Generative Organizational Grammars and the Unit Dose System

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We join two theoretical trends in the study of organization -- generative grammars and computational design -- to model a newly adopted and important hospital practice known as the 'unit dose' system, and to compare it with the practice it replaced.

The term 'unit dose' is short hand for the method hospitals use to prepare and distribute drugs ordered by physicians for their patients. This practice first emerged in the early 1980s and is now the prevalent institution. It differs from prior practice primarily in that doses of prescribed drugs are prepared in the hospitals central pharmacy by pharmacy personnel. Previously, nurses prepared medicines and IVs for the patients on their floors from bulk stocks acquired from the central pharmacy. Despite surface similarities in the two systems, the change to 'unit dose' is profound and addresses some problems of the earlier system while introducing its own new problems.

Reviewing these historical changes for handling pharmaceutical presents organizational theory with an important general question: How can we identify and evaluate differences between two organizational designs for the same task? In this case, the task is to provide patients with the right treatment in the right amounts at the right time. Both the unit dose system and it predecessor do this.

Commonly used approaches for comparing organizational practices typically do not review their actual design differences as much as the outcomes associated with each alternative. Thus, labor costs might be analyzed, or production quality or errors. Limits to such comparisons are obvious. Only operational designs can be evaluated. Outcomes associated with complex systems are not easily attributed to any particular features of those systems, making improvement difficult. And, comparisons are inherently restricted to anticipated outcomes, ignoring unexpected disasters or undesigned perversions.

A different strategy for comparing organizational designs is to generate the theoretically available alternatives for a task and evaluate their implications for outcomes. This is the approach recommended by computational organization design and the approach taken here. In particular, we have three purposes: (1) To model two common hospital practices for administering drugs to patients; (2) to identify and evaluate their differences; and (3) to generate a set of designs within which these two are embedded and evaluate the potential superiority of these additional systems. Finally, we expect to be able to describe the theoretical issues affecting this important hospital function.

Our approach to modeling the unit-dose system follows from Salancik and Leblebici's (1988) work on a generative theory of organizational transactions. In recent years, generative theory has served as framework for explaining organizational variation among restaurants (Salancik and Leblebici, 1988), institutional change (Leblebici, Salancik, Copay and King, 1991), and the performance of technical services (Pentland, 1991). In this view, organizational tasks are seen as a set of activities assigned to organizational agents and structured according to interdependencies among the activities and the capabilities of agents. In a later work (1992), Salancik and Leblebici introduce an algorithm for translating task interdependencies into a formal grammar of the system. The grammar articulates rules for organizing activities, and thus the alternative organizational designs available for that task. An alternative organizational design is essentially a sequence of acts valid for the agents and the rules. Much as with a grammar in language, an organizational grammar (Pentland and Crowston, 1992) attempts to explain complex patterns in terms of a set of primitives (actions and capabilities), and a set of rules for combining them (interdependencies). In constructing an organizational grammar, the interest, however, is in uncovering all valid designs within the constraints of the activities, the capabilities of the agents and the interdependencies that relate them.

Constructing a Model of Unit Dose Tasks

Like computational design, generative theory is premised on thorough analyses of activities. This requires knowledge of the activities associated with a task at a suitable but not overwhelming level of detail. We take it as generally true that such knowledge is never complete and always is abstracted into in manageable concepts. Our knowledge comes from observing drug administration practices at several Pittsburgh hospitals, fifteen years of nursing experience, and a century long history of the development of Pittsburgh hospitals (Brindle, 1992)

Centralized unit dose systems began appearing in the early 1980s, partly from concerns about nursing errors in preparing drug dosages accurately and partly because of growing national concerns about security in hospitals handling drugs. Nursing errors came about from insufficient knowledge or inadequate tools for measuring quantities and scoring pills. By the late 1980s, the new unit dose system was entrenched in most hospitals. This was due less to the technical superiority of the system and more to the fact that pharmaceutical companies learned they could sell the same drugs for more money by prepackaging them into anticipated dosages. Ironically, their forecasts often need correcting by pharmacist or nurse. In addition, the new system typically increased the numbers of parties involved in filling prescriptions. Because preparation was separated from administration in time and place, intermediaries had to be hired to chase patients around hospitals and to check and double check that prescriptions were filled as ordered. Our modeling of the two systems shows how these features affected the overall goal of delivering the right drug to the right patient in the right amounts at the right time.

Our modeling proceeds in three stages. First we identify the major activities involved in the task. As mentioned, this is primarily a creative effort. The major analytic aspect is that some activities are taken to be constancies for the task. They are constant in that they are present for every alternative design of the system and are allocated to the same organizational agents to execute, and are necessary for the task to be undertaken at all. In our case, the major constancies are (1) a doctor always begins a production sequence by prescribing for a patient, (2) a pharmacist always acquires and validates the involved bulk drug supplies from suppliers, (3) the task is completed successfully when the patient takes the prescribed drugs. Other activities involved in the task are vary as to who may or does do them, and when they get done. Among these are preparing dosage orders, labeling prepared dosage packets, delivering doctors' orders for filling, packaging doses, delivering filled orders to patients, administering dosages to patients.

The second stage of the modeling involves defining the interdependencies assumed to exist among activities, and between agents and activities. This stage, like the previous, is creative rather than analytic and involves articulating a theory about the nature of the resources involved in the task. It requires defining for each activity (1) the resources (capabilities in the language of Salancik and Leblebici) that are necessary for a given activity to be undertaken, (2) the resources generated for particular agents by a given activity, and (3) the resources depleted when an activity is undertaken. These assumptions about each activity fully specify the interdependencies in the task system (Salancik and Leblebici, 1992) and determine the constraints on who may undertake what activities and how activities may be sequenced. The assumptions are written as formal propositions, X--->Y, or equivalently, Not-Y--->Not-X.

Examples of several propositions for hospital drug administration, stated informally: Preparing drug doses requires bulk drugs be available; preparing dosages requires doctors' prescriptions be available; administering prepared doses requires a patient be available, and a prepared dose be available; patients must be alive and on the nursing floor to be available; once administered, a dose is no longer available for administration; once delivered to a nursing station, a dose is available for delivering to a patient; a dose delivered to one patient is unavailable for delivering to another; a dose delivered but not administered to a patient can be delivered to a nursing station.

The propositions generated for the second stage are used to generate the rules for an organizational grammar of the particular task system. This is the third stage of our modeling. The algorithms for transforming the assumptions into production rules in a grammar are presented in Salancik and Leblebici (1992). The particular grammar that is constructed is equivalent to a finite state machine for the task system which specifies all possible paths from the start of the task (ie., the doctor's prescription) to the completion of the task (ie., the ingestion, injection or infusion of the drug dose into the patient). Tasks need not always complete, and may end in errors, defined here as the right drug going to the wrong patient or the wrong drug going to the right patient or the drug never reaching the patient.

Evaluation of Organized Tasks

Following our presentation the grammars constructed for each drug administration system, we evaluate their features and limitations. Because of the systems are represented as grammars, this is essentially a matter of comparing the rules that underlie each organizational design. Our comparison evaluates the rules in one design that are not in the other, and consists of reviewing the implications of the unique rules for their impact on the probability that the task will complete successfully. In the case of prevalent unit dose system in most hospitals today, prepared drugs often do not reach the intended patient because there is a high probability that they become unpacked and reassembled by a nurse for delivery to another patient.

Most problems in the current delivery system arise because of its major structural difference from the previous system: A division of labor exists between the preparation of a drug dose for a patient and its administration to the patient. This central design feature, ironically, was intentional and was rationalized on the basis that it would reduce the very errors it appears, in our analysis, to increase.

Thus, once again, we visit the well-noted proposition from organizational theory that differentiation without integration creates poorly performing systems. The generative approach presented here points to several designs that achieve both.