient knowledge of the internal workings of the adopting organization must identify or establish some mechanism that will permit the adaptation to go forward. This mechanism can be an existing department or unit, a newly created unit or committee, or (less efficiently) responsibility can be assigned to an individual. It should be stressed that the internal organizational adaptations must be feasible and sound in order for the innovation to be well understood and applied.

STAGE III: Implementation

The implementation stage addresses the process of incorporating the action guidelines (both technological content and embedding content) into an operating organization in such a way as to ensure its effective use and long-term stabilization. This stage may include the following components:

— A mechanism to implement the innovation is established (or responsibility is assigned to an existing mechanism).

— The action guidelines (the innovation designed in Stage II) are applied in the pilot site on a trial basis.

— As difficulties arise, adaptations are made in the innovation (either in technological content or, more likely, in embedding content) to make it function better, with possible recycling to Stage II.

— Evaluation procedures are applied to obtain data (formal or informal) on benefits and cost.

— On the basis of evaluative data, a decision is made to continue, expand, or terminate the innovation.

— If the decision is to expand, steps are taken to extend the innovation from the pilot site to other relevant sites within the organization (internal diffusion).

Implementation is often called demonstration or development of a pilot program because it refers to a trial that takes place over a limited time span and often in a limited geographic area. In some cases, the trial aspect of implementation is skipped, e.g., when an executive orders a solution into effect as if it were going to be permanent and system-wide. Since likelihood of success under these circumstances is reduced, a localized implementation is preferable. Sometimes an innovation, by its very nature, must be implemented throughout a system or organization, but this is always more difficult.

Another pitfall is conducting a demonstration in a "hot-house" atmosphere with special supervision and support. This cannot be considered a real trial implementation; it too closely resembles a laboratory test. For this reason, industrial research and demonstration efforts often incorporate a series of trials, ranging from laboratory demonstrations to feasibility tests, pilot tests on a small scale, and full-blown demonstrations, before launching organization-wide adoption of the innovation.

Evaluation

The organization should not only implement a trial of the innovation, but also have a solid plan to evaluate its effects. One must ensure that the innovation is working as intended and that it has benefits sufficient to justify permanent adoption. If the organization cannot be convinced that an innovation is an improvement, it is senseless to urge adoption. Evaluation procedures are planned as part of *Stage III — Implementation.* The purpose of evaluation is to obtain information that will permit an informed decision as to whether to retain the innovation, modify it, or extend it beyond the trial area into other parts of the organization.

Evaluation is often a difficult procedure to sell within the adopting organization. Personnel may view evaluation with suspicion and consider it an attempt to measure their individual competence. Therefore, careful presentation of the purpose of the evaluation (e.g., to obtain measurements of the usefulness of the innovation) is necessary. In general, the more visible the benefits of an innovation, the more likely it is to be adopted. In agriculture, innovations have been accepted when farmers could see the material benefits of the new technology. When benefits are less visible, more stringent evaluation may be needed. In patient care, for example, the benefits of a new procedure may be subtle but the amount of work in changing roles is obvious. An evaluation procedure that clearly documents the benefits of the procedure to the patient and to the staff will be essential in assuring an informed decision about adoption.

Stage IV: Diffusion

In this stage, the emphasis is on wide-scale applications (replications) of innovations which have been successfully developed in *Stage II — Design* and implemented in a few pilot sites (*Stage III*). The stage of diffusion is likely to incorporate the following steps:

— Mechanisms are established to provide continuity for the diffusion process (e.g., intermediary agencies, extension departments of a university, etc.)

— "Packages" for transmitting each innovation and its variations are prepared: written and audio-visual materials, training manuals, etc.

— Information systems are established for retrieving such materials about each innovation.

— Communication networks are developed to promote personal contacts between resource systems adopters, and among adopters.

— Formal communication devices are provided: extension bulletins, conferences, etc.

Diffusion may have both internal and external aspects. Internally, a successful pilot test or demonstration is usually followed by the decision to diffuse the innovation into other parts of the organization. External diffusion takes place as other organizations or systems borrow an innovation from one which has successfully experimented with it. This borrowing process may involve a series of condensed repetitions of the first three stages of the innovating process in the organizations that borrow. Each repetition may generate variations in the innovation to fit new and different circumstances. Eventually, a standard set of variations may emerge in place of the original one innovation. A standard set of variations may, in turn, give rise to even wider diffusion.

KEY ACTORS IN THE INNOVATING PROCESS

To understand how innovation occurs, it is essential to recognize that different actors (individuals or groups) may be involved at each stage. There are at least five broad sets of actors. First are organizational *managers* (decision-makers, policy-makers) who will support or oppose an innovation depending on how it affects the organization and attainment of organizational goals. Second are *workers* (staff members at several levels) whose tasks, influence, status, or job security may be affected by the innovation. Third are innovation *sources* — inventors or researchers who have developed the innovation and who benefit from having it used. Fourth is a heterogeneous set of *external agencies* that we can call social controllers. This set may include federal policy-makers or regulatory agencies, customers in a competitive market, or groups representing client or community interests; in general, this category is associated with "the public interest." Finally, there is a set which can be called *intermediaries* — change agents or diffusion agents whose function is to link innovation sources with potential users (managers or workers).

These five groups of actors are "key" to the innovating process only if they have both a power base and an interest in the outcome. For example, clients of a health service may have an interest in an innovation, but no basis of power if they are admitted to the health service by a physician, and payment for services is made by the federal government. Physicians may have the power to influence an innovation, but no interest if the innovation affects only nursing practice. Obviously, an innovation which affects the interests of a large number of powerful actors will have a stormier history than one which affects only a few.

It should be expected that different groups will be "key" at different stages of the innovating process. Social controllers will be active in the diagnosis but not the implementation stage. Organizational managers will be active in diagnosis and implementation, but less so in design; they may have no interest in diffusion to other organizations, or even actively oppose it (protection of "trade secrets"). Workers will rarely participate in diagnosis, and their power base may be relevant only at the implementation stage.

There is no intrinsic reason why the interests of any of these actors should determine the criteria of "good" innovative practice. Rather, a prolonged process of *negotiation* among the various actors may be expected. Each set will develop its own criteria, and then seek through political or organizational interaction to secure support from enough other key actors to have its own criteria used as the basis for decisions. (In adoption of cost-containing innovations in hospitals, the role of negotiation among key actors is described by Munson and Hancock (1972).

Successful innovation is often found to turn on the effectiveness of one group of key actors in securing a harmony of interest with another group. For example, it makes good tactical sense for an innovation source to assist the intermediary, since the power that comes from controlling communication channels is considerable. It also makes good sense for organization managers to modify or select innovations so as to secure strong support from workers, since these two groups are likely to have the strongest interests and power bases in the implementation stage.

The National Shipbuilding Research Program illustrates these roles rather clearly; it also illustrates how such a harmony of interest may develop. Initially the external agency, MarAd, and the shipyard organization managers had conflicting diagnoses about which technical problems should be addressed. With the successful introduction of the Ship Production Committee, MarAd accepted the shipyard's definition of priority problems, and the shipyard managers accepted the industry-wide context for diagnosis pressed on them by MarAd. Innovation sources within the industry could now be linked to a wider range of potential users by Technical Panels. Moreover, this intermediary function could be performed directly at the implementation stage by the respective Program Managers. The Shipbuilding Research Program Office is, in a real sense, the operating arm of MarAd, and the program it administers and funds represents an important shift in the innovative capacity of the industry. It is not clear that workers have a significant role in the program, though members of the Technical Panels may well be among the important organization members whose tasks, status, or security are affected by the innovations introduced.

BUILDING INNOVATIVE CAPACITY

There is a conceptual distinction between the innovating process for a single innovation, and building innovative capacity. Innovative capacity refers to an organization's capability to sustain a series of innovations in a more or less regular manner. Introducing a single innovation — even if successfully — does not ensure that the adopting organization will develop a continuing capability to innovate. Building such capacity is usually not articulated as a systemic goal. Often the people involved in a single innovation are either those who have invented a given piece of technology and want to see it implemented, or those who have a particular organizational problem and are seeking a solution. In either case, they are concerned with the innovating process only with respect to a particular innovation. Their interest tends to wane when the innovation has been incorporated or the problem solved.

Although adoption of specific innovations and the development of innovative capacity are both important, the latter has greater long-term impact. Unless an organization has such capacity, efforts to introduce specific innovations are likely to dissipate as soon as the impetus behind these specific innovations is withdrawn. Reflecting their concern with developing innovative capacity, the CRUSK staff are collaborating with the College of Nursing in a project mentioned earlier to help hospital nursing departments develop an ongoing capacity for self-initiated innovations. (The official title is *Conduct and Utilization of Research in Nursing — CURN*, sponsored by the Division of Nursing of HEW.) This project illustrates some important strategies for establishing innovative capacity in a variety of operational systems.

The Michigan Nursing Project — CURN

The nursing project has two objectives:

- ★ *To promote the utilization of existing research findings in the ongoing practice of hospital nursing.*
- ★ *To encourage the design of collaborative research planned jointly by nursing practitioners and researchers on topics that are readily transferable to nursing practice.*

Under the *utilization* component, 18 hospitals in southern Michigan were selected for the initial phase; 9 of these were designated as experimental and 9 as control hospitals. The 9 experimental hospitals were divided into two diffusion clusters of 4-5 hospitals each. A single hospital in each of the two diffusion clusters was then selected to participate in a pilot program aimed at development of organizational innovating capacity. Survey and other evaluative data are being collected from all 18 hospitals periodically throughout the project. (In a subsequent phase, the process will be repeated to obtain a total of three dozen hospitals.)

Each of the two pilot program hospitals has established a Central Innovation Team composed of six to eight nurses representing different functional areas and roles within their departments, and headed by a coordinator. Membership includes someone at the level of an associate director of nursing, to provide a clear channel of communication between the team and the director of nursing.

Each member of the Central Innovation Team, including the team coordinator, carries out project responsibilities on a part-time basis while continuing to fulfill other regular nursing functions. The teams as a whole have taken responsibility for the innovative process within their respective hospitals. Their functions include:

1. scrutinizing a number of potential innovations,
2. selecting an innovation for trial,
3. adapting the innovation to the local setting,
4. conducting a trial,
5. evaluating the success of the trial,
6. deciding whether or not to adopt, modify, or discontinue the innovation, and
7. diffusing the innovation internally if it is adopted.

When this process is completed with one innovation, the cycle is repeated with another. It is hoped that repetition and routinization of this process will develop an organizational, self-initiating mechanism for innovation — i.e., an innovating capacity — that is not dependent on outside support or pressure. A subsequent step in the nursing project focuses on the external diffusion capacity, and will, therefore, be discussed under those headings.

A few hallmarks of the utilization component of the CURN project should be mentioned. First, the Central Innovation Team does not begin by a broad assessment of problems, since it is likely that most problems do not yet have a research base to provide solutions. Rather, the CURN staff have prepared a set of research-based innovation packages. The team diagnoses the needs of its department relative to the offered innovations, and then selects the innovation that best addresses their needs. This approach is more one of knowledge utilization than of problem-solving. Second, the project does not provide funds to participating organizations to cover salaries, overhead, or any other departmental costs. Participating departments cover the time and salaries of their team members, while the project covers costs associated with training workshops and conferences.

The question of funding for the Central Innovation Teams is seen as a central issue by the CURN staff. Too often, demonstration projects are initiated only when outside funding agencies pay the participants to cooperate. When funding is withdrawn in such cases, the demonstration usually collapses. Therefore, providing monetary support for the teams is seen as counter-productive in a project aimed at developing an indigenous innovating capacity.

The second component of the nursing project addresses the development of *collaborative research* planned jointly by practitioners and researchers. The intent is to explore ways of encouraging practitioners and research to cooperate in the initial stages of research design. It is hoped that such collaborative planning will produce research that has practical value and can be readily applied. Seed money is provided for this component. Participating hospitals and universities must, however, match project funds on a 50-50 basis. The funds provided cover only the planning phases of research projects; funds to support actual research activities must be obtained elsewhere.

Contrasts with MarAd Program

It is interesting to contrast the Michigan nursing project (CURN) with the Maritime Administration's (MarAd) National Shipbuilding Research Program. The two have many similar elements, but some divergence in emphasis. The MarAd program pays more attention to adoption of specific innovations, whereas the nursing project places more emphasis on building innovative capacity. The programs emphasize different stages of the innovating process. The MarAd program stresses diagnosis and design; CURN stresses implementation and diffusion.

The funding patterns also differ. The MarAd program provides funds for carrying out specific research projects under the direction of Program Managers housed within American shipyards. The salaries of the Program Managers and those of his assistants (if any) are also paid by MarAd. Research projects are designed by Technical Panels of the Ship Construction Committee of the Society of Naval Architects and Engineers. The Technical Panels are composed of shipyard production personnel. The research planning activities of the Technical Panels are not directly supported by MarAd.

Another distinction is that the MarAd program proceeds on a *problem-solving basis*, while the nursing project proceeds on a *knowledge utilization* basis. In order to encourage regular ongoing innovation, the CURN staff feel that it is unwise to start with attempts to solve the most serious problems facing the organization. In the field of nursing, there is no assurance that the research-based solutions to many problems can be retrieved or generated. Systematic and regular introduction of innovations is more easily nourished by early success experiences. Each successful innovation experience adds to the organization's confidence in the process. Successful innovations are more likely to occur if the organization selects an improvement from several that have already been researched and tested.

Hunting for solutions to serious organizational problems can be a time-consuming process and may not always be rewarding. In particular, the search for solutions to organizational problems that are essentially non-technical — such as high staff turnover, contradictory lines of command, and interdepartmental conflict — is likely to be less than fruitful. The problem-solving approach may, however, be highly appropriate for organizations such as the maritime industry, with a variety of problems that are susceptible to technological solution. Here the development of new technology and new hardware must, essentially, proceed from problem-solving.

A final important difference between the Michigan nursing project and MarAd Shipbuilding Research Program is that the two use different mechanisms to carry out their activities. The CURN project is directly aimed at development of organizational innovative capacity and uses a *team* approach. The MarAd program is primarily aimed at design of research leading to shipyard innovations; it uses a committee approach in design of research specifications, but uses *individual leadership* in management of research programs. Although the Program Managers responsible for administering each research project are housed within individual shipyards, their responsibility for developing the innovative capacity of the shipyards remains somewhat nebulous. Nevertheless, the Program Managers often represent the only ongoing impetus for innovation within the yards.

An assessment of the strengths and weaknesses of the individual vs the team approach to developing organizational capacity may have important implications for future program planning in the maritime industry. Appointing a single individual may be convenient to coordinate one innovation within the organization, but may be ineffective in building innovative capacity. Further, the ineffectiveness is likely to increase, the lower the organization's single innovator is in the organizational hierarchy. Involving representatives from different levels within an organization in the innovating process is more likely to develop self-perpetuating innovative capacity. This approach may also be more cost-effective in designing and implementing the embedding content of innovations.

The team or committee approach provides a more stable base for organizational commitment to the process. Top management must also be involved if they are to have a sense of responsibility for the innovating process. In the nursing project, the directors of nursing were intimately involved in selecting their team, but did not serve on it. It was felt that their participation might cause other team members to feel less personal responsibility in formulating decisions. The membership, however, included nurses who reported to the director. Thus, a clear channel of communication to top management was ensured, while responsibility for developing innovating capacity was dispersed.

The applicability of the team or committee approach will, of course, vary from organization to organization. Using the example of the National Shipbuilding Research Program, possible adaptations of the team approach include —

1. Establishing an innovating team within a given shipyard with the Program Manager serving as the executive.

   or

2. Establishing an innovating team within a given shipyard that is responsible for developing the innovating capacity of the yard while the Program Manager carries out his assigned functions of design and implementation of specific innovations.

The first approach has the benefit of making use of the existing focal point for innovating activity. The second may have the benefit of encouraging the examination and possible adoption of existing innovations that fall outside the Program Manager's area of technical competence.

DIFFUSION PROCESS

Diffusion is both the final stage in the innovating process and a broad concept in its own right. The diffusion process refers to the means by which one individual, organization, or system transmits an innovation to another individual, organization, or system. Diffusion process can also refer to the means by which one organization or system transmits knowledge that leads to the development of innovative capacity in another organization or system.

The National Shipbuilding Research Program has developed a diffusion process based on three distinct mechanisms.

- ★ *The program office within MarAd is a focal point for diffusion of information about the program itself and about the activities undertaken and new advances achieved by other branches of MarAd. It is interesting that the Society of Naval Architects and Marine Engineers, which houses the Ship Production Committee component of the program, has assumed responsibility for mailing information releases generated by the MarAd program office to its membership.*

- ★ *The Ship Production Committee and its Technical Panels provides a second mechanism for diffusion. As previously noted, the Technical Panels pool both problem information and potential solution information in the course of developing research specifications for funding consideration by the MarAd program office.*

- ★ *The Program Managers who administer research projects in specific areas also carry out diffusion functions. Formal functions, such as the distribution of project final reports and the holding of workshop demonstrations of project results, are integral parts of the MarAd program.*

The diffusion functions of the Program Managers have also been expanding on an informal basis. Perhaps becuase of the visibility the program provides for Program Managers in their particular technical areas, they are becoming information gatekeepers. It is not unusual for a Program Manager to receive calls from engineers in other shipyards requesting information about problems related to the technical area being researched. Thus, lines of communication are being established among shipyards. It should be noted, however, that these lines of communication tend to grow only within isolated technical areas, since both the Technical Panels and the Program Managers focus on discrete topics such as welding, surface preparation and painting, and development of computer aids to production. Consequently, the developing diffusion process concentrates on the diffusion of particular innovations or sets of innovations in particular areas.

The Michigan nursing project, in contrast, seeks to develop a diffusion process which focuses on diffusion of organizational innovative capacity. During the initial phase, two pilot hospitals gained experience in negotiating the innovating process under the guidance of CURN staff. This experience is being transmitted to two diffusion clusters consisting of 2-4 additional hospitals. A series of seven cluster meetings will be held over a nine-month period, attended by the respective Central Innovation Teams. In addition to training materials supplied by CURN, it is hoped that the teams in each cluster will become acquainted with each other and will draw upon each other for assistance.

BUILDING DIFFUSION CAPACITY

The distinction between the diffusion process for single innovations, and building diffusion capacity, is analogous to the distinction between the innovating process and building innovative capacity. Thus, the creation of one diffusion process within a system should create a potential for continuing diffusion. The system's appetite for diffusion should increase with successful experiences. The distinction between a single active diffusion process and a deliberate effort to build diffusion capacity lies in identification of leadership responsibility for maintenance of diffusion within the system.

Both the CURN project and the MarAd program illustrate mechanisms for initiating an external diffusion process that can function without an intermediary. Both contribute to the expansion of the diffusion capacity of their respective systems. However, both have the same drawback from a systems point of view. The responsibility for carrying out the diffusion process is decentralized and may not be the first priority of any of the organizations in the system. It is questionable, then, just how far either program can advance toward the goal of building an ongoing diffusion capacity for their systems.

In general, those systems which have been more successful in building diffusion capacity have a designated intermediary to carry out this function. In an effort to apply this observation, the Michigan nursing project was funded by a grant from HEW to the Michigan Nurses Association. Subcontracts were then let by the Association to collaborating units at the University of Michigan and Michigan State University. The parent grant was housed within the Michigan Nurses Association to encourage that organization to assume responsibility for building diffusion capacity. As a step in this direction, the Association has authorized continuing education credit to Innovation Team members participating in the diffusion workshops.

Many professions emphasize the need for continuing education. For example, a university-sponsored program of continuing education in hospital innovation could be launched; a hospital department that had successfully innovated would become a "resource hospital," and members of its staff would serve as adjunct instructors of the university program. Other hospitals interested in innovation could request assistance from resource instructors and pay fees for consultation or continuing education.

A similar model might prove effective in facilitating diffusion within the National Shipbuilding Research Program. If one shipyard has been successful with a particular innovation, it is not unreasonable that another shipyard — one that would like to adopt the innovation — would be willing to pay consultative fees in order to have the benefit of the first adopter's experience. Since much of the embedding content of shipyard innovations is likely to be transferable, the model holds considerable potential.

Although there are few models of successful strategies for developing diffusion capacity, such capacity is highly desirable. Member organizations of a system with effective diffusion capacity have access to information that will allow a cooperative approach to problem-solving, as well as an expansion of the innovating capacity of each member organization.

SUMMARY

It is hoped that by bringing this conceptual framework to bear on innovation and technology transfer, those in the maritime industry will be able to chart a clearer course in their planning for the future. Four points are to be emphasized. First, it must be remembered that there is much more to innovation than the introduction of specific technological changes. Each technological change must be viewed from the perspective of its impact on the adopting organization. It is often necessary to develop a series of embedding activities that ensure the survival of the innovation and the fit of the new technology into the adopting organization.

Second, in addition to focusing on the successful adoption of individual innovations, it is necessary to address the issue of ensuring the continuation of the innovating process. Instead of reinventing the process each time an innovation is introduced, ongoing mechanisms and procedures should be in place within each organization. This usually means that there must be a focal point for the innovating process. Some person or group must assume the leadership function in this area. Building innovative capacity within an organization necessitates the creation of continuing staff roles or positions.

Third, effective diffusion is critical. Two bodies of knowledge must be diffused: knowledge about specific inventions and innovations, and knowledge about ways to build innovative capacity in organizations. Building innovative capacity within the industry depends on diffusion of knowledge about the innovating process. As was seen in the case of the innovating process and building innovative capacity, there must be a focal point for carrying out the diffusion process and for building diffusion capacity.

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