The Scientific Management of Information Overload

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Examining Frederick Winslow Taylor's seminal work, The Principles of Scientific Management, reveals why many of his ideas were considered controversial. While one might argue against his view of workers' motivation, the principles underlying his efforts towards productivity improvements still apply today. To make a case for the relevance of his contributions for management practice in the 21st century, this article shows first how Taylor's thinking relates to key aspects of lean manufacturing, a popular and contemporary business practice. The coherence of scientific management and lean principles are then further applied to a current and growing problem, information overload, to yield testable propositions for further study. Suggestions for addressing information overload, based on anecdotal evidence, are presented as illustrative.

Many industrial engineers who endeavored to apply manufacturing best practices to professional services firms (Brennan, 2006; Brennan & Orwig , 2000) regularly encountered the types of resistance that Taylor faced: e.g., people are not machines; we have been doing this and know more about how it should be done than you; you are just trying to eliminate jobs, etc.

Taylor's (1911) views of the workers of his day, such as "the workman… is so stupid…" (p. 59), and "almost all tradesmen [are opposed] to making any change in their methods and habits…" (p. 81) have been discredited. However, his methodology did achieve productivity improvements for large industrial concerns, such as The Bethlehem Steel Company. In his extensive biography of Frederick Taylor, Kanigel (1997) gave many examples of the application of scientific management to nonscientific realms, e.g., education, libraries, and home kitchens.

Is this work relevant to management practices in the 21st century? Indeed, it can be asserted that it is quite relevant, in both the manufacturing sector (under the auspices of lean principles) as well as to knowledge work. The following section explains how the principles and practices of scientific management cohere with those of lean manufacturing. Then the specific contemporary issue of the information overload of knowledge workers is considered. By applying lean, scientific thinking to the problem of overload, several propositions are developed.

Management Principles and Practices

The profession of applying science to management was known as scientific management and gradually changed to industrial engineering over the years, becoming formalized in the late 1940's (Emerson & Naehring, 1988, p.119). Kanigel (1997, p. 7) suggested that, "Taylor's thinking… so permeates the soil of modern life we no longer realize it's there… He helped instill in us the fierce, unholy obsession with time, order, productivity and efficiency that marks our age."

While Taylor is renowned for his time studies and work measurement, he did not start out with ideas of efficiency or economy. He was deeply troubled by what he saw as a conflict between labor and equipment. For Taylor, it was a burning social concern (Drucker, 1968). In his own words, Taylor (Taylor, 1911, pp. 9-11) wrote that "the principal object of management should be to secure the maximum prosperity for the employer, coupled with the maximum prosperity for the employé *(sic)". The words 'maximum prosperity' were used, in their broad sense, to mean not only large dividends for the company or owner, but the development of every branch of the business to its highest state of excellence, so that the prosperity might be permanent … the greatest prosperity… can be brought about only when the work … is done with the smallest combined expenditure of human effort…" (Taylor, 1911, pp. 9-11). Work studies and standardized tasks became vehicles for accomplishing this.

Henry Ford was a strong proponent of scientific management and advocated standardizing processes and eliminating waste. He and The Ford Motor Company were the link between Frederick Taylor and Ohno Toyoda, creator of the Toyota Production System (TPS). Ohno read Ford's book, *Today and Tomorrow*, benchmarked the manufacturer's continuous flow assembly line, and began the development of the TPS. Today, principles and practices of the TPS are widely employed in the manufacturing sector under the auspices of "lean production" (Liker, 2005, p. 226).

The concept of "lean" indicates that the proverbial "fat," typically referred to as waste, has been trimmed from the process. Activities in a lean process have the potential to add value. This is true whether describing a manufacturing process, a service process, or even a customer's consumption process.

While the TPS is grounded in manufacturing and based on several broad principles, three can be seen as direct derivatives of scientific management: the need for *direct observation,* the *standardization of tasks*, and *the elimination of waste*. Both Taylor and Ohno advocated the need to really understand the work and observe it closely – and at length. Taylor's studies gathered copious levels of data, task-by-task, second-by-second. Ohno, too, believed in the power of going directly to the source (*genchi genbutsu*) and deep observation. According to Teruyuki Minoura, former president of Toyota Manufacturing in North America, Ohno had him draw a circle on the floor of the plant, stand in it, watch the process, and "think for himself" for eight hours (Liker, 2005, p. 226).

Standardization of tasks was the foundation of continuous improvement, according to the TPS. Similarly, "Perhaps the most prominent single element in modern scientific management is the task idea. This task specifies not only what is to be done but how it is to be done and the exact time allowed for doing it" (Taylor, 1911, p. 39). The conceptualization of standardization at Toyota is broader than it was in Taylor's time, when it was focused on finding the one best way to do a task and then freezing it. The TPS' thinking is that "it is impossible to improve any process until it is standardized. One must standardize, thus stabilize the process, before continuous improvements can be made" (Liker, 2005, p. 142).

Often, improvements under lean operations are targeted to eliminate waste in a process, where waste is considered any activity that does not add value, i.e., overproduction, waiting, unnecessary transport, unnecessary processing, excess inventory, unnecessary movement, and defects. In the same way, Taylor emphasized "the enormous saving of time and therefore increase in the output which it is possible to effect through eliminating unnecessary motions…" (Taylor, 1911, p. 24).

Conceptually, these principles applied to all types of work, not just production processes. Taylor saw knowledge, not muscle power, as the prime productive resource, and today the 'knowledge' industry is looked to as the source of most new jobs" (Kanigel, 1997, p. 9). Indeed, management guru Peter Drucker acknowledged that the most important step toward a knowledge economy was scientific management (Drucker, 1968).

The question is, are these principles of practical use in a knowledge economy? Certainly, lean principles have been extended beyond manufacturing applications (c.f., Womack & Jones, 2005; Anand & Kodali, 2010; Peterson, 2010). To understand if – and how – they can be applied to one of the greatest challenges for knowledge workers, it is important to understand the problem of information overload.

The Challenge of Information Overload

Overload can be defined as the state of having more than can be handled, whether measured in terms of quantity, weight, rate, or size. Information overload is therefore having more information than one can acquire, process, store, or retrieve. In their comprehensive review of the literature on information overload, Eppler and Mengis (2004, p. 326) offered the following description: "Information overload occurs when the supply exceeds the capacity. Dysfunctional consequences … and a diminished decision quality are the result."

This is arguably one of the biggest challenges for knowledge workers in this age of technology-driven explosions of information availability. Jaques (1995, p.48) reported on published research from the Economist Intelligence Unit, warning that problems associated with information overload are reaching acute proportions for large enterprises, and that the management of key information sources and intellectual property is spiraling out of control at many companies.

Researchers across various disciplines have found that performance of an individual correlates positively with the amount of information he or she receives, up to a certain point (Eppler & Mengis, 2004). Beyond this point, the individual's performance will rapidly decline, described by an inverted-u curve (Chewning & Harrell, 1990).

Why is information overloading a challenge? In the knowledge economy, information is presumably people's most valuable commodity (Hemp, 2000, p. 83). However, overload often leads to *stress*, *inefficiency*, and *mistakes* that can result in poor decisions, bad analysis, and/or miscommunication (Eppler & Mengis, 2004).

In 1989, Richard Wurman coined the term "information anxiety," a state of stress caused by an overwhelming flood of data, much of it from computers and much of it unintelligible (Wurman, 2000). More recently, Hemp (2009, p. 84) acknowledged, "The stress of not being able to process information as fast as it arrives… can deplete and demoralize you." Stress can also be caused by concern about not having all of the relevant information needed for a task or project.

Of course, all of the information received is not necessarily relevant. In fact, the Information Overload Research Group (http://iorgforum.org) referred to "information pollution." Shih, Chiang and Lin (2008, p. 117) examined the problem of "spamming… the practice of sending mass mailings to large numbers of people who have no relationship with the seller. As a result, spam was expected to represent 77% of emails sent worldwide by the end of 2009." Hemp (2009, p. 85) reported, "a survey of 2,300 Intel employees revealed that people judge nearly one-third of the messages [of the average of 350 messages/week] they receive to be unnecessary." In fact, one of the leading causes of stress can be the feeling that other people are wasting your time.

In addition to wasted time, information overload can create inefficiencies in several ways. One key way is by multitasking. Another is neglected work due to information addiction, e.g., "Crackberry" users. Accessing the right information at the right time can also be problematic.

Multitasking, processing different information for different tasks at the same time, is a common phenomenon in knowledge work. According to research conducted by Stanford professors Eyal Ophir, Clifford Nass and Anthony Wagner, multitaskers underperformed compared to their non-multitasking peers in three key areas: filtering out irrelevant details, remembering information, and switching between tasks. The researchers attributed this to the multitaskers' distraction of thinking about the task they were not doing and the inability to focus on the task at hand (Ophir et al., 2009). In another study, Crovitzthe (2008) found that, not only did knowledge workers change activities every three minutes with frequent distractions such as an electronic message or a phone call; it then took nearly 30 minutes to get back to the task once attention was lost. A study commissioned by a large high technology company indicated that the IQ scores of knowledge workers distracted by email and phone calls decreased 10 points" (Hemp, 2009, p. 84).

It is no wonder that mistakes can be caused by information overload with the stress and distraction of knowledge workers. Information can be easily overlooked or mistakenly discarded. Some people are so overloaded that they declare email bankruptcy and delete all of their mail (Hemp, 2009). In his efforts to reduce errors in medical practice, Gawande (2009, p. 13) reflected on the situation:

> We have accumulated stupendous know-how…. Nonetheless, that know-how is often unmanageable. Avoidable failures are common and persistent… across

> many fields – from medicine to finance, business to government. And the reason is increasingly evident: the volume and complexity of what we know has exceeded our individual ability to deliver its benefits correctly, safely, or reliably. Knowledge has both saved us and burdened us.

Mistakes may also arise from the incorrect use of information – or from the use of incorrect information.

Stress, inefficiency, and mistakes are not the sole purview of knowledge workers. Scientific management revealed that overload was counterproductive long ago, when Frederick Taylor examined the throughput of the pig iron handlers. He noticed that there were physical limits to the amount men could carry fully loaded, and that "as the load [became] lighter, the percentage of the day under which the man can remain under load [increased]" (Taylor, 1911, p. 57). In other words, by reducing the overload, the men were more productive. In a similar vein, "Ohno considered the fundamental waste to be overproduction, since it causes most of the other wastes" (Liker, 2003, p. 29). Too much could often be less beneficial.

Analysis

With the understanding that overload is problematic, the following analysis examines the problem through a lens common to scientific management and lean principles: the need for direct observation, the standardization of tasks, and the elimination of waste. The question is, how might a synthesis of lean (TPS) and scientific thinking help to address the problem of overload?

Direct Observation

Direct observation, or "go and see for yourself," suggested the need to understand the ways in which the individual knowledge worker processes information. What sources supply information? How is new information received? Filtered? Stored? Accessed? Processed? Discarded?

In addition, it is important to understand the personal factors that can contribute to overload, such as individual traits and personal situational factors (Eppler & Mengis, 2004). For example, the time of day, the amount of noise, or whether the individual felt rested could all make a difference in how much information he or she can process.

Direct observation required an investment of time by the individual to track information sources and processes. While a knowledge worker might not need the stopwatch precision of Taylor, the staying power of Ohno will be required to do this effectively. Observation was, and still is, likely to span days to achieve a clear vision and full understanding.

One approach would be to identify all the roles, personal and professional, in which the knowledge worker used or consumed information. Etzel and Thomas (1996) identified eight key information actions: create, change, store, retrieve, integrate, decide, communicate, and discard. Cross-referencing the roles and the tasks led to the next step, describing the types of information needed for each role, e.g., a social networking group of fathers of teenagers and a school calendar as a parent; company sales data, product information, and competitive analyses as a sales manager; weather reports, and selected blogs as an avid golfer. In this framework, the individual could track the sources and uses of information over a period of time.

For each type of information needed, the overloaded individual could then determine the best sources of information and how often he wanted to or should monitor them. The idea was to define what is important (Etzel & Thomas, 1996). The last step in direct observation would be a gap analysis, determining what information is received but not needed and what is needed but not received, and then addressing the gaps. This should not only lighten the load, but improve the quality of the information use as well.

Standardization

As for the standardization of tasks, several researchers have identified task and process parameters that contributed to information overload (Tushman & Nadler, 1975; Schick, Gorden & Haka, 1990; Bawden, 2001). By establishing routines, simplifying processes, and avoiding interruptions, the overload could shrink. It may take some time to develop the discipline this requires – and it may create some resistance from others – but eventually it would provide relief from overload.

For example, consider a telecommuter, someone who has a home office as well as a traditional office at work. Making a routine weekly schedule that lets coworkers know when she will be working at home eliminates the guesswork and unnecessary communications. It might be possible to simplify things by keeping materials associated with a particular project in one location. This might be stacks of paper in the home office or working files on a computing cloud. This saves the telecommuter from transporting the information and avoids the situation of lost or left behind data. To avoid interruptions, she may impose a discipline of checking mail and messages at certain times, limiting the frequency. Standardization, or in the case of information overload, making the routine as routine as possible, makes sense.

By using the results of direct observation and standardization, there can be many opportunities to reduce the waste created by information overload. This analysis addresses each type of waste, i.e., overproduction, excess inventory, unnecessary transport, unnecessary processing, unnecessary movement, waiting, and defects, and offers empirically-based suggestions for waste reduction.

Types of Waste

Overproduction is producing more than is required, typically by the next process or the customers. This waste is visible in storage needs, which can take time, space, and money. If whatever is produced cannot be used, the disposal process also can have costs (Brue & Howes, 2006).

In terms of information overload, information providers often produce more information than is necessary. Peek (2010) refers to "Social Network Overload" and "Commentary Overload" as two sources of over production. In a business context, the providers may want to maintain a regular line of communication, even if the content is thin, as in the case of weekly or daily "blasts" that may be of little use to the recipients. The proliferation of news outlets has further exacerbated this problem with the pressure to fill empty air space, every hour of every day. In these situations, information is pushed to the recipient. To stem the overload, the individual has some options. One is to employ a "pull" model, only receiving information when it is needed, i.e., "pulled." Another is to impose filters, cognitive or technological, to receive information that is specifically targeted to the individual's interests. In either case, the idea is to improve the individual's screening skills for information (Van Zandt, 2000; Eppler & Mengis, 2004).

Of course, knowledge workers are typically the ones who overproduce. Sometimes, the overproduction is simply thoughtless. Avoid unnecessary email, especially one-word replies such as "Thanks!" or "Great!" (Goldsborough, 2009). One of the most blatant violations is the reflexive "reply all" response in email. To counteract this, Hemp (2009) suggested a "non-cash" stamp daily allotment to each employee, with a feedback system to decrease the allotment of time-wasters. However, that may be more technologically complicated than needed. For example, the website http://five.sentenc.es, suggests establishing a "personal policy that all email responses regardless of recipient or subject will be five sentences or less." An organization may establish a broader policy with rules for information and communication design (Bawden, 2001). Over the long term, the goal would be to have a culture focused on creating value-added information (Simpson & Prusak, 1995).

Excess inventory and *work in process* are also key opportunities for waste, and often occur as a result of overproduction. Lean thinking works on inefficiencies, product complexity, bad scheduling, unreliable deliveries, and poor communications (Brue & Howes, 2006). In the context of information overload, it might be thought of as working on too many things at once.

This can in turn be manifested as multitasking – which, as noted earlier, is extremely inefficient – and can be viewed by the knowledge worker as a habit to break. Another bad habit, and one of the most egregious contributors to an individual's overload, is the tendency to hold on to information "just in case." This excess inventory of information creates an unnecessary layer of complexity in an individual's cognitive workload.

Excess work in process might also take the form of having too many projects open at once. Think of the attorney who has a crushing case load. He essentially becomes the bottleneck in all of these cases, slowing his overall throughput. Each case takes much longer than it should, in overall elapsed time, because of competition for his attention. Frantic scheduling, missed deadlines (i.e., deliveries), and frustrating communications with clients are plausible outcomes.

Excess inventory and work in process for a knowledge worker can be avoided with awareness and self-discipline. Scheduling uninterrupted blocks of time for completing critical work is one positive step (Sorohan, 1994). With the benefit of direct observation and gap analysis, the individual should have a clear idea of what is pertinent and what is not (inventory), and when too many projects and tasks (work in process) constitute overload. This may be an annual exercise to see if and how information needs have changed. Stebbins (2010) advocates scheduling regular "decluttering sessions," which can address physical as well as mental clutter. In addition, by addressing the wastes of overproduction and excess inventory, storage reduction can be achievable.

Transportation, moving anything around during a production process, should be minimized. It generally adds no value for the consumer. Efficient layouts, improved flows, and storage reduction are techniques for eliminating this waste (Brue & Howes, 2006).

For information overload, unnecessary transportation takes the form of paper that is carried to be processed, moved to make room for new information, or pushed aside until it is needed. One way in which layout can mitigate this is with the creation of a "dump zone." Stebbins (2010, p. 153) recommended finding "a space to corral all the stuff you don't have time to put away…Once you're ready to get organized, you won't have to hunt all over…".

From a process standpoint, good in-box management advocates "touching" an inbound piece of information only once: act on it, file it, or discard it (Allen, 2002). Thompson (2006, p. 98) suggests that "for things you need to act on… if you can do it in two minutes, go ahead and do it." If unable to do this, then it can be incorporated into an overall organization system.

A popular lean technique, 5S, stands for "sort, straighten (or set in order), scrub (shine), systematize, and standardize (sustain)" i.e., *seiri, seiton, seisq, seitketsu, and shitsuke* in Japanese (Feld, 2001). The overloaded knowledge worker can benefit by applying 5S particularly to places where information is received and processed, whether at work, the home office, the kitchen, or in a briefcase. This was echoed by Ale Sandrini (1992, p. 80-81): "Turn your desk from a distraction to a work surface by [taking the information and] clean it, leave it for someone else, eliminate it all together, act on it, or read it."

Lean organizations are very neat. Everything has its place, in order to avoid unnecessary transportation and other kinds of waste. Henderson and Larco (1999) asserted, "Most people underestimate the importance of safety, order and cleanliness of the workplace… Toyota and Honda will tell you 25 to 30% of all quality defects are directly related to [these issues]."

Defects and *mistakes* cause waste in several ways. Crosby (1980) identified four costs of quality: prevention, appraisal, and the internal and external costs of defects. Examples of internal costs of defects include scrap and rework, charges related to late payments, inventory costs to allow for some percentage of defect rate, engineering change costs for design correction, premature failure of products, and correcting documentation; external costs of defects can stem from warranty repairs, field service personnel training, complaint handling, customer dissatisfaction, future business losses, and litigation (Ireland, 1991).

These costs apply to defects in knowledge work as well. As noted earlier, errors are often the result of stress and distraction caused by information overload. Eliminating other forms of waste, and thereby reducing at least some of the overload, should logically lead to fewer defects and mistakes.

In addition, to avoid situations where information is overlooked, mistakenly discarded, or incorrectly used, a knowledge worker might use another lean technique known as fail-safes or "*poka yokes*." *Poka yokes* try to prevent errors from occurring. A *poka yoke* can be a warning that signals the existence of a problem, a precautionary measure to prevent a problem from occurring, or a control that stops production until the problem is resolved (Chase, 1994).

For example, overlooking information can be avoided by something as simple as a checklist (Gawande, 2009). Physical *poka yokes* can also be easily implemented, such as placing car keys with meeting materials that might be forgotten in a rush. Technological fail-safes such as data masks, automated backups, and confirmation screens can also be effective prevention measures. Broida (2009) suggested that, to avoid making errors that contribute to others' overload, consider installing a plug-in that alerts the sender to forgotten attachments when sending email.

Unnecessary processing is an obvious source of waste that can be overlooked without a task-by-task evaluation of a process. This situation may be a result of merging operations without streamlining processes. It is also frequently caused by changes in other processes. Another way in which a task may become unnecessary is through technology changes. As sources of information overload, each of these situations can be mitigated in the process of direct observation and gap analysis.

Another source of unnecessary processing, specific to knowledge workers is "tool abuse," i.e., using an information technology inappropriately. The inappropriateness might stem from overuse (witness "Crackberry" addicts and overly elaborate presentation materials) or from incorrect use of a tool. This is particularly evident in computer-mediated communications.

One common phenomenon is "telephone tag," or the exchange of voicemail messages without accomplishing any actual communication. In addition, people overly rely on email, and use it to accomplish tasks for which it is completely ineffective, such as to explain complex procedures, solve complicated problems, and air grievances (Levinson, 2010). Hemp (2009) advocates making suggestions in an email, rather than asking open-ended questions, e.g. when setting up an appointment.

Eliminating unnecessary human motions was a hallmark of scientific management. It reduces cycle time and stress on bodies. Improvements in workplace organization and method consistency can reduce this waste (Brue & Howes, 2006).

Building on the 5S tool, a visual factory adds the element of visual cues and signage. This saves time on storing, search, and retrieval. A knowledge worker might apply this concept using something as basic as labels – on files, drawers, binders, and shelves. In a similar vein, Broida (2009) offers another illustration, using the subject line in email messages to make it a short but informative summary of what is in the body of the email. The idea is for the knowledge worker to visually underscore priorities and view the big picture (Ale Sandrini, 1992).

Waiting is a waste that needs no explanation – but is hard to avoid. To mitigate waiting, an overloaded knowledge worker has two general options. One is to make good use (an individual preference) of the time spent waiting. The other is to address the cause of the wait.

A primary cause of waiting is bottlenecks. A bottleneck is a constraint that limits throughput (Goldratt & Cox, 1994). In knowledge work, the bottleneck may be an overloaded individual or an overloaded process. A chronic problem with a bottleneck should be addressed.

Waiting on an individual may be addressed with follow-up and reminders (euphemisms for nagging). It may be appropriate to set a deadline on a response, e.g., "If I don't hear back from you by next Friday, I will assume the plan is acceptable to you." Proceed with caution, however: an overloaded individual who is a bottleneck merits a judicious and diplomatic approach.

Alleviating bottlenecks in overloaded processes is a study unto itself and largely beyond the scope of this article. Suffice it to say, the subject process should be standardized as much as possible in order to make it stable enough to analyze for improvement. Issues of process capacity and bottleneck relief are informed by the Theory of Constraints (TOC) (Goldratt & Cox, 1994). To apply the TOC, there are the "4 Steps of TOC," which are broadly applicable to any process (Sheinkopf, 1999):

* Identify the constraint.
* Decide how to exploit (i.e., alleviate) the constraint.
* Subordinate and synchronize everything else to the first two decisions.
* Elevate (i.e., improve) the performance of the constraint.

Solutions may result in process changes to eliminate other forms of waste, as well as improvements to increase the effective capacity of the bottleneck in the process.

Liker (2004, p. 29) suggests an eighth source of waste, "Losing time, ideas, skills, improvements and learning opportunities by not engaging or listening to your employees." Brue and Howes (2006, p. 352) echo the idea that *underutilizing people* is a waste, but suggest it is the least obvious source of waste because companies and managers might not be aware of the potential. Perhaps this oversight occurs because of their information overload: either the employees are too overloaded to show their true potential, or the managers are too overloaded to perceive it.

Discussion

Trends E-Magazine, in its October 2009 issue, in its analysis of the trend of information overload, offered four forecasts related to the trend (pp. 33-34):

1. There is a rising wave of backlash against information technology, and reassessing so-called productivity tools.
2. To respond to this backlash, there will be a surge of companies offering solutions. This sort of problem is much more likely to see a successful solution coming from a complete unknown in a small entrepreneurial start-up.
3. Many of these contenders will go by the wayside.
4. The most promising solutions to information overload are likely to be social and behavioral rather than technological.

Etzel and Thomas (1996, p. 15) went so far as to suggest that the individual should use her brain more effectively, i.e., improve her memory, rather than rely so heavily on technology. While a better memory may not be an option for some individuals, the idea that social and behavioral changes offer promising solutions are reinforced by the propositions offered in this article.

Propositions

The scientific management of information overload suggested here is based on three key principles: the need for direct observation, the standardization of tasks, and the elimination of waste. Based on the analysis presented here, the following propositions are offered:

P1: To address the problems of information overload, the individual must first use direct observation to understand the scope of the problem.

P2: Cross-referencing an individual's roles and information actions provides a catalog of information needs, tracked over time.

P3: Applying gap analysis to the catalog of information needs will enable the individual to reduce the overload and improve the quality of information use.

P4: Standardization of information handling is needed to identify sources of waste in information processes.

P5: Reducing waste in information processing will further alleviate information overload.

These propositions have been illustrated with anecdotal evidence and can be further tested for more rigorous application. Specific changes identified in the preceding analysis are summarized in Table 1 and labeled as behavioral (B), social (S), or technological (T) in nature.

Table 1: *Suggestions by Type of Waste*

Type of Waste	*Suggested Change*
Overproduction	Pull needed information instead of receiving pushed communications (B) Use cognitive filters (B) Establish communication policies and value-added culture (S) Apply computer filters to incoming information (T)
Excess inventory and work in process	Break habit of multi-tasking (B) Avoid keeping information "just in case" (B) Schedule uninterrupted time for focused work (B) Conduct regular "decluttering sessions" (B) Limit the number of open projects at one time (S)
Unnecessary transportation	Create a "dump zone" to contain information to be processed (B) Establish an organizational system to process incoming information (B, T) Organize work areas using the 5S technique (B)
Defects and mistakes	Maintain focus resulting from direct observation and gap analysis (B) Establish poka yokes to prevent or detect mistakes (B, T)
Unnecessary processing	Avoid "tool abuse" and match the medium to the message (B) Craft email and voicemail messages to be more informational (B, S, T)
Unnecessary human motions	Employ visual cues for information access (B)
Waiting	Make good use of waiting time (B) Address individuals who represent bottlenecks (S) Alleviate constraints of bottlenecks in processes (S, T)

Conclusion

While the propositions and anecdotes and suggested changes might not be considered rigorous, the logic underlying this analysis is sound. It has been argued that Taylor's thinking was a direct influence on Henry Ford and subsequently on the Toyota Production System and lean production. Core tenets of these management practices can be applied to the information overload of knowledge workers, a key challenge of the current age. The legacy of Frederick W. Taylor thus remains relevant for the 21st century.

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