Engineering Technology and Behavior Analysis For Interdisciplinary Environmental Protection

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Abstract

Engineering strategies for saving environmental resources have been widespread. However, many of those engineering advances have not been widely accepted nor generally applied by large segments of the general population. This paper considers the need to examine behavioral/environmental variables in the application of engineering technology, with particular reference to specific behavioral strategies for encouraging the use of engineering technology from an interdisciplinary perspective. A model for the study of factors contributing to the solution of ecological/environmental problems is presented and examples of interdisciplinary research are described. The model implies a need for the examination of the effects of antecedent and consequent manipulation of a variety of variables including: behavioral, physiological, environmental, technical and legal conditions. It is concluded that while interdisciplinary research efforts between engineering technologists and behavioral analysts are necessary, they have not received sufficient attention in the literature nor have they focused on the comprehensive study of antecedents and consequences as they relate to ecological/environmental problems. Thus, an extended "family" of research efforts is important for the success of these efforts.

The union of engineering technology and the behavioral sciences has been long overdue and the consummation of that relationship has only recently produced offspring of which we can boast and be proud. The results are evident in many places, although still only infants. Their continued development will require great care and nourishment throughout the coming years.

So much for the marital analogy. Few individuals would question that the close, collaborative efforts between engineering technology and applied behavioral science are only part of a more global conceptual framework from which environmental problems will be successfully resolved. The purpose of this paper is to discuss the development of a conceptual model for

continuing collaborative efforts between several important areas concerned with the control and improvement of the environment and the community. These areas include policy development, engineering technology, education, and behavioral analysis. Without an interface between these areas, a comprehensive solution to environmental and urban problems is impossible. Conversely, when these areas have closely collaborated, the results have had exciting and productive ramifications. These efforts demand further exploration. This discussion focuses on the need for collaborative, interdisciplinary research between engineering technology and applied behavior analysis.

Policy development is important from the position of allowing advances in engineering technology, behavior analysis and education to be applied and further developed. Moreover, policy development can be very effective in encouraging the development of these other areas. In fact,

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policy development can serve a detrimental function (e.g., prohibiting the further development of engineering technology), a neutral function (e.g., giving permission or allowance for the further development and application of educational principles), or a positive function (e.g., encouraging the development of behavioral science applications in the community).

Many advances in controlling the environment have come through the development of appropriate engineering technologies. While not all of these developments have been well accepted or without their problems, many, such as fuel and energy saving devices, have greatly contributed to meeting ecological needs. Many policies would never have been developed without the availability of relevant engineering technology. For example, policy mandates that require the installation of energy saving devices in newly constructed homes would be absurd without first having those devices commercially available (e.g., insulation, water flow restrictors, electricity monitors). And while behavior analysis and education have contributed to the dissemination of engineering advances (e.g., programmed learning approaches to computer operation), these fields have also benefited from these modern technological developments (e.g., biofeedback devices). In fact, progress that has been made today in the development of policy, the behavioral sciences and education would have often been impossible without the aid of engineering technology.

Education is integral to the development of effective solutions to environmental problems. The results of engineering technology and new developments in applied behavior analysis are disseminated through this process. Moreover, education can be important in the process of creating new opportunities for more innovative efforts in the fields of policy development, engineering technology, and applied behavior analysis.

Last, and perhaps the most neglected, is the role of behavior analysis in contributing to the solution of environmental problems within this framework. More specifically, there are four points at which behavior analysis can assist productively in the solution of serious environmental problems. Although engineering technology has been selected as the best example from which to draw, these points apply to the areas of education and policy development as well. Hence, positive gains can result from the interface of behavioral science and engineering technology:

1. *When the appropriate engineering technology has been developed and is available for widespread dissemination.* The mere development of appropriate engineering does not insure the widespread adoption of these new techniques. A collaborative effort between the behavioral analysts and engineers can enhance the acceptance or marketability of these products through a simple understanding of basic principles of behavior. A good example with regard to this point is the current availability of water saving devices. While these products have been on the market for years, and while few people would question the need to conserve water, the actual use of these devices is quite limited. Moreover, the computer technology necessary for a complete assessment of the energy conserving needs of a given home has been developed and implemented. For example, the Commonwealth of Virginia has made simple, easy-to-complete, energy audit forms readily available at no cost to homeowners interested in an analysis of what they can do to save residentiavergy. Fortunately, the response to the availability of this analysis has been great, with over 100,000 people requesting forms. Unfortunately, the return of the completed forms has been minimal, with less than 3% returning them (Kehoe & Geller, 1980). An analysis of the behavioral principles involved in the widespread adoption of this advanced

technology could contribute much to a comprehensive solution of the energy problem.

2. *While the technology is being developed.* Darley (1978) described the investigation of principles of behavior involved in the adoption of a "psychostat." This is a clock driven thermostat that can be automatically set to raise and lower residential temperatures at specific times during the day, with a special "override" feature which enables the consumer to select a temperature setting not originally programmed. He discovered that there are some important principles that partially determine the probability of eventual adoption of these appropriate energy technologies by the consumer. Translated into behavioral terminology, and without reference to the cognitive and "nonbehavioral" terms employed by Darley (1978) these principles are: 1) only a small portion of any given population will experience contingencies strong enough to influence the initiation of the chain of behaviors necessary for installation of such a device; 2) the contingencies experienced must be such to enable the consumer to see desirable changes in the environment; and 3) excessive response costs and/or weak positive reinforcers will result in consumers not initiating the chain of behavior necessary for successful adoption of this engineering device. Corollary to this is the fact that those who do experience positive outcomes as a result of this behavior will become "second-stage innovators" or will be more likely to adopt other innovations, while those who experience excessive response costs or punishing events will be less likely to adopt other innovations (Darley, 1978).

Careful consideration of each of these controlling factors in the design phase of developing engineering innovations will increase the probability that those appropriate engineering strategies will be adopted by the consumer on a large scale. At the same time, neglect of these

behavioral contingencies risks the marketing of engineering technologies that consumers will ignore or refuse to adopt with any degree of efficacy.

3. *When current engineering strategies are not working.* There are two specific cases with respect to this point. First, engineering technology is often insufficient to meet current needs. For example, recycling is an integral part of any comprehensive energy cocation plan because these efforts result in decreased energy consumption when producing goods for the marketplace, or, when collected garbage is used to produce additional energy. However, as Geller (in press) has noted, high technology systems (which do not require the separation of garbage into specific, recyclable piles, and which produce energy by burning the garbage collected) are costly, inefficient, and polluting. Low technology systems (which rely on the consumer to separate the garbage into recyclable piles) require the systematic application of behavioral antecedents and consequences to encourage trash-separating behaviors. Thus, the effective application of behavioral principles is essential to improving upon available engineering technology which, by itself, is not sufficient to provide a complete solution to shortages of environmental resources.

Second, current engineering technologies are often not used by the consumer. An example that nicely highlights this problem concerns automobile safety. Automobile manufacturers have been installing safety belts in vehicles they produce for well over ten years. However, field observations of seat-belt usage indicate that no more than 20% of the public wear safety belts. This is a clear case where the engineering technology has been developed and is available for use by the general public but has not been widely applied. It is noteworthy that low usage rates of safety belts has resulted in a federal mandate that 1982 cars contain passive restraints (e.g., air

bags and "automatic" shoulder belts), which are significantly inferior to currently existing shoulder and lap belts. Thus, an inferior safety system has been mandated due to a failure to consider the careful application of behavioral principles or the development of new behavioral technologies to increase the use of the more appropriate "active" restraint systems.

4. *When no engineering technology is available.* There are a host of environmental problems for which no engineering solutions exist. For example, until the relatively recent introduction of cameras, alarm systems and mirrors in shops across the country, no engineering technology was available to help curtail shoplifting. Thus, at times, behavior analysts must provide solutions to problems that are pressing but which have no engineering solutions. This is not to say that no engineering solutions will ever be available. In fact, through frequent feedback between engineers and behavior analysts, we can learn more about the current technological needs of a community and can gain a broader perspective into the limitations and advantages of applying available engineering strategies.

The recent community-wide energy conservation project in Davis, California highlights the beneficial outcomes of collaboration among policy developers and engineers (*The Davis Experiment*, 1977). This city made a decision to conserve as much energy as possible through the application of available engineering strategies. Although the report does not explicitly mention the involvement of behavioral analysts, the comprehensive Davis program could not have succeeded without at least considering principles from applied behavior analysis. Although the program is too broad to present in its entirety here, some examples will help clarify the benefit of collaborative efforts toward a comprehensive conservation program.

The foci of the Davis program were

primarily within the areas of residential and transportation energy use. With respect to the former of these, building codes were designed which made maximum use of "natural" energy sources. For example, the city's building codes were redesigned to reflect the appropriate positioning of a building with regard to location of the sun so as to decrease heating and cooling costs. Specifications of this type were included in the city's building code. Flexibility was built within the code to allow developers to adopt the standard plan (which was rather rigid with regard to the specifications) or to be more innovative in their efforts to conserve energy. Also, the city, using a grant from the Department of Housing and Urban Development, built solar houses to be used as engineering models for developers and builders interested in the concept. Further, city officials collaborated with developers in designing and explaining the code in order to develop the fairest standards possible and to disseminate that information once the code had been fully developed.

Transportation was another area of concern for the Davis community. Davis already had a great number of bicycles, due to the presence of a university. However, community planners decided to encourage bicycling as a primary mode of transportation by altering environmental conditions. A well developed educational program concerned with bicycle safety was implemented in the school system (i.e., response priming). The environment was altered by funding construction projects for bike ways. Thus, policy developers used environmental manipulating and education to effect a substantial decrease in the consumption of transportation energy. Davis, a community of 33,000 people, now has 25,000 bicycles registered.

One final point of interest with respect to Davis concerns its recycling program. Although the project initially experienced deficits that had to be supplemented by ci-

ty tax revenues, the city developed a source separation system which enabled the recycling program to break even each month. More specifically, this city encouraged the separation of garbage into piles of newspapers, glass, aluminum and used oil. These piles were retrieved by the garbage collection company with whom the city contracts for services and were then sold to other companies on the open market. The collections were made via the same method used to collect all garbage (i.e., a garbage truck), with the exception that a specially designed scooter was used. Thus, the individual had the convenience of door-to-door pick-up for recyclables without the response cost of having to take collectables to some central drop point, a fact that often results in decreased recycling and a waste of transportation energy.

It is unfortunate that this community did not initially plan (or at least makes no mention of a plan) to involve educators and behavioral analysts in the design, implementation and evaluation of their energy conservation plan. However, although the program developers may be

unaware of it, they have managed to incorporate some very important behavioral and educational principles into their project which have paid handsome dividends in the outcomes they have experienced (e.g., decreasing response costs, altering environmental contingencies, promoting conservation behaviors in the schools).

It is evident that interdisciplinary, collaborative efforts can result in highly productive results. However, no such attempt to solve environmental problems is complete without consideration of the entire system of concern. Figure 1 illustrates such an approach from a research and development perspective, and within a systems frame of reference. By way of explanation, the solution to any given community environmental problem begins with a thorough specification of problem behaviors. From this assessment are developed specific behavioral objectives and empirical criteria by which to measure the success of any program designed to impact upon a given problem area. Integral to this process is a detailed analysis of the resources available to assist in meeting these objectives. At times,

Figure 1. A model for behavioral community intervention.

human creativity can be fascinating with regard to "making do" with relatively few environmental and technical resources for the solution of environmental/community problems. However, a realistic assessment of those contingencies available for alteration is critical. Also, it is important to analyze the projected response costs and benefits of a given approach. Some approaches may be quite effective in their outcomes, but require such a cost that would make that solution economically (or otherwise) prohibitive. Next, specific strategies are tested through research in a sub-system that involves actual small-scale implementation and evaluation. Then, depending upon the outcomes of the initial behavioral or environmental-change strategies, large-scale implementation and evaluation may occur, with a subsequent reassessment of community problem behaviors, and so forth with the cycle repeating itself.

While this process is rather straightforward, it is rarely applied. Further, it is not quite as simple as it may initially seem. For example, the analysis of costs and benefits often take into account only the economic gains or losses from a given effort. This is blatantly insufficient for research and development purposes. There are, at a minimum, two general areas of cost and benefit that must be considered: (1) *Economic costs and benefits* are perhaps the most obvious and, in fact, play a large role in determining the feasibility of any intervention. (2) *Behavioral costs and benefits* are not so obvious and require careful consideration. For example, the illustration cited earlier from Darley (1978) with respect to the "psychostat" suggests that the response cost for using a given engineering device may be important for predicting actual use of that device. Thus, the gains and losses from a behavioral perspective are important to consider. Social gains and losses (i.e., increased or decreased opportunities to engage in rewarding social exchanges) and physical

discomfort created by new engineering strategies should also be an integral part of any behavioral cost-benefit analysis. Very simply, those actions that result in the greatest physical benefits with minimal physical costs are most likely to be continued.

Although these areas are important, effective interdisciplinary research must examine more than the costs and benefits or the simple outcomes of planned interventions. In fact, attempts to solve ecological/developmental problems can be viewed as efforts to manipulate the antecedents or consequences to specific behaviors of interest. More precisely, behavioral, physiological, and environmental events can serve as antecedents or consequences to behaviors relevant to improving the ecological quality of the environment (cf., Winett & Neale, 1979). While this is not an earth-shattering revelation, only passive regard for this widely accepted statement can be detected in the literature. Truly effective interdisciplinary research concerned with environmental ecology must be especially careful to examine legal and technical behaviors as events that affect the ecology of the environment. While often implemented, these tools are rarely studied as techniques for behavior change under controlled, scientific conditions.

Technical advances can influence the outcomes of specific interventions from both an antecedent and consequent perspective (with the focus of technical intervention being the primary determinant for classifying it as an antecedent or consequent event). Legal antecedents and consequences must also be examined to determine the influence of this potentially powerful variable. Again, legal strategies can be introduced as antecedents to environmental and behavioral change (e.g., building codes and littering ordinances) or as consequences for actions (e.g., penalties for not adhering to specific building criteria or for littering). In summary, a more comprehensive approach to

the study of community ecological/environmental problems that consider behavioral, physiological, and environmental events as antecedents and consequences to behavior is important to the development of sound interdisciplinary research. Also important is the study of behavioral as well as economic response costs for ecologically relevant behaviors.

Interdisciplinary research between engineering technology and applied behavior analysis needs time to grow and flourish. But the union of these two disciplines is clearly not sufficient to provide the necessary answers to our very pressing environmental and urban problems. What is needed is an extended "family" of research and development efforts that effectively combines the expertise of many fields into an interlocking network that has its common goal the cost

effective solution of ecological/environmental problems.

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