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Abstract

Building Research is urged to expand into areas concerned with human behavior, and a need for information on how people react physically and mentally, and how they perform their various tasks in environment created for them by the design professions, is cited. A research project at the University of Michigan is described, aimed at measuring the effects of all aspects of the environment on the learning process. Environment is considered in terms of--(1) atmosphere, (2) light, (3) sound, (4) spatial arrangement, and (5) social groupings. Human behavior is considered in terms of--(1) physiology and anatomy, (2) perception, (3) mental reactions, (4) performance, and (5) learning. (RH)

Needed Research on the Effect of Buildings on Human Behavior

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It is an astonishing fact that the problem of human requirements has received less attention than other kinds of building research. Sporadic attacks on the problem have been made during the last three decades or so. There has been much talk, a substantial body of folk lore has come into existence, and the art of pretentious know-how has flourished. But scientifically grounded knowledge about the effects buildings should have on their inhabitants seems to be minimal. This is indeed curious, since after all, buildings are designed for people, and an understanding of those for whom you are designing should be the first order to business. Yet, what should be first is the last problem to which building research has been directed.

The reason is that building research has traditionally and properly dealt with buildings and their components. Experts in the understanding of human beings and their requirements have, by and large, not concerned themselves with buildings. The two have seldom met together. Consequently, the problem of applying what the latter know, and of turning their attention to buildings, still remains.

Perhaps a synoptic look at the traditional agenda of building research will help us to an understanding of what can and needs to be done. Looked at in one way, it may be said that the criterion of efficiency dominates building research. In this, of course, building is not unique. It simply partakes of the general approach to problems which colors our whole existence. The drive is directed towards efficiency, productivity, performance. It is basically a technological drive, revolving around engineering, production, and costs. In building research it has taken typical forms. First and foremost, perhaps, is the development of new products and the improvement of existing ones. The problem here is to find something which will do a particular job better, or perform in a way no other product can. Then there are investigations into new or improved ways of putting things together, organizing processes, mechanizing operations. The attack here is on finding more effective, less costly and less time-consuming means for producing a building or its components. There is, in addition, the search for ways of integrating all building components so that they fit and dovetail into each other without further processing. This is the problem of standardized and interchangeable parts, and of modular coordination. All of these forms of building research converge in their different

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ways on the problem of minimizing materials and cost inputs, or maximizing product and performance output, or both.

Let us concentrate on the product, where the research problem is the development of new and better products with enhanced performance. Here we deal with such matters as: structural members and systems which can carry increasingly heavier loads with less and less use of materials, or which can span ever larger areas; walls and partitions having ever more functions built into them; heating and air conditioning systems which are more and more adequately responsive to changes in environmental conditions, and which can completely stabilize atmospheric conditions; acoustical and lighting systems which are so flexible as to be able to create almost any desired acoustical and lighting environment.

Stated in this way, the goal of building product research is a drive towards ultimate performance of buildings and their components. It is a drive grounded in, and enamored of, a technological ideal, one which is devoted to the exploration of the utmost limits of the possible. The main emphasis is on the performance of buildings and their parts. This can, and in many instances does, come close to the creation of virtuosity in buildings for its own sake. Here we have the ideal of the bigger and better, where better means greater versatility and putting on a good show. Largely dominating building research, this efficiency criterion results in "see-what-I-can-do" buildings.

This, of course, is both admirable and necessary. For it tells us what buildings can do for humanity. It is not, however, enough for building research to stop there. It needs to go on and find out what buildings should do for their users. Perhaps some of the ways in which we make buildings perform are harmful to those who use them. We all have some general ideas, and even strong feelings, about what is bad and what is good for people in buildings, but we have very little real evidence, let alone precise knowledge, about how and in what ways buildings are harmful or beneficial to their inhabitants. Should we aim at environmental constancy or stability at what seems a reasonable level of adequacy? Should we endeavor to minimize the effort involved in human adjustment to environment? Or should recognition of the human need for variation in environment lead to the creation of flexible conditions which building users can manipulate to suit their convenience? And if so, how do we know that we are building in the right kind of flexibility, and are being flexible about the right kinds of things?

It is quite possible that what we make buildings do may be harmful to the human body or mind, or to the tasks in which men engage. What we need to do is not only to make buildings perform as we want them. What we need to know is not only how buildings and their components perform. Even more urgently we need to know how people react physically and mentally, and how they perform their various tasks in the environments we create for them in buildings.

Work on the impact of the environment on human behavior is by no means new. Apart, however, from isolated and sporadic forays, most of them notably dealing with housing, those concerned specifically with buildings have hardly ventured into this type of research. They do appear to have an increasing awareness of the problem of human requirements, but building research in this area is still in a pioneering stage. In order even to begin to consider this problem of human requirements, it is necessary to shift our perspective from the building, its parts and its installed equipment to the environemntal conditions created by them. The focus of attention becomes this environment, with the building and its components regarded as devices for the attainment of the environmental conditions required by those who live and perform their various tasks in it. The environment is thus interposed between the building and its users. The type of analysis now indicated is one which seeks to establish connections between the environment and human behavior—connections which permit us to know how buildings and their components need to perform, not simply how they do perform.

Earlier this year, we embarked on a research program along these lines. This is a University of Michigan Research Institute project, centered in the Department of Architecture under the direction of Prof. C. Theodore Larson, and sponsored by the Educational Facilities Laboratories of the Ford Foundation. It is an endeavor encompassing many disciplines. We have a general supervising and advisory committee of some 20 members, known as the School Environments Research Planning Group. Actively participating in the research is a group of faculty consultants who are experts in such diverse fields as engineering (mechanical, illumination, acoustical), mental health, physiology, education, meteorology, human engineering and other branches of psychology. The day-to-day work is carried on by a research staff of equal diversity. This array of talent is indispensable because the problem is a large one: namely, to measure the effects of all aspects of the environment on the learning process.

This is a long-range program, involving the development of methods and procedures, testing them in classroom situations, and creating laboratory classroom facilities where they can be applied. At present, we have funds for searching the literature and making an inventory of what is known about the effect of the environment on learning. This material we hope to sum up and evaluate, using it at the same time as a point of departure to evolve methods and procedures for a more definitive attack on the questions under consideration.

As some of the problems emerged, the first that presented itself was the clarification of what is meant by environment and by learning, and the identification of the variables which had to be considered in each category. The clarification of what constitutes learning is proving exceedingly difficult. There is no agreement among educators, nor is there any satisfactory measure of learning achievement. Yet, we must have some operational way of handling learning if we are to develop and apply a technique for testing the effect of the environment on learning. At the moment, the solution appears to be to concentrate on specific tasks and specific types of learning. Even so, the identification of significant learning types and tasks is not going to be easy; nor, unfortunately, will the problems associated with learning end with its clarification.

There is a dearth of material on the impact of the environment on learning. Experimental evidence is meager and inconclusive, and points up the difficulty of arriving at any definitive conclusions. We rather expected this, and decided to cast our net wider than the learning process and encompass the effect of the environment on human behavior in general. We did this because we felt that if we could establish connections between the environment and other aspects of human behavior, we might in turn be able to find connections between these and learning. As a consequence, our problem was expanded towards clarifying and identifying the variables of human behavior in its widest sense.

At the present time, we are considering the environment under five main headings:

1) The atmosphere - temperature, humidity, air composition and air movement.
2) Light - intensity, contrast, color, surface and media characteristics.

3) Sound - frequency and intensity, fidelity of communication, and background noise.
4) Spatial arrangement - positional relations and dimensions of objects (including people) and building components.
5) Social groupings - the characteristics and behavior of groups.

We are considering human behavior also under five main heads:

1) Physiology and anatomy - body temperature and fluids, blood constituents, the central nervous system and posture.
2) Perception - vision, hearing, smell, feel.
3) Mental reactions - comfort, attitudes and moods, morale, alertness.
4) Performance - efficiency, task accomplishment, group activity.
5) Learning - verbal and motor.

The problem is to determine what effects (if any) the environmental variables have on the behavioral variables, with special emphasis on performance in general and learning in particular. Because certain behavioral variables—physiology and anatomy, perception, and mental reactions—act as intermediaries between the environmental and the performance (including learning) variables, it becomes important also to try and determine the effects of these behavioral variables upon the performance ones. Since our ultimate concern is with the total environment, interrelations among the environmental variables are as important as among the behavioral variables.

In the pursuit of these tasks, it is necessary to break down and decompose our major categories into variables which can be measured. This means that we cannot rest with variables which are complexes of many things and whose meaning is not clear. We must push on towards variables so clearly identifiable that they can be quantified. Only then will it become possible to perform experiments to determine which variables, and what relations among them, are significant. Altogether too many experiments fail to refine and clarify sufficiently such notions as comfort or performance. Unless this is done with some degree of exactitude, it is frequently difficult to interpret the results of experimentation.

Let us now look a little more closely at what our search through the literature has so far uncovered about the effects of the environment on human behavior. The experimental evidence seems to raise more questions than it answers. Our coverage is as yet far from complete and, even in the areas like temperature and humidity where its extent warrants preliminary evaluation, we have not had the opportunity to begin pulling the material together. However, from my acquaintance with what we have found, it would seem that definitive and reliable relationships between environmental and behavioral variables are not going to emerge in any great profusion, nor is it going to be at all easy to evaluate such standards as we now accept.

Many of the experiments reported in the literature contradict or seem to contradict each other. As usual in such circumstances, this raises questions of adequacy of experimental techniques, specificity of conditions, and interpretation of results. For example, several experiments showed that high intensity noise of the order of 105-115 decibels had no effect on mental performance. Yet, another experiment showed that a task involving a considerable memory load was performed at a slower rate at 100 than at 70 decibels, and this slowdown continued after quiet was restored. Also, both declines in performance and no effects of noise on performance were found by different experiments on "vigilance" tasks. One experiment even showed that amplification of autogenously developed muscular flexion noise acted as an auditory stimulus to work output. Does the effect of noise on performance vary with type of task, complexity of task, or both? When it is shown that a complex mental task performed in relative quiet is less demanding physiologically than when performed in 110 decibel noise, are we to infer that what is physiologically demanding is also physiologically harmful?

Much the same kind of question arises from the experimental results of the effects of distracting stimuli. One test showed that visual and auditory distraction did not affect performance of a mental task. Another showed that the intelligibility of material presented either visually or by audio means was reduced by distracting influences. Contradictory results also appear in endeavors to find the relative effects on learning of audio and visual methods of presenting material. One study showed no significant differences in examination grades of students taught by television, television plus discussion, or through regular classroom lectures. Another showed that a group taught by television scored significantly higher grades than one taught by radio, which in turn had significantly higher grades than the ones which saw and heard the lecturer or simply read mimeographed copies of the lecture. A re-examination, covering the same material, given 8 months after learning, showed the television group again to be superior, with the group who saw and heard the lecturer moving up from last to second place. To what extent novelty or motivation influenced the results, we do not know. Nor do we know what disturbances were present, and how they affected absorption and retention of the material presented.

Turning to the effect of atmospheric conditions on behavior, it is not surprising that the same kind of problem emerges. We have experiments showing deterioration of performance in hot, humid environments. On the other hand, we have experiments showing no significant differences between performance in such conditions and in cooler, drier atmospheres. In the experiments cited, deterioration occured in the performance of motor tasks and not in complex mental tasks. However, the degree of motivation in the subjects varied from one experiment to another, and it is not clear how (if at all) this counteracted adverse atmospheric conditions. In addition, the tasks varied from one hour to five months. We still do not know much about the effects of acclimatization, and how people would perform when exposed to the same conditions for long periods. The experimental evidence on the effects of ionization (a subject currently of considerable interest) varies from no definite effect, to slight but insignificant improvement in physical efficiency, to indications of possible beneficial effects on health.

We have come across a few experiments which show students able to recall learned material better in the same surroundings where the learning took place. The presence of the same instructor also helped. Experimentation with the presence and absence of a distractive but not unpleasant odor, showed better performance when the conditions under which recall occurred remained the same. This raises the question of whether it is better to have all the experimental conditions the same, or only certain key ones. And if the latter, then which?

An experiment concerned with solving a mental problem showed greater efficiency and quality of work in an orderly than in a disorderly room. Another showed the brighter students to be less affected by the environment than the less bright ones. An experiment on rats showed dull rats improving their learning ability to the level of bright ones when reared in a stimulating environment; while the learning ability of bright rats reared in an uninteresting environment was reduced to the level of the dull ones. There is a good deal of such isolated experimentation containing interesting and suggestive results, but it needs to be supplemented by additional evidence, and with work designed to bring out the impact of specific variables rather than of order in general or a generally stimulating type of environment.

Much work still needs to be done on the interrelations of effective temperature, the feeling of comfort, physiological processes, and performance. Many experiments have shown that there is no necessary connection between how one feels and how one performs. Others, however, have shown ties between physiological responses and comfort sensations, between effective temperatures and comfort, between body temperatures and performance. Perhaps complicating factors like diurnal changes in body temperatures have obscured the interrelations. If, moreover, as has been experimentally indicated, such diurnal changes affect performances, then what we should aim at is not a constancy of climatic conditions, but a controlled variation, and this makes it mandatory exactly to describe and measure the diurnal changes.

The often noted interrelation between the senses raises the question of how and in what manner visual, auditory and other types of stimuli can reinforce each other in improving performance. The experimental evidence offers some hints. For instance, it has been shown that the presence of certain colors can raise or lower the threshold of perception of certain tones. It has also been indicated that auditory pre-training on verbal learning materials facilitates later visual recognition of the same materials. Another experiment, where subjects learned to identify shapes through one sense and then learned to identify the same shapes using another sense, showed that visual recognition after touch learning required fewer trials and gave fewer errors than the converse. Such experiments are but a beginning towards an understanding of the impact of sensory interrelations on performance.

On the whole problem of theoretical and methodological considerations, it is only possible to give a few examples. Over a decade ago it was shown that the effective temperature index (which describes the various combinations of temperature, humidity and air movement, which give an equal sensation of comfort) overestimated the effect of humidity in the moderate range and underestimated it in the higher range. Whether a proposal to use skin temperature to correct the effective temperature index was ever systematically explored, I do not know. It is, however, in line with other attempts to place subjective sensations on an objective basis. A great many experimenters put people in a controlled environment and then asked them how they felt. Some of the research is directed at devising more exact methods of measuring human reaction to environment. Those engaged in odor research are particularly conscious of the necessity for doing this, and attempts have been made to move towards objectively grounded methods for measuring odor intensity. This movement from subjective to objective measurement is well illustrated by an experiment which showed that muscular tension decreased progessively when people read at successively higher and higher levels of illumination.

Underlying all these technical problems is the organizational one. How do you bring order into a large body of the most diverse kinds of data, and evaluate it in terms of building requirements? How, moreover, do you bring together specialists of equal diversity, convince them of the importance of focusing their continuing attention on building problems, get them to work together and understand one another, and have each participate in the development of a new intellectual outlook which incorporates them all? This task is truly formidable. So far, we have only been able to make some small beginnings.