Taylor and the Systems Theoreticians

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Numerous thinkers, writers, and practitioners have contributed to the development of systems theory and its practical application, systems analysis. For this essay, I have chosen several who seemed most important, based on their mention in our textbook (Osborne & Nakamura, 2000) and lectures (Burns, 2004), and most accessible, and read the works which contained basic statements of their ideas. These works included *General System Theory: Foundations, Development, Applications* (1968), by biologist Ludwig von Bertalanffy, generally regarded as the founder of systems theory; *Cybernetics* (1948) and *The Human Use of Human Beings* (1954), by mathematician Norbert Wiener; economist Kenneth Boulding's *The Organizational Revolution* (1953) and *Conflict and Defense* (1962); and Frederick Winslow Taylor's *Shop Management* (1911a) and *The Principles of Scientific Management* (1911b). My goal was to see how their ideas related to one another, and to the process of systems analysis we have learned this semester. Somewhat to my surprise, the ones I actually found most relevant turned out to be those of Taylor, who seemed to realize some of the key points made by the systems theoreticians fifty years in advance, and who prescribed a specific method for improving the operations of an enterprise that in many ways anticipates systems analysis.

Von Bertalanffy's book is a compilation of many of his basic writings on general systems theory. It explains how he became aware of the limitations of the principle scientific paradigm of his time: reductionism, breaking things down into, and explaining them in terms of, their constituent parts, ultimately the particles of physics (Von Bertalanffy, 1968, p. 89). Von Bertalanffy's studies, however, were leading him to view the content of many fields as systems, as combinations of components whose relationships mattered as much as their nature, so that, with no mysticism involved, "the

whole was greater than the sum of the parts" (p. 18, p. 55). Von Bertalanffy grounds his ideas in mathematics, replacing the independent variables of reductionism with sets of many equations that reflect the interrelationship of the parts of systems. Of course, these can become fantastically complex and difficult to solve (p. 26). But then, that is how he defines a system, as "organized complexity" (p. 34). He cites numerous examples, starting with biological systems that must regulate themselves to stay alive (pp. 120-185), and moving on to human psychology (arguing against the "robot model" of stimulus and response then current (p. 188-9)); sociology (referring to Boulding's book on human organizations (p.47)), and even the long-term study of history (p. 197). He mentions Wiener's work on feedback in control systems as relevant (p. 44 and elsewhere). But though he acknowledges the "practical application, in systems analysis and engineering, of systems theory to problems arising in business" (p. 196), he does not give concrete examples of this application. He does not cite Taylor. Thus, while Von Bertalanffy provides the theoretical basis for systems analysis, his work is not so useful to the analyst in the trenches.

Wiener's most important idea is that of feedback, by which a system receives actual information (Wiener, 1950, p. 24) about its state and acts on it to improve its performance and counter "entropy" (p. 12), the opposite of organization and information, the tendency of a system to decay into random disorder and lack of structure. (One problem is that generating information always takes energy (p.39).) His favorite model is the thermostat, in which one part of the system, the "effector", takes an action, turning on or off a switch, based on information from a sensor. He shows how feedback works in living systems, such as in the regulation of the heartbeat (Wiener, 1948, p. 17), and how

during World War II, it was used in systems for targeting antiaircraft weapons (p. 5). From there, he discusses the possibilities of information processing machines, making some predictions about the future role of computers that are quite prescient. He imagines the automated factory of the future as an extension of Taylor's work on time studies (Wiener, 1950, p. 150). But he also (p. 159) imagines their application to white-collar work, replacing clerks and putting people out of work. At the highest level, he emphasizes that humans must use communication, feedback, and information, to prevent their organizations and societies from decaying into entropy. Observing what was happening in the 1950's, he worries that we were failing to do so.

Boulding's two books deal with the structure of organizations, from businesses to the international system of states, and the role of individuals and information flow within them. Organizations are information systems (Boulding, 1953, p.85), running on feedback. He uses the term "cybernetic" (p. xxix) and the analogy of the thermostat (p. 69), and speaks of "effectors" and "receptors" (p. xxxi), but without reference to Wiener. Organizations by definition have a hierarchical structure (p. xxxiv), and as information flows upward, it is condensed and abstracted (p. 134). Organizations, like organisms (although Boulding does not cite Von Bertalanffy), tend to grow, until they reach the capacity of their internal communications systems (p. 23); at that point, it becomes harder for information to flow as needed within them, and to maintain internal cohesion and the loyalty of members (p. 215). Those at the top can become cut off from the reality at the bottom and the outside world. Improved communications systems, such as railroads and telephones, and improved information systems, such as the "electronic brains" (p. 207) of the day, have made possible large nation-states and business entities. Within

organizations, individuals strive to achieve their own goals, and pursue their own interests (Boulding, 1963, p. 179), which may not be the same as the group's; they may "spin out" their work, taking longer than necessary to complete it in order to insure the continuity of their jobs (p. 215), or even committing sabotage (p. 180). Organizations require control systems to keep the lower levels in line with the goals set at the top (p. 183).

Having outlined the ideas of the theoreticians, let us turn our attention to Taylor, who was writing forty to fifty years earlier. He looks at actual operations of organizations devoted to accomplishing certain tasks. He gives concrete advice, some of which can be applied directly to any organization today, even to libraries. His methods include many of the steps, such as problem definition, data collection, data analysis, and system design and implementation, used in systems analysis today.

Taylor saw one basic problem in industrial organizations: workers were not producing as much as they could be. In most businesses, Taylor found, workers did as little as they could get away with, even collaborating with each other to keep production slow (Taylor, 1911b, p. 50), since there was no reward for doing more, and in fact a general fear that it could lead to loss of jobs. They could get away with this because managers had little idea of how much work they could reasonably expect of an employee. Managers did not keep track of the amount produced by each employee, to see who was "soldiering" (to use Taylor's term for "slacking" (p. 14)) and who deserved better pay, because they had no intention of giving better pay. Some enterprises tried to use a system of "initiative and incentive" (p. 35), hoping that promises of rewards would make the workers, on their own, to want to do better. But each worker was left to figure out how to

do his job on his own, and most were not smart enough to realize the best way of doing it, or if they could, they could not get their fellow-workers to adopt it. In modern systems analysis, we might look for more particular problems in particular organizations and define them more narrowly, but most of them will come back to the general ones identified by Taylor: employees – and this can include even managers of departments – having too much independence in choosing methods, not enough monitoring, and too little expert advice. In short, the problem in organizations was one of information flow and lack of feedback. Boulding would say similar things, but much later.

To remedy these problems, Taylor prescribed a process of study of the organization by specialists in planning and management. This corresponds very closely to the data collection phase of a modern systems analysis. First, one had to identify the "task" (p. 39), the basic purpose of the organization. Then, one would see how that purpose was being accomplished. His basic tool was the "time study" or "motion study", in which each operation would be examined to determine just what the workers were doing and how, and how long each step took. He describes very precisely how to make and record measurements in such studies, even recommending the construction of special measuring tools, if necessary (p. 99). He also recommended interviewing the workers, especially the most productive ones, to find out what methods they used. He thus anticipates three basic methods of data gathering: observation of workers on the job, action logs, and employee interviews.

Once the data had been gathered, the planners would analyze it to find the "one best way" of going about the task. Taylor advocated "functional management" (Taylor, 1911a), which "consists in so dividing the work of management that each man from the

assistant superintendent down shall have as few functions as possible to perform." This sounds a lot like the process of identifying the actual processes that go on in an organization using data flow diagrams or flow charts. The plan might call for creative thinking and acceptance of non-obvious ideas, such as that the way to improve workers' daily productivity might actually be to shorten the working day, so that workers would socialize in their own time (Taylor, 1911b, p. 88). The plan had to be grounded in reality; this might happen involve independent studies of just how much work an employee could actually do (p 56).

Once conceived, the plan would be implemented. The workers could make suggestions during the study process (p. 128), but once that was done, they would be told exactly what to do by the planners and managers. Taylor outlines ways of securing acceptance of the new plan, both by workers and by managers (Taylor, 1911a). Management and workers would have to cooperate much more closely, in a spirit of goodwill, and workers would have to be trained carefully and patiently to undertake their tasks (Taylor, 1911b, p. 70). The new methods could not be used as a "club" (p. 134), to coerce workers (we have seen that Boulding also felt that coercion in organizations was counterproductive); instead, workers would have to see the advantages of the new methods and adopt them enthusiastically. Leadership would have to be "optimistic, determined, and hard-working" (p 85).

But as in modern systems analysis, data gathering and evaluation would continue. Taylor calls for meticulous records to be kept of each worker's production. He cites the example of a ball-bearing plant, in which quality control inspectors would take random samples of accepted and rejected product to check on the work of producers, and samples

of the inspectors' work would be examined by another layer of inspectors (p. 91). He engages in a form of cost-benefit analysis (p. 96). He reveals that the studies of systems can sometimes run up huge costs, (p. 106), which can lead some to question their value, but he assures the reader that in the end, studies of organizations will be worthwhile. After all, he asserts, the work of analyzing the operations is already being done, just by individual workers, rather than a central planning department. He notes that it can take a long time to implement a system such as he describes, estimating two to three years, but allowing up to five (Taylor, 1911a).

Taylor's approach foreshadowed systems analysis in other ways. He looked at the interaction of technology, procedures, and people. When he determined that shovelers should only move a certain amount at once for maximum efficiency, he had them re-equipped with tools that held exactly this amount (Taylor, 1911b, p. 66). He also describes Frank Gilbreth's study of bricklayers, whose productivity was vastly improved by the use of better equipment for holding bricks and mortar, and streamlined procedures for picking them up and laying them (p. 77). The work of machines, too, should be analyzed (Taylor, 1911a), with time studies being performed on them just as on the humans who used them. Still, he felt that the organization of the enterprise was much more important than the actual physical devices used: "There is no question that when the work to be done is at all complicated, a good organization with a poor plant will give better results than the best plant with a poor organization." Procedures should be rigidly outlined, and each worker given a card prescribing what he was to do each day, and evaluated on how well he followed it. In other words, manuals were not to be ignored.

In short, Taylor realized that in an organization, information flow was key. Extra management personnel – "brain workers" - should be hired to gather all the information necessary about operations, and pass all the information necessary on to the manual workers, completing the feedback loop. Taylor discusses various means – a "tickler" system, an efficient messenger system – for keeping track of and distributing information properly within the organization (Taylor, 1911a). He emphasizes the "exception principle", that the information that reached the highest levels of the organization should be "condensed [and] summarized", to avoid overwhelming the decision makers with paperwork. In this idea, he again anticipates Boulding, who does not cite him.

It might be asked, is Taylor's work relevant only to manufacturing organizations? After all, libraries are very different from shoveling or even making ball bearings. Taylor provides an illustration of the application of his methods to "the higher classes of work" (Taylor, 1911b, p. 97), which in this case is the production of machine tools. He still asserts that "the workman who is best suited to doing the work in incapable…of understanding this science", and needs to be directed by the managers. The managers, on the other hand, can apply their skill at management to just about any field, much as Von Bertalanffy asserted that the systems theory was an independent science in itself, applicable to many fields that worked basically the same way. Taylor explains: (p. 103), "When men, whose education has given them the habit of generalizing and everywhere looking for laws, find themselves confronted with a multitude of problems, such as exist in every trade and have a general similarity one to another, it is inevitable that they should try to gather these problems into certain logical groups, and then search for some

general laws or rules to guide them in their solution." Taylor also anticipates Von Bertalanffy in describing how an operation can involve so many interrelated variables that the equations describing it can seem insoluble (especially in an era without computers!) (p. 111) But even in this extreme case, scientific analysis works better than "rule of thumb" guesses by workers.

Taylor even anticipates Von Bertalanffy's key idea of holism, stating, after summarizing the elements of his system, that "It is no single element, but rather this whole combination, that constitutes scientific management" (p. 140). He uses the term "system" repeatedly in a meaning close to its modern one, of a carefully planned combination of people, procedures, and technology. "In the past," he writes, "The man has been first; in the future, the system must be first" (p. 7). The systems theoreticians of the middle of this century have fascinating ideas with broad application. But Taylor's work contains many of them, and lots of practical advice that can be immediately applied in systems analysis as well.

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