A DESIGN RESEARCH STRATEGY UTILIZING SIMULATED HEALTH CARE PROCEDURES IN AN ENVIRONMENTAL MOCK-UP UNIT

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Architects facing the challenge of designing facilities for problem areas of a specialized nature or for areas new to their experience face the formidable task of acquiring a sufficient base of information to permit the full utilization of their design capabilities. The architect today would like to identify his role as a comprehensive problem solver and yet works within a fee structure and time schedule more reflective of a less demanding description of his functions. His ability to deal thoroughly with design issues is frustrated by his inability to command the resources of time and manpower to develop the necessary information base needed for a penetrating design analysis. On normal time pressures, he can penetrate the problem to the extent of becoming familiar with some of the basic literature, perhaps visit comparable facilities and in addition to whatever can be supplied by the owner group, make do with this level of preparation. The same pattern of involvement is repeated over and over in various communities with little possibility for any designer to make a significantly greater depth of penetration into the problem except through specialization. The architect so prepared is not in a strong position to raise, in the prc - gramming phase, the penetrating questions which direct the users to more thoroughly question their premises and demand a significant improvement in the performance expected, nor can he serve as well the function of providing preliminary design and cost implication of various alternative operating policies which are valuable, essential elements of the programming dialogue.

The hospital user group faces similar problems in having limited resources to investigate the field in depth and to be more knowing in describing their problem in a way that has the highest potential for matching needs and capabilities.

Typically, a facility planning committee in the hospital or any other institution while professionally competent will usually have had no previous experience in programming building facilities and when the problem involves new and unfamiliar special facilities may have had no experiences in either the design or use of such spaces. The likelihood of significant design improvement emerging from this situation is obviously not hopeful.

The project described in this paper while set up to meet the specific needs of coronary care units is seen and presented as a possible model approach to a needed area of applied design research. This type of research is described as situational rather than general. It is both pragmatic and eclectic, utilizing whatever approaches that may be necessary to yield the information required.

To illustrate the range of research tools utilized in the study, the matrix shown in Figure 1 depicts the major decision areas in the CCU planning and design process against the various techniques available for developing contributing information in these areas. This is included to indicate that while this presentation deals more specifically with the problems and impact of environmental mock ups, that it is only one of many devices used and that it's use was related to insights gained through various other techniques.

The researchers were concerned that the studies and results should be complete and authoritative yet not become an inhibiting factor for continuing innovation by establishing overly doctrinaire and absolute recommendations. Nevertheless, many small hospitals with limited ability to explore the problem area require unambiguous models to aid their decision process. The strategy was to make specific recommendations whenever supporting evidence was available, and to present

● MAJOR IMPACT

○ MINOR IMPACT

RESEARCH TECHNIQUES / DECISION AREAS	determination of need	alternative care strategies	policies and procedures	unit capacity	unit location	unit configuration	room size	equipment layout	room amenities
total system model analysis	○	●	○		○				
generic nursing station type study				○	●	●	●	○	
generic CCU type study		○	○	○	●	●	●	○	
literature search	○	●	●	○	●	●	○	○	●
patient questionnaire		○	○			●	○	○	●
medical staff questionnaire	○	●	●	●	●	●	○	●	●
activity analysis			●		○	●	○	●	
computer simulation of patient flow	●	●	○	●					
mini-max storage analysis			●		○	○	○	●	
CCU observation study			○		○	○	●	●	○
simulation of emergencies in mock-up			○			●	●	●	
ergonomic studies using mock-up			○			●	●	●	
expert consultation	○	●	●	○	●	●	○	●	●

Figure 1.

issues clearly when significant differences in supporting evidence existed, but in any event to relate all design recommendations to care strategies and procedures and to document thoroughly all data involved in making design decisions. In this way various users will be able to extract data ranging from a most basic level to that of complete design description.

As a design oriented project it stops short of undertaking basic research into man environmental relations. The approach defines a middle ground between what each designer-owner group can develop in isolation and the laborious and meticulous scientific research ultimately needed as a basis for design.

While it is felt that the coronary care unit represents an excellent vehicle for developing an approach to this research strategy, entry into the field of coronary care was simply fortuitous.

In the spring of 1970, Colin Clipson, a designer interested and experienced in systems and ergonomic studies and the author were approached by a team of physicians, nurses and hospital administrators to consult with them on their efforts to improve the capability of Michigan hospitals in providing a high level of care for patients suffering heart attacks.

The project's charge is to aid Michigan hospitals establish and improve their capabilities in providing coronary care through nurse and physician training and advice and financial assistance is setting up units. The project staff after a year of operation perceived a problem in that unit design and layout have presented serious obstacles to proper performance of the clinical procedures and psychologically supportive environment for the patient. While both principals had some previous experience in the hospital field, they were essentially uninformed in the area of intensive care for cardiac patients. After a briefing by project physicians, visits to local CCU's and a review of the classic literature, a three month summer involvement was undertaken to both offer architectural consultation with project hospitals and to develop a research plan to bring to bear specialized design insights in the development of next generation coronary care units.

From the outset the design research team viewed the CCU project as an excellent vehicle for establishing a model for the study and presentation of design oriented data for specialized facilities of all kinds, though acceptance of our proposal was based strictly on the anticipated benefit to be derived in the coronary care area generally and on the design of the intensive coronary care areas specifically. While it is not, for the purpose of this paper, necessary to expand on the specifics of coronary care units, some general familiarization is important.

The concept of caring for coronary patients in a specialized intensive care area dates back only to the early 60's. The clinical basis for the CCU rests on the discovery that externally applied electrical shock can restore effective pumping to a heart developing potentially fatal arrhythmia. This along with the ability to temporarily maintain blood flow in an arrested heart by rhythmic compression of the sternum made recusitative effort feasible and practical.

Development of electronic monitoring of cardiac rhythm and other physiological parameters with audio and visual alarms when conditions exceed present limits, set the stage for the development of the CCU.

Intensive coronary care has been described as a system of specialized care for preventing death from complications of acute myocardial infarction (heart attack). It requires the delegation of authority to specially trained nurses to diagnose and treat specified complications. Nurses are available 24 hours a day and care for 2-3 patients per nurse assuring a high level of personal care. Ideally the physician care is centralized in the unit director as a means of assuring prompt unambiguous application of the best care procedures available.

The CCU is the setting in which predetermined policies, trained personnel, electronic monitoring, emergency equipment and supplies are all immediately available for instant response to life threatening emergencies.

In recent years the emphasis in the CCU has shifted from resuscitative to preventative efforts. The complications that cause sudden death provide premonitory signs sufficiently

early to permit preventative measures and consequently the preventative management of the coronary patient has significantly reduced the number of emergencies in the unit.

The early experience with the CCU's demonstrated that the hospital death from myocardial infarction could be reduced by approximately 33%. This same level of success is being achieved by most hospitals with Coronary Care Units and serves as a stimulus for all but the smallest hospitals to provide this type of specialized care. Since the early 60's probably 3000-4000 hospitals have established units and pressure exists to install units in the remainder as well as to expand and improve existing units.

The role of environmental mock up and simulation can best be introduced by listing a number of distinct purposes to be served by this study technique.

Purpose

1. To familiarize the design research team with emergency procedures utilized in coronary care.

2. To aid in evaluation, of existing space standards as promulgated by various agencies.

3. To provide the setting for obtaining photographic records of emergency procedures and making them available through publication to other designers.

4. To function as a catalyst in eliciting expert opinion on CCU procedures and design.

5. To enable researchers to investigate optimum locations for fixed and moveable equipment items and to document recommendations.

6. To test new configurations under simulated conditions and obtain expert evaluation.

7. To obtain a spectrum of controlled photographs to be used in assessing psychological responses to varied clinical settings

8. To serve as an aid in coronary care nursing education.

Mock Up Description

The structure is comprised of a set of easily erected, easily changed wall panels, storage units, and life support equipment, which can be set up in a wide variety of ways, to realistically provide an operational and physical environment for cardiac care. The mock up unit carries a complete range of room furnishings, so that the resulting configuration is both operationally and visually very realistic.

The unit was fabricated by the researchers in the department wood shop using 1" x 4" pine frames with 4' x 8' homosote face panels painted a typical hospital yellow-tan. Using simple drilling jigs and assembly jigs, 17 wall panels, service panels for electrical supply, oxygen, air and suction, fabrication of bracing members, shelving and painting, etc. were all completed in less than seven man/days.

Materials in the unit ammounted to $320.00.

Five of the seventeen wall panels were built with removeable window areas and could be readily moved into any position as well as quickly replaced by a solid panel. Frames were pre drilled to permit edge to edge bolting in three places. A 1 x 4 carrying a K.V. track is sandwiched between each panel frame to permit adjustable height shelving wherever required.

The initial installation of the unit was in a carpeted classroom in the Towsley Center for Post Graduate Medicine. The structure had to be free standing, and for this reason, was stabilized with 2 x 6 beams at each module with external diagonal bracing. The overhead 2 x 6 beams were utilized for hanging T.V. lights and cameras. A crew of four men completely erected and furnished the unit in less than two hours.

This data is included to indicate that the mock up does not require a major committment of time and materials, and can be considered as a study device on relatively low budget projects.

Simulation procedures

A series of cardiac conditions are simulated by the utilization of Resusci Anne, a life like "robot" patient which can be electronically programmed to develop a range of arrythmias and life threatening states, e.g., ventricular tachycardia, ventricular fibrilation, cardiac arrest. Changes in the ECG output of the "patient" are displayed on cardiac monitoring equipment, in and around the unit. The patient is also equipped with a special thorax skin so that cardiopulmonary resuscitation can be performed. Three member teams of nurses watch the progress of the patient on monitors which are both at the patient bedside and at the nursing station adjacent to the patient bed area. The nurses are provided with the patient's case notes, so that as each simulation period starts, the nurses can familiarize themselves with the patient's condition, much like at a change of shift.

Each group of three participants operated in the unit over a 40 minute period responding to three distinct sets of problem events. The course of the three events was determined within an overall framework by the training nurse in control who could program normal and arrythmical ECG traces via Resusci Anne on the monitor. This nurse, at a control desk responded by voice for the patient, answering nurses questions and raising typical complaints and concerns. The nurse in control adjusts the "patient's" response to treatment interventions both electronically and verbally while the second training nurse kept a check list with notes for a subsequent critique.

After each 40 minute session the configurations were changed and the design researchers and training nurses and participant nurses discussed problems of clinical procedure, design variables and suggested alternatives. In earlier sessions critiques of the simulation itself led to subsequent changes.

A layout of the simulation area is shown in Figure 2.

Video Recording

Recording of the activities in the mock up is achieved by the use of two T.V. cameras. One camera is located over the unit, providing an elevated view down into the mock up. A second camera is situated outside the walls of the unit, and provides eye level views through openings in the sides of the mock up. Both cameras are controlled and synchronized from a central T.V. control panel adjacent to the mock up. Simultaneously, the visual output is displayed on T.V. screens for the benefit of the instructors, observers, and other classes outside the mock up area. "Instant replay" can be used for discussion and critique seminars after the training seminar is completed.

A thirty-five minute video tape has been prepared for general educational purposes.

Summary of experiences

This section will expand upon the purposes established for the unit, and discuss results achieved.

1. To familiarize the design research team with emergency procedures utilized in coronary care.

Perhaps the major reason leading to the use of the environmental mock-up unit was the difficulty of obtaining first hand experience with the events involved in emergency treatment of patients. Though the various members of the research team spent many hours in many hospitals, it was nearly a year before an emergency was observed by a member of the design research Team.

The design team documented from the literature and through consultation, the sequence of procedures, number, and role of participants and yet lacked an operational grasp of the emotional and spatial dynamics of the situation. A cardiac emergency is the ultimate medical emergency. The patient is literally resuscitated from a condition only problematically distinguishable from final death. The resuscitative activity is at a high level with the area crowded with 5 to 7 direct participants, and even more peripherally involved or redundant medical personnel.

Even given the possibility of observing without interference, the architect desirous of witnessing an actual emergency must be prepared to

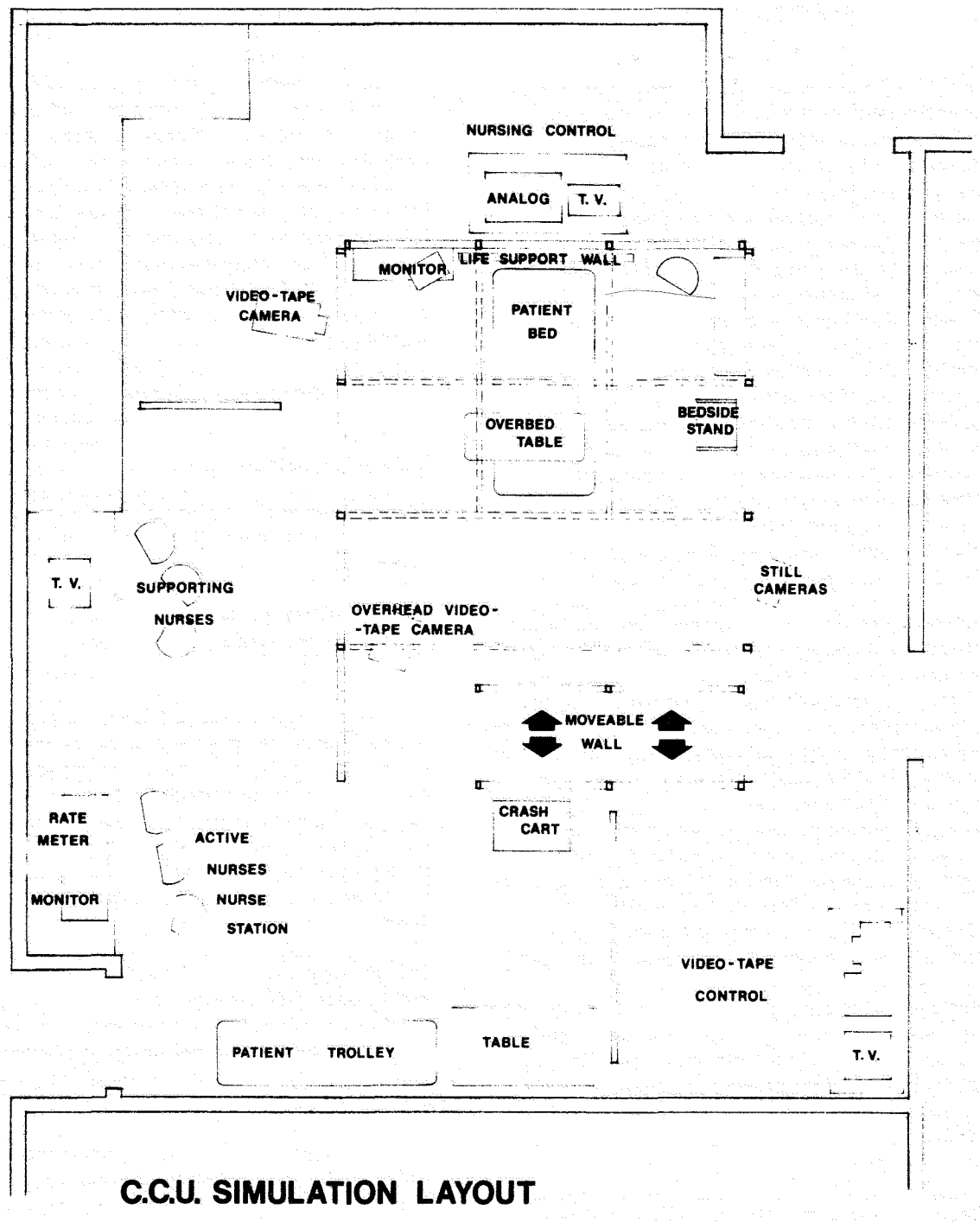
NURSING CONTROL
ANALOG
T. V.
MONITOR
LIFE SUPPORT WALL
VIDEO-TAPE CAMERA
PATIENT BED
OVERBED TABLE
BEDSIDE STAND
T. V.
SUPPORTING NURSES
STILL CAMERAS
OVERHEAD VIDEO--TAPE CAMERA
MOVEABLE WALL
CRASH CART
RATE METER
ACTIVE NURSES
MONITOR
NURSE STATION
VIDEO-TAPE CONTROL
PATIENT TROLLEY
TABLE
T. V.
C.C.U. SIMULATION LAYOUT

Figure 2.

spend many hours in the unit awaiting the event for which massive efforts are being expended to prevent. Currently, in well managed units of moderage size emergency procedures are becoming more and more rare, often only 2-3 per month.

The possibility of installing CCTV in an actual patient room was considered and ultimately rejected as an intrusion into both patient and staff privacy at so critical a time. In addition, there was no way of determining how situation dependent these observations may have been. Thus the decision was made to use a changeable, realistic mock-up, wherein the procedures could be studied under controlled and varied conditions.

Results

There was little doubt that the use of the unit fulfilled the objective. Subsequent experience with witnessing actual procedures convincingly demonstrated that the simulation presented a good fascimile of actual events. The crowding around the patient, the physical effort required, the need for coordination, as well as individual effort were made extremely clear as one watched the events develop.

One's perception undergoes a considerable change when he goes from a situation in which he knows that a patient's chest will be rhythmically massaged to when he experiences a nurse climbing onto the bed and utilizing her whole efforts to load and unload the sternum with a stiff and rocking motion. Seeing half a dozen physicians and nurses straining to read monitors, hurrying by people and equipment, stepping over and reaching over electrical cords, tubing and electrodes, hearing orders, comments, and requests, deliver a good approximation of the action.

While excellent as straight reportage of what occurs, and even though participants were serious and trying to perform effectively, one cannot simulate the emotional climate that exists when a life is in the balance. Knowing this, the researchers felt that potentially disruptive events would be more serious in actual practice. The element of mess was also missing In heart stoppage, patients may vomit or void themselves thus adding additional trauma in the form of stench and waste in and around the patient's bed. These are certainly drawbacks but have been accounted for by extrapolating beyond that which could be observed.

2. To aid in evaluation of existing space standards as promulgated by various agencies.

As the clinical experience of the pioneer CCU's were published, first generation units were built following the examples of the pioneer units. Upon entry into the problem area, many of the characteristics which identify the CCU were contained in a variety of available guides and standards. Typically, these standards would specify the services oxygen, air, suction, electrical outlets, etc., recommended room dimensions, and safety precautions. Analysis indicated that most hospitals were unable to meet the full recommendations and that lacking insight into the relationships between operation and facility, the architect and to a lesser degree, the hospital staff, were unable to satisfactorily adapt in less than ideal circumstances. Beyond this, more refined determination of equipment and services was beyond the designer without a major effort to immerse himself in understanding the critical events involved in treating cardiac patients. The goal was to produce a comprehensive set of design recommendations based on the latest cardiac care procedures.

Results

Experience with the unit suggested that firm recommendations regarding overall size and clearance could be overly simplistic. Initial configurations, set up to provide the generally recommended room sizes, indicated they were workable and probably even desirable. From experience in hospitals one could also see that many rooms were, because of existing conditions, not nearly as spacious and yet supported these activities. Work with the unit indicated that working space could be reduced below generally recommended levels and resuscitative activities could still be carried on. The larger rooms were simply more forgiving of placement of emergency items, and could tolerate the presence of furniture and other items of a temporary nature that might be in the room at the time of the emergency.

It was found that smaller rooms could work effectively when, by preplanning, staff would agree on locating moveable equipment in designated area and to clearly allocate roles, and limit the number of staff involved.

Similarly, trade-off between space and built-in equipment could make smaller rooms satisfactory. Beyond this we were able to show that emergency situations were better handled with fewer participants than normally present.

We concluded that the larger rooms were good practice not necessarily for the present, but in anticipation of new equipment and procedures that might begin to reduce the mortality from circulatory failure which, at present, CCU's are essentially no better at preventing than are regular medical areas.

Conclusions in this area are subject to the same potential critiques observed under the first objective, i.e. under truly emergency conditions, behaviour, and therefore space needs, might vary from observations made under less stressful circumstances.

3. To provide the setting for obtaining photographic records of emergency procedures and making them available through publication to other designers.

Beyond running the experiment for the benefit of the research team, we faced the problem of developing an equivalent familiarity with process and facility for the users of published information. High priority was given to recording the event through both Videotaping and still photography; and subsequent sequence photography from the taped footage. In the first simulation, the photographic record had the advantage of spontaneity while lacking in the most descriptive camera angles largely as a result of the space in which the unit was constructed.

The present location provides an improved set-up for obtaining more useful photographs. In addition previous experience will aid in reproducing situations most likely to identify critical events as they relate to facility design.

Results

We have over 3 hours of Videotape which have been reviewed for relevancy to physical design and layout. An edited 30 minute segment is available for interested designers as well as for nurse training purposes.

Thirty-five mm. sequences have been shot from the footage to document specific space standards. Additional situations are now being set up and photographed directly in the newest version of the mock up unit which utilizes the most modern equipment donated by manufacturers for the purpose. First generation photographs while unsuitable for publication have demonstrated their potential usefulness.

4. To function as a catalyst in eliciting expert opinion on CCU procedures and design.

This objective is admittedly after the fact. It was found that, prior to experience with the unit, attempts at deriving design related information from nurses and physicians was less than satisfactory. Experts when communicating with architects tended to filter their experiences and tell only what they thought the architect wanted to know. A pleasant unanticipated benefit of the mock-up unit was its effect on structuring a higher level of pertinent communication between physicians, nurses and the research team.

Following each 40 minute simulation, researchers met with the participants in a brief review session. These discussions yielded not only critiques of the CCU room layouts but served as a springboard for comments and insights across a wide range of CCU policies, procedures and design.

Results

Follow-up sessions produced a large number of valuable anecdotal experiences in CCU, suggestions and insights and contradictions which led to the formulation of a questionaire which was run as a pilot on a nurse training group of experienced CCU nurses and subsequently on an expanded list of trained nurses.

5. To enable researchers to investigate optimum locations for fixed and moveable equipment items and to document recommendations.

In an environment where seconds saved in procedures requiring coordinated efforts of a

number of trained specialists each of whom have specific, tasks involving fixed and moveable equipment, the optimum location of people and machines has dramatic and serious consequences. Experience with CCU's in many hospitals has shown considerable variation in placement of key equipment items and some evidence that people learn to "make do" with some horrendous situations. Existing hospital rooms permit an analysis of a given configuration but mitigate against controlled manipulations and detailed study of alternative positions. The variable mock-up allows the researcher to personally take on the role of participant as well as to observe and study actual participants as they perform specified tasks under varying situations.

Results

These studies have not as yet been made, although pilot studies utilizing some of the largest equipment items has been done. No difficulty is foreseen in performing the studies and documenting results

6. To test new configurations under simulated conditions and obtain expert evaluation.

The sum of all investigatory techniques will begin to indicate possible departures from current practices. To whatever extent this becomes true, whether in terms of basic layout or in more detailed aspects of the design, it is intended that these potential recommended practices be subject to experimental use by medical teams to assess their effectiveness.

Basic relationships of bed position, room openings, clearances and toiletting provisions, fixed and movable equipment will be varied and used under controlled conditions. In some instances physiological stress may be measured as an indicator, in others patient and staff preferences will be sought and analyzed. Medical personnel will operate the facility as well as the research staff in order to provide comprehensive evaluation of potentially innovative configurations.

Michigan hospitals planning new units may set up alternative configurations for evaluation by project staff and hospital staff as an aid in reaching design decisions.

7. To obtain a spectrum of controlled photographs to be used in assessing psychological responses to varied clinical settings.

The range of experimental data relative to the impact of the CC room on the psychological state of the patient is extremely limited. On the other hand it is clear that patients requiring the facility are in a state that makes their electrical stability extremely sensitive to various emotional factors. An assessment of the specific environment experienced by a patient is made difficult because the level of care in CCU's involving usually one nurse to not more than three and often two patients that this personal attention overides any focussing on specific disatisfaction with environmental factors.

By identifying features of the patient area environment that may be more or less stress producing, it is intended that comparative photos be made as a basis for determining preference on the part of healthy people in general as well as former patients.

8. To serve as an aid in coronary care nursing education.

The interdisciplinary make up of the project team facilitated easy cooperation in meeting nurse training as well as design needs in the use of simulation. Nurse participants, many of whom had CCU experience were able to gain experience in operating under standing orders different than in force at their own hospitals. In addition, they could participate in various roles as another means of broadening their experience.

A major advantage relative to the training function was the ability to observe one's own performance immediately after the event through the medium of Video tape. Combined with group critiques, nurses not only could see their actions but also discuss alternative actions which may have been more widely used by other participating nurses.

Results

To date approximately thirty nurses have participated in training sessions as an applied portion of their specialized training. Directors of the nurse training program express enthu-

siasm for it's value in clinical training and have considered taking the unit to out state locations for additional sessions. Though limitations of budget ruled this out, the 30 minute Video tape edited from the first training effort is being so used in current training sessions around the State of Michigan.

Request for opportunities to use the facility have been received from the Inservice Education Div. of the University Hospital and another from the University Hospital's CCU. It is planned to mock up versions of their new unit as a means of breaking in new nurses assigned to the unit.

A peripheral benefit of the collaboration has been achieved in that the nurses exposure to the project architects has tended to increase their concern with problems of layout and design. It is likely that nurses so exposed will be better able to get the most from their own unit layouts as well as to be better participants in future unit planning activities.

Summary

In summary, we have described an overall eclectric approach to providing procedural and environmental design information for a specific specialized facility. For reasons which may to some extent be unique to our study area the use of an environmental mock up unit together with use simulation has provided and promises to further provide important contributations to both our understanding of and ability to communicate findings related to Coronary Care to hospital officials and architects facing the design of these facilities. Value of the technique relative to effort expanded was considered to be excellant. Since our efforts with environmental simmulations revolved exclusively around our immediate needs we can only speculate on it's value in other applications.

When some of the following conditions exist the use of environmental mock up might be considered.

1. When design information gained can be applied to large numbers of units under design.

2. When subject area is difficult to study and manipulate in situ.

3. When the man-machine-environment is observably responsive to changes in its parameters.

4. When effects can be observed and studied over a limited time span.

5. When motivation of participants is sufficient to ensure proper response.

6. When the critical elements of the environment can be properly controlled.

The project described is now approximately 60% completed. Those associated with it are optimistic that it represents an important area in the overall spectrum of environmental design oriented research. Major effort now is focussed on communicating information developed in the course of the project into a format sufficiently flexible to serve a wide range of needs without being either overly prescriptive nor open ended to the point of vagueness. If successful, the work should serve to raise the level of design of Coronary Care facilities by eliminating the informational impediments that limit the creative interactions between well informed designer and user.

Beyond the immediate application is seen the possibility of similar process oriented design investigations attacking problem areas in all fields. As this time approaches further efforts should be expended in improving storage and access to this material as well as to assure regular updating of stored information.