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Learning to Lead at Toyota

by Steven J. Spear

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Toyota is one of the world's most storied companies, drawing the attention of journalists, researchers, and executives seeking to benchmark its famous production system. For good reason: Toyota has repeatedly outperformed its competitors in quality, reliability, productivity, cost reduction, sales and market share growth, and market capitalization. By the end of last year it was on the verge of replacing DaimlerChrysler as the third-largest North American car company in terms of production, not just sales. In terms of global market share, it has recently overtaken Ford to become the second-largest carmaker. Its net income and market capitalization by the end of 2003 exceeded those of all its competitors. But those very achievements beg a question: If Toyota has been so widely studied and copied, why have so few companies been able to match its performance?

In our 1999 HBR article, "Decoding the DNA of the Toyota Production System," H. Kent Bowen and I argued that part of the problem is that most outsiders have focused on Toyota's tools and tactics—kanban pull systems, cords, production cells, and the like—and not on its basic set of operating principles. In our article, we identified four such principles, or rules, which together ensure that regular work is tightly coupled with learning how to do the work better. These principles lead to ongoing improvements in reliability, flexibility, safety, and efficiency, and, hence, market share and profitability.

As we explained in the article, Toyota's real achievement is not merely the creation and use of the tools themselves; it is in making all its work a series of nested, ongoing experiments, be the work as routine as installing seats in cars or as complex, idiosyncratic, and large scale as designing and launching a new model or factory. We argued that Toyota's much-noted commitment to standardization is not for the purpose of control or even for capturing a best practice, per se. Rather, standardization—or more precisely, the explicit specification of how work is going to be done *before it is performed*—is coupled with testing work *as it* *is being done*. The end result is that gaps between what is expected and what actually occurs become immediately evident. Not only are problems contained, prevented from propagating and compromising someone else's work, but the gaps between expectations and reality are investigated; a deeper understanding of the product, process, and people is gained; and that understanding is incorporated into a new specification, which becomes a temporary "best practice" until a new problem is discovered. (See the sidebar "The Power of Principles.")

It is one thing to realize that the Toyota Production System (TPS) is a system of nested experiments through which operations are constantly improved. It is another to have an organization in which employees and managers at all levels in all functions are able to live those principles and teach others to apply them. Decoding the DNA of Toyota doesn't mean that you can replicate it.

So how exactly does a company replicate it? In the following pages, I try to answer that question by describing how a talented young American, hired for an upper-level position at one of Toyota's U.S. plants, was initiated into the TPS. His training was hardly what he might have expected given his achievements. With several degrees from top-tier universities, he had already managed large plants for one of Toyota's North American competitors. But rather than undergo a brief period of cursory walk-throughs, orientations, and introductions that an incoming fast-track executive might expect, he learned TPS the long, hard way—by practicing it, which is how Toyota trains any new employee regardless of rank or function. It would take more than three months before he even arrived at the plant in which he was to be a manager.

Our American hotshot, whom we'll call Bob Dallis, arrived at the company thinking that he already knew the basics of TPS—having borrowed ideas from Toyota to improve operations in his previous job—and would simply be fine-tuning his knowledge to improve operations at his new assignment. He came out of his training realizing that improving actual operations was not *his* job—it was the job of the workers themselves. His role was to help them understand that responsibility and enable them to carry it out. His training taught him how to construct work as experiments, which would yield continuous learning and improvements, and to teach others to do the same.

The Program

Dallis arrived at Toyota's Kentucky headquarters early one wintry morning in January 2002. He was greeted by Mike Takahashi (not his real name), a senior manager of the Toyota Supplier Support Center (TSSC), a group responsible for developing Toyota's and supplier plants' competency in TPS. As such, Takahashi was responsible for Dallis's orientation into the company. Once the introductory formalities had been completed, Takahashi ushered Dallis to his car and proceeded to drive not to the plant where Dallis was to eventually work but to another Toyota engine plant where Dallis would begin his integration into the company. That integration was to involve 12 intensive weeks in the U.S. engine plant and ten days working and making observations in Toyota and Toyota supplier plants in Japan. The content of Dallis's training—as with that of any other Toyota manager—would depend on what, in Takahashi's judgment, Dallis most needed.

Back to Basics. Bob Dallis's first assignment at the U.S. engine plant was to help a small group of 19 engine-assembly workers improve labor productivity, operational availability of machines and equipment, and ergonomic safety.[1] For the first six weeks, Takahashi engaged Dallis in cycles of observing and changing individuals' work processes, thereby focusing on productivity and safety. Working with the group's leaders, team leaders, and team members, Dallis would document, for instance, how different tasks were carried out, who did what tasks under what circumstances, and how information, material, and services were communicated. He would make changes to try to solve the problems he had observed and then evaluate those changes.

Dallis was not left to his own devices, despite his previous experience and accomplishments. Meetings with Takahashi bracketed his workweek. On Mondays, Dallis would explain the following: how he thought the assembly process worked, based on his previous week's observations and experiences; what he thought the line's problems were; what changes he and the others had implemented or had in mind to solve those problems; and the expected impact of his recommendations. On Fridays, Taka-

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hashi reviewed what Dallis had done, comparing actual outcomes with the plans and expectations they had discussed on Monday.

In the first six weeks, 25 changes were implemented to individual tasks. For instance, a number of parts racks were reconfigured to present materials to the operators more comfortably, and a handle on a machine was repositioned to reduce wrist strain and improve ergonomic safety. Dallis and the rest of the group also made 75 recommendations for redistributing their work. These were more substantial changes that required a reconfiguration of the work area. For instance, changing the place where a particular part was installed required relocating material stores and moving the light curtains, along with their attendant wiring and computer coding. These changes were made with the help of technical specialists from the maintenance and engineering departments while the plant was closed over the weekend, after Dallis's fifth week.

Dallis and Takahashi spent Dallis's sixth week studying the group's assembly line to see if the 75 changes actually had the desired effects. They discovered that worker productivity and ergonomic safety had improved significantly, as shown in the exhibit "The U.S. Engine Plant Assembly Line—Before and After." Unfortunately, the changes had also reduced the operational availability of the machines. This is not to say that the changes that improved productivity and ergonomics made the machines malfunction more often. Rather, before the changes were made, there was enough slack in the work so that if a machine faulted, there was often no consequence or inconvenience to anyone. But with Dallis's changes, the group was able to use 15 people instead of 19 to accomplish the same amount of work. It was also able to reduce the time required for each task and improve workload balance. With a much tighter system, previously inconsequential machine problems now had significant effects.

After Dallis had improved the human tasks in the assembly line, Takahashi had him switch to studying how the machines worked. This took another six weeks, with Takahashi and Dallis again meeting on Mondays and Fridays. Takahashi had Dallis, holder of two master's degrees in engineering, watch individual machines until they faulted so that he could investigate causes directly. This took some time. Although work-method failures occurred nearly twice a minute, machine failures were far less frequent and were often hidden inside the machine.

But as Dallis observed the machines and the people working around them, he began to see that a number of failures seemed to be caused by people's interactions with the machines. For instance, Dallis noticed that as one worker loaded gears in a jig that he then put into the machine, he would often inadvertently trip the trigger switch before the jig was fully aligned, causing the apparatus to fault. To solve that problem, Dallis had the maintenance department relocate the switch. Dallis also observed another operator push a pallet into a machine. After investigating several mechanical failures, he realized that the pallet sometimes rode up onto a bumper in the machine. By replacing the machine's bumper with one that had a different cross-section profile, he was able to eliminate this particular cause of failure. Direct observation of the devices, root-cause analysis of each fault, and immediate reconfiguration to remove suspected causes raised operational availability to 90%, a substantial improvement though still below the 95% target that Takahashi had set for Dallis.

The Master Class. After 12 weeks at the U.S. engine plant, Takahashi judged that Dallis had made progress in observing people and machines and in structuring countermeasures as

The Power of Principles

The insight that Toyota applies underlying principles rather than specific tools and processes explains why the company continues to outperform its competitors. Many companies have tried to imitate Toyota's tools as opposed to its principles; as a result, many have ended up with rigid, inflexible production systems that worked well in the short term but didn't stand the test of time.

Recognizing that TPS is about applying principles rather than tools enables companies that in no way resemble Toyota to tap into its sources of success. Alcoa, a company whose large-scale processes—refining, smelting, and so on—bear little resemblance to Toyota's discrete-parts fabrication and assembly operations, has based its Alcoa Business System (ABS) on the TPS rules. Alcoa claims that ABS saved the company $1.1 billion from 1998 to 2000, while improving safety, productivity, and quality.

In another example, pilot projects applying the rules at the University of Pittsburgh Medical Center and other health care organizations have led to huge improvements in medication administration, nursing, and other critical processes, delivering better quality care to patients, relieving workers of nonproductive burdens, as well as providing costs savings and operating efficiencies.

experiments to be tested. However, Takahashi was concerned that Dallis still took too much of the burden on himself for making changes and that the rate at which he was able to test and refine improvements was too slow. He decided it was time to show Dallis how Toyota practiced improvements on its home turf. He and Dallis flew to Japan, and Dallis's first three days there were spent working at Toyota's famous Kamigo engine plant—where Taiichi Ohno, one of the main architects of TPS, had developed many of his major innovations. On the morning of their arrival, Takahashi unleashed the first of several surprises: Dallis was to work alongside an employee in a production cell and was to make 50 improvements—actual changes in how work was done—during his time there. This worked out to be one change every 22 minutes, not the one per day he had been averaging in his first five weeks of training.

The initial objective set for Dallis was to reduce the "overburden" on the worker—walking, reaching, and other efforts that didn't add value to the product and tired or otherwise impeded the worker and lengthened cycle times. Dallis's workmate could not speak English, and no translator was provided, so the two had to learn to communicate through the physical environment and through models, drawings, and role-playing. Afterward, Dallis speculated that the logic of starting with "overburden" was to get buy-in from the worker who was being asked to do his regular job while being interrupted by a non-Japanese-speaking stranger. There is also semantic significance in the phrasing: Focusing on "overburden" emphasizes the impact of the work design on the person. By contrast, focusing on "waste" suggests that the person is the problem.

Dallis applied the approach he had learned at the U.S. engine plant. On day one, he spent the first three hours observing his new workmate, and by the shift's end proudly reported that he had seven ideas, four of which he and his workmate had implemented. Then Takahashi unleashed his next surprise: He told Dallis that two Japanese team leaders who were going through the same training—people with jobs far less senior than the one for which Dallis was being prepared—had generated 28 and 31 change ideas, respectively, within the same amount of time. Somewhat humbled, Dallis picked up the pace, looking for more opportunities to make improvements and trying even more "quick and dirty" methods of testing ideas: bolting rather than welding things, taping rather than bolting, and holding rather than taping—anything to speed up the rate of feedback. By 11 am on the second day, he and his coworker had built the list to 25 ideas. Takahashi would visit the machine shop while they were working, ask what Dallis was concentrating on, and then follow up with very specific queries about the change idea. "Before I could give a speculative answer," recalled Dallis, "he sent me to look or try for myself."

Dallis found that his ability to identify and resolve problems grew with practice, and by the morning of the third day, he had moved from examining the details of individual work routines to looking at problems with how the production cell as a whole was laid out and the effects on workers' physical movements: "There were two machines, with gauges and parts racks. A tool change took eight steps on one and 24 on the other. Was there a better layout that would reduce the number of steps and time? We figured out how to simulate the

The U.S. Engine Plant Assembly Line—Before and After

The following table describes the impact of the changes Dallis made to the U.S. engine plant assembly line during his first six weeks there. He made substantial improvements in productivity—reducing the number of workers and cycle times. He and the group also made significant improvements in safety (eliminating four processes and improving the rest). But machine availability actually decreased during the period from 90% to 80%. In Dallis's second six weeks, he and his team were able to restore availability back to 90%, but this was still below the 95% target.

	Before	After
Productivity		
Number of operators	19	15
Cycle time	34 seconds	33 seconds
Total work time/engine	661 seconds	495 seconds
Ergonomics*		
Red processes	7	1
Yellow processes	2	2
Green processes	10	12
Operational availability	≈ 90%	≈ 80%

* Processes were rated from worst (red) to best (green) on the basis of their ergonomics—a formula that took into account weight lifted, reaching, twisting, and other risk factors.

change before getting involved with heavy machinery to move the equipment for real," Dallis said. By the time the three days were up, he had identified 50 problems with quality checks, tool changes, and other work in his machine shop—35 of which had been fixed on the spot. (The effects of these changes are summarized in the exhibit "The Kamigo Report Card.")

Takahashi had Dallis conclude his shop-floor training by presenting his work to the plant manager, the machine shop manager, and the shop's group leaders. Along the way, Dallis had been keeping a careful log of the changes and their effects. The log listed operations in the shop, the individual problems Dallis had observed, the countermeasure for each problem, the effect of the change, and the first- and second-shift workers' reactions to the countermeasure. (For a snapshot of the log, see the exhibit "Excerpts from Dallis's Log.") Photographs and diagrams complemented the descriptions. "During the presentations," Dallis reported, "the plant's general manager, the machine shop's manager, and its group leaders were engaged in what [I and the other] 'lowly' team leaders said. Two-thirds [of the audience] actively took notes during the team leaders' presentations, asking pointed questions throughout."

After Dallis made his presentation, Takahashi spent the remaining week showing him how Toyota group leaders—people responsible for a few assembly or machining teams, each with three to seven members—managed and presented their improvement projects. In one case, a group leader was exploring ways of reducing machine changeover times and establishing a more even production pace for an injection-molding process. In another, a group leader was looking for ways to reduce downtime in a machining operation. In all the presentations, the group leaders explained the problems they were addressing, the processes they used to develop countermeasures, and the effect these countermeasures had on performance. Dallis quickly realized that people at all levels, even those subordinate to the one for which he was being developed, were expected to structure work and improvements as experiments.

Lessons Learned

Although Takahashi at no point told Dallis exactly what he was supposed to learn from his experience, the methodology of the training just described is so consistent and specific that it reveals at least four fundamental principles underlying the system. Together with the rules we described in our 1999 article, the following lessons may help explain why Toyota has remained the world's preeminent manufacturer.

Lesson 1
There's no substitute for direct observation.
Throughout Dallis's training, he was required to watch employees work and machines oper-

The Kamigo Report Card

During his three days at Kamigo's machining shop, Dallis documented the effects of the 50 changes he made to work motion (the physical movements of assembly-line workers) and cell layout. The changes are categorized according to the nature of the activity—walking, reaching, or other movements. They cut about half a mile of walking per shift per operator in addition to reducing ergonomic and safety hazards.

	Quality checks*			Tool changes*			Other work
	Walking	Reaching	Other	Walking	Reaching	Other	
Number of changes	8	8	13	7	4	5	5
Effect of changes	20-meter reduction (50%) per check	2-meter reduction in reaching	Elimination of tripping risk, organization of tools to reduce risk of confusion	50-meter reduction per tool change	180-cm reduction in reaching	Improvement of ergonomics, organization to reduce risk of confusion	Elimination of tripping risk, simplification of oil change

* Quality checks were performed two to three times an hour, and tool changes were made once an hour.

ate. He was asked not to "figure out" why a machine had failed, as if he were a detective solving a crime already committed, but to sit and wait until he could directly observe its failure—to wait for it to tell him what he needed to know.

One of the group leader presentations at Kamigo described this principle in action. In a project to improve machine maintenance, it became clear to the group that machine problems were evident only when failures occurred. In response, the shop's group leaders had removed opaque covers from several machines so that operators and team leaders could hear and see the inner workings of the devices, thus improving their ability to assess and anticipate problems with the machines. This is a very different approach from the indirect observation on which most companies rely—reports, interviews, surveys, narratives, aggregate data, and statistics. Not that these indirect approaches are wrong or useless. They have their own value, and there may be a loss of perspective (the big picture) when one relies solely on direct observation. But direct observation is essential, and no combination of indirect methods, however clever, can possibly take its place.

Dallis's previous experience managing plants might have prepared him to look at operations of greater scale and scope, but had Takahashi given him a project with greater scope, Dallas might not have learned to observe with such precision. Dallis's first six weeks at the U.S. engine plant meant that he had up to 23,824 opportunities to observe complete work cycles. Because his work was limited to a 19-person line, he could view more than a thousand work cycles per person. That gave him deep insight into the line's productivity and safety.

Lesson 2
Proposed changes should always be structured as experiments.

In the scientific method, experiments are used to test a hypothesis, and the results are used to refine or reject the hypothesis. Dallis's problem solving was structured so that he embedded explicit and testable assumptions in his analysis of the work. Throughout his training, therefore, he had to explain gaps between predicted and actual results. In his meetings with Takahashi at the U.S. engine plant, for example, he was required to propose hypotheses on Monday and the results of his experiments on Friday. In Japan, he had to present his changes as tests of causal relationships, stating the problem he saw, the root cause he suspected, the change he had made, and the countermeasure's actual effect on performance.

Of course, many people trying to improve a process have some idea of what the problems are and how to fix them. The difference with

Excerpts from Dallis's Log

Throughout his training, Dallis kept a precise log of identified problems, proposed solutions, expected results, and actual outcomes. Records like the one below are essential to the Toyota Production System, as they help encourage the precision that is necessary for true experimentation.

The following excerpt shows two of the problems Dallis identified. Note that he obtained approval of his changes from the people actually doing the work. That's because at the end of the day, the people doing the work must own the solution. This kind of hierarchical inversion is a common feature of Toyota operations.

Problem #	Location	Description	Countermeasure	Result	Date	Shift 1 approval	Shift 2 approval
4	Station 6R	Team member walks 4 meters to get and then return first-piece check gauge during tool changes	Move first-piece check gauge from table to shelf between stations 5 and 6	4-meter reduction in walk/tool change	May 8	Yes	Yes
58	Part gauging area	Team member walks 5 steps to return cams to return chute, walking around light pole	Remove light pole (obstruction) and move part gauge 45°	Reduce walk 2 steps	Not done	Yes (Pending help from maintenance department)	Yes

TPS—and this is key—is that it seeks to fully understand both the problem and the solution. For example, any manager might say, "Maybe the parts rack should be closer to the assembler's hand. If we move it here, I'll bet it'll shave a few seconds off the cycle." Were he to try this and find that it saved six seconds, he would probably be quite pleased and consider the problem solved.

But in the eyes of a Toyota manager like Takahashi, such a result would indicate that the manager didn't fully understand the work that he was trying to improve. Why hadn't he been more specific about how far he was going to move the rack? And how many seconds did he *expect* to save? Four? If the actual savings is six seconds, that's cause for celebration—but also for additional inquiry. Why was there a two-second difference? With the explicit precision encouraged by Takahashi, the discrepancy would prompt a deeper investigation into how a process worked and, perhaps more important, how a particular person studied and improved the process.

Dallis was asked not to figure out why a machine had failed but to sit and wait until he could directly observe its failure—to wait for it to tell him what he needed to know.

Lesson 3

Workers and managers should experiment as frequently as possible.

At Toyota, the focus is on many quick, simple experiments rather than on a few lengthy, complex ones. This became particularly evident when Dallis went to Japan. Whereas in the United States he made 25 changes in six weeks (before the weekend blitz during which 75 were completed), in Japan he had to make 50 changes in 2 shifts, which meant an average of one change every 22 minutes. This encouraged Dallis to learn from making small incremental changes rather than large system-design changes. He would observe work actually being done, quickly see where struggles were occurring, then rapidly test his understanding by implementing a countermeasure, thereby accelerating the rate at which he discovered "contingencies" or "interferences" in the process. This is precisely the way Toyota workers practice process improvement. They cannot "practice" making a change, because a change can be made only once. But they can practice the process of observing and testing many times.

To ensure that Dallis received the practice he needed and that he internalized his understanding of it, Takahashi structured Dallis's training so that the complexity of his experiments increased gradually. When Dallis started at the U.S. engine plant, he conducted "single factor" experiments, changing small, individual work elements rather than taking a system perspective. What's more, his efforts there started with individual work methods, progressing to more complex and subtle machine problems only when he had developed his observation and problem-solving skills over the six weeks. Thus, he moved from problems that were easier to observe to those that were harder. If each learning cycle is kept small and bounded, then the learner can make mistakes and the consequences will not be severe. This approach increases the learner's willingness to take risks and learn by doing. Dallis's training at Kamigo mirrored this progression: He began, once again, with work-method issues of "overburden" before moving on to machines.[2]

Lesson 4

Managers should coach, not fix.

Dallis's training not only gave him insight into how Toyota delivers continuous improvement but also helped him understand the unique relationships between Toyota's managers and workers. Dallis himself had been rewarded by his previous employer for being a problem solver, albeit one with a more participative and inclusive approach than most. What he saw at Toyota, by contrast, was workers and low-level managers constantly solving problems. Indeed, the more senior the manager, the less likely he was to be solving problems himself.

Toyota managers act as enablers. Throughout Dallis's training, Takahashi—one of Toyota's most senior operational managers—positioned himself as a teacher and coach, not as a technological specialist. He put Dallis through experiences without explicitly stating what or how he was to learn. Even when specific skills were imparted, these were purely to assist Dallis's observation and experimentation. For instance, Takahashi showed Dallis how to observe an individual worker in order to spot instances of stress, wasted effort, and so on, and he explicitly advised Dallis on how to develop prototypes. But at no point did he suggest actual process improvements. Rather, he directed Dallis on how to find opportunities for those improvements (as in, study this person or that machine, looking for various types of stress, strain, or faults) and on how to de-

"I saw a line [at Kamigo] that was 15 years old but that had the capacity to build 90 different engine types."

velop and test possible countermeasures.

Takahashi also gave Dallis the resources he needed to act quickly. For example, at Kamigo, Dallis had the help of a maintenance worker to move equipment, create fixtures, relocate wires and pipes, and provide other skilled trade work so that he could test as many ideas as possible. Takahashi and the shop manager also came to the cell of the machining operation to review Dallis's ideas; they gave him tips on piloting his changes before asking support workers to make parts or relocate equipment. When Dallis wanted to rotate some gauges that tested parts, the shop manager showed him how to quickly and inexpensively make cardboard prototypes to test location, orientation, size, and so on.

The result of this unusual manager–worker relationship is a high degree of sophisticated problem solving at all levels of the organization. Dallis noted, "As a former engine-plant person, I saw a line [at Kamigo] that was 15 years old but that had the capacity to build 90 different engine types. It was amazing that they solved so many problems with such simple equipment. Behind the changes was some pretty deep thinking." The basic company philosophy is that any operating system can be improved if enough people at every level are looking and experimenting closely enough. (After all, if only the big shots were expected to make changes, all that "little" stuff would get overlooked.) The fact that Dallis, after just three months at the U.S. engine plant, was able to empower others to implement 50 improvements at Kamigo, one of Toyota's top plants, offers insight into why Toyota stays ahead of its competitors.[3]

Back to America

To see if Dallis had learned the right lessons from his training, Takahashi sent him back to the U.S. engine plant where his instruction had begun. As we have seen, Dallis had already helped make substantial improvements in the assembly line's labor productivity and ergonomic safety before going to Japan. But he hadn't been able to raise operational availability to 95%. Now, upon Dallis's return to that plant, Takahashi had him attempt this goal again. However, there was a marked departure from Dallis's earlier approach, in which he primarily saw himself as a problem solver.

With Takahashi's help, Dallis worked with the line's group leader and assistant manager in order to develop the problem-solving skills of the line's team members and team leaders. The point was for the team to learn to solve little problems simultaneously so that the line could recover quickly when problems occurred. For instance, the team realized that it had difficulties in keeping track of what work needed to be done and in identifying problems as they occurred. It therefore had to improve its "visual management" of the work—what was going well, what was going wrong, and what needed to be done. Dallis sat down with the group leader and assistant manager and set out a schedule for identifying specific problems and allocating responsibility for them across the team. As the team members observed and developed countermeasures, Dallis would drop by much as Takahashi had done, asking them specific questions that would oblige them to observe their allotted problems more closely as they happened. To its delight, the group hit its mark ahead of schedule and raised operational availability to 99%.

Dallis had returned to America with an altered focus. He had realized from the way Takahashi had managed his training, and from what he'd seen of others' training, that the efforts of a senior manager like himself should be aimed not at making direct improvements but at producing a cadre of excellent group leaders who learn through continuous experimentation. The target of 95% operational availability at the U.S. engine plant was the same, but he now knew whose target it really was, and it wasn't his. At this point, Takahashi finally released Dallis from his training to take on his full-time managerial responsibilities.

• • •

For anyone trying to understand how the Toyota Production System really works, there is probably no substitute for the kind of total immersion that Dallis received. TPS is a system you have to live to fully understand, let alone improve. Besides, anyone like Dallis coming into Toyota from the outside, regardless of his or her experience, is coming into an organization with a long history of making improvements and modifications at a pace few organizations have ever approached. No one can expect to assimilate—let alone recreate—such a strong and distinct culture in just a few weeks or even a few months. Nevertheless, any company that develops and implements a training program such as the one Dallis participated in is sure to reap enormous dividends. The organization that applies the rules in designing its operations and that trains its managers to apply those rules will have made a good start at replicating the DNA of the Toyota Production System.

1. Operational availability equals machine run time/machine use time. For instance, if a machine requires eight minutes of process time to grind a surface, but, because of jams and other interruptions, ten minutes are actually spent from start to finish, then operational availability would be 80%. Ideally, operationally availability would be 100%—that is, the machine always runs when it is needed.

2. The incremental approach was also helpful to Takahashi, who used it to teach Dallis. He directly observed Dallis's work by creating short learning cycles with rapid feedback so that he could continually reassess Dallis's knowledge and skills, both to provide feedback in order to help him learn and to design the next learning increment.

3. According to Takahashi, the expectation was that group leaders at Kamigo—managers who supervised several operating shops or cells—would spend 70% of their time doing process improvement work. This time would often be shared among three to four teams, implying that team leaders—people managing one shop or cell—were expected to spend a minimum of 20% of their time on improvement work.

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