Strategic Management Journal
Strat. Mgmt. J., **21**: 981–996 (2000)

THE SATISFICING PRINCIPLE IN CAPABILITY LEARNING

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Whether an organization has a certain capability is often a matter of degree. Thus, in the context of initial learning of a capability, there is generally no clear-cut or automatic answer to the question of when an organization should be expected to cut back its learning efforts and affirm that the desired capability has been achieved. This paper offers a simple conceptual model for this question, based on the satisficing principle. More specifically, the question addressed is: 'When does overt learning stop?'—where 'overt' learning is understood as being marked by observable allocation of attention and resources to the task of acquiring the capability. The model provides the framework for a discussion of various influences on the aspiration level in the satisficing model, and hence on the nature of the capability that has been achieved when learning stops.

Overt learning efforts may be resumed at some time later if external factors operate to lift aspiration levels relevant to the capability. The paper discusses how such 're-ignition' of learning may occur as a result of an organizational crisis, or of the institution of a quality management program. Copyright © 2000 John Wiley & Sons, Ltd.

INTRODUCTION

Perhaps there are some cases where the state of an organization's ability to accomplish some specific desired result R could be adequately represented by a single dummy variable: either the organization can do it ($X_R = 1$) or it can't ($X_R = 0$). In the former case, we would say that the organization has the R capability, while in the latter case we would say that it lacks such a capability. In such cases, if they exist, the question of what it means to 'have' the capability has a sharp answer that is quite distinct from the question of how the capability is created. In all other cases, the two questions are entangled: the statement that an organization 'has' a certain capability is of meager import by itself; it generally needs to be followed by the words 'in the sense that …' followed by a list of key criteria, values of performance measurements, and so forth. These details vary over time, generally in the direction of improvement, as the capability develops.

I doubt that examples of the dummy variable type actually do exist. Isn't it always the case that there is more than one significant performance dimension, and that some significant dimensions are appropriately represented by continuous variables, or at least ones that are not binary? True, it does matter whether our flight actually reaches its destination or not, and a safe arrival certifies, in a limited way, the airline's possession of a capability to mount such a flight. But '*almost on time*' beats '*hours late because of an equipment problem identified at the departure gate*,' which in turn beats '*hours late because of the emergency*

Key words: capabilities; organizational learning; satisficing; aspirations
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landing en route' —and, come to think of it, there are also significant differences within the $X_R = 0$ category: '*cancelled*' beats '*crashed*'.

In any case, this essay deals with capability learning situations in which the outcome variable for an individual exercise of the capability is multidimensional and on some dimensions non-perfectible—i.e., performance could always be made at least a little better, perhaps because performance varies continuously in some dimensions and cannot realistically be driven to an ideal limit value, if such exists. These situations pose the questions of what it means for an organization to 'have' the capability, how the details of performance come to be determined, and what organizational learning has to do with the latter question. Consideration of these issues leads to an ecological and evolutionary perspective on organizational capabilities and capability learning. It is ecological in the sense that the simple notion of 'having' a capability is seen as meaningful only in relation to a particular competitive context at a particular time, and evolutionary in the sense that changes in competitive standards, and learning responses to those changes, are seen as key drivers of long-term change in capabilities. It is evolutionary, also, in the sense that its basic answer to the question of 'Where did all of these intricate and marvelously designed production capabilities come from?' parallels the biologist's answer to the corresponding question about advanced life forms: they evolved out of the similar but somewhat less marvelous instances of the recent past, which in turn, …, and so on. (In the capabilities case, at least, we can often identify origins that weren't all that marvelous in terms of quality of design.)

In the following section, I address conceptual issues involving the terms in my title and give a stylized description of the learning process and the end of what I call 'overt' learning. The third section examines the influences on the performance levels that an organization aspires to as it attempts to acquire a capability. In the final section, the analysis is employed as a perspective on organizational crises and on the quest for 'continuous improvement.' First, however, I review a relatively familiar example of a specific organizational capability and its acquisition, for the sake of establishing one specific reference point for the subsequent discussion.

Nucor adopts compact strip production[1]

In 1983, the steel producer Nucor Corporation initiated a search for a casting technology that would permit it to enter the flat-rolled sheet segment of the steel market. Like other minimill producers, Nucor had concentrated on 'low-end' steel products, such as structural shapes, where the usefulness of the output was more robust to the quality problems caused by the impurities in the steel scrap that fed the minimills' electric furnaces. The best margins in the steel business went to firms who could meet the quality standards of the high end of the flat steel market. At the time, only the large integrated mills were in that group. In contemplating entry to the flat-steel segment, Nucor faced not only the challenges of acquiring new capabilities and of the quality problem but also a substantial scale economy barrier associated with the conventional casting technology.

In 1986, Nucor decided to become the first adopter of a new steel-shaping technology called compact strip production (CSP), which was being marketed by the German equipment manufacturer SMS Schloemann-Siemag. This was one of several potentially viable but unproven technologies for casting steel in thin slabs, thus reducing the difficulty and cost of further processing the steel into flat sheets. It reduced the indivisibility challenge because an efficient plant could be built at a capacity equal to about one-third of that of a conventional plant. The central innovative element in the CSP process was a lens-shaped mold in which the steel cooled. While this may suggest a modest technical challenge, the opposite is suggested by the fact that prior to Nucor more than 100 companies are said to have sent representatives to observe the SMS pilot operation, but did not sign on.[2] Or at least, the challenges must have seemed large relative to the estimated economic advantages, which were significant but not overwhelming.

Steel making and casting is a batch production process. In a minimill, one 'heat' of steel results when an electric furnace is charged with scrap steel which is then melted over a

[1] This account is drawn from Ghemawat (1992, 1997), and especially from Rosenbloom (1991).

[2] Ghemawat (1992) and Rosenbloom (1991) seem to diverge on the innovativeness of CSP, with Ghemawat tending to downplay it.

period of 5–10 hours. The entire heat of molten steel goes from the furnace to a ladle, from which it is poured into the molds and then cools into solid form. There are various ways in which this process can fail. A particularly spectacular failure is a 'breakout'—a rupture of the partially solidified skin of the emerging steel strand that allows molten steel to escape and run through the machinery, welding parts together. Less spectacular problems in the casting, rolling, and coiling of the steel may cause the finished steel to be deficient in quality or unusable.

In 1988, Nucor initiated construction of its Crawfordsville, Indiana, plant implementing the CSP technology. The first attempt to use the new caster was made in June of 1989. The following months were 'a roller coaster of success and failure, with breakouts and breakdowns occurring daily' (Rosenbloom, 1991: 6). In spite of the difficulties, the Crawfordsville plant pulled ahead of the planned production ramp-up schedule after a few months of operation. The quality of the steel was not sufficient to make it possible to serve the high end of the flat steel market as originally contemplated, but there was more than adequate demand for the plant's products. The level of success achieved, if not 100 percent, was high enough so that Nucor soon began expanding its thin-slab capacity.

CONCEPTUAL GROUNDWORK

What is a capability?

Given the fact that there is a rather thick terminological haze over the landscape where 'capability' lies, it may be helpful to begin with an attempt at definition.[3] *An organizational capability is a high-level routine (or collection of routines) that, together with its implementing input flows, confers upon an organization's management a set of decision options for producing significant outputs of a particular type.* This definition takes the notion of routine as a primitive, and can be explicated by identifying the ways in which capabilities differ from routines in general. First, whereas routines can be of any size and significance, capabilities are substantial in scale and significance. A capability is reflected in a large chunk of activity that enables outputs that clearly matter to the organization's survival and prosperity. Second, whereas routines are sometimes entirely invisible and unknown to the management, capabilities are necessarily known at least in the minimal sense that the control levers and their intended effects are known. The 'set of decision options' language emphasizes this managerial control aspect and the fact that a capability is deployable in various directions. By contrast, many routines are 'wired directly to the environment' and get invoked in response to external stimuli without managerial choice. Finally, the reference to 'implementing input flows' is a reminder that is as relevant for routines in general as for capabilities, but perhaps more significant in the context of capabilities. It is a reminder that the coordinating information flows and information processing of a capability are only its nervous system; producing output requires actual input services from its bones and muscles.

Also, the focus here is on the learning that yields, for a business firm, the capability to produce marketable output. That learning may itself reflect a *dynamic capability* (Teece, Pisano, and Shuen, 1997) of the organization, if its approach to learning is a systematic and persistent feature of the organization (Zollo and Winter, 1999). Thus, for example, Nucor learned the capability to produce marketable steel with the CSP technique. The pace at which it accomplished that learning arguably reflected persistent features of the organization, some of them also the result of learning, that collectively endowed it with a dynamic capability for innovation in steel making—a dynamic capability whose 'output' is not steel but new capabilities for making steel. The creation of such dynamic capabilities is, however, a subtle matter, and one that is not necessarily within the scope of the satisficing logic discussed here.

The notion of 'learning' itself has some substantial ambiguities, and might be thought to require careful definition. In fact, few of the puzzles that can arise with the broad concept are actually relevant here. What counts as learning for purposes of this analysis is, at least for the most part, what counts as learning for the managers involved in the process.

[3] The terminological problems are discussed at some length in the Introduction to *The Nature and Dynamics of Organizational Capabilities* (Dosi, Nelson, and Winter, 2000).

What is satisficing?

As classically expounded by Simon (1955, 1956), satisficing is a theory of choice focused on the process by which alternatives are examined and assessed. As such, it contrasts with optimization theory. Simon has explained that the contrast is between 'looking for the sharpest needle in the haystack' (optimizing) and 'looking for a needle sharp enough to sew with' (satisficing) (Simon, 1987: 244). Under many circumstances (e.g., a large haystack containing a substantial number of heterogeneous needles, many sharp enough to sew with), the costs of the satisficing process are radically lower than those of optimizing, and this is put forward as the central appeal of the satisficing approach to the decision-maker—and hence, indirectly, to the decision theorist. The example makes clear the following related points about this classic formulation: (i) the discovery of a satisficing alternative ends the assessment process; (ii) assessment of alternatives precedes action; (iii) the search process explores a well-defined set of preexisting alternatives, i.e., alternatives are discovered rather than created; (iv) the defining criteria of a satisficing alternative are static. Although less evident in the example, it is also true in the classic formulation that (v) the costs of assessment are conceived, primarily if not exclusively, as computation costs.

Later work involving the satisficing principle has often embedded it in some formal model of decision, and has generally given it a more expansive and dynamic interpretation (Winter, 1971; Levinthal and March, 1981; Nelson and Winter, 1982). A *search* for alternatives may be conceived as involving creation, rather than mere discovery and assessment of alternatives that are in some sense preexisting.[4] The principle may govern not merely the termination of search, but also its initiation or its *resumption*, if the criteria characterizing a satisficing alternative are subject to change. Some action precedes assessment in the sense that search typically departs from a working *status quo* alternative rather than from a null alternative. It may be that the most important costs arise not from computation in any narrow sense, but from the fact that alternatives must first be created and then can be effectively assessed only *on-line*—the only cost-effective way to assess the performance of an alternative is to implement it.[5] When the necessity for on-line assessment is joined with the common circumstance that performance is affected by a multiplicity of contingencies, both systematic and random, it becomes clear that assessment is likely to be both costly and time-consuming. When the new alternative displaces the *status quo* alternative, rather than being implemented in parallel to it, the costs of the experiment include opportunity costs, the foregone benefits of operating with the status quo alternative. Finally, and for present purposes very importantly, the dynamic adjustment of *aspirations* modifies the criteria for a satisficing alternative. As March has observed, 'discussions of search in the limited rationality tradition emphasize the significance of the adaptive character of aspirations themselves.' (March, 1991: 72).

To illuminate capability learning, it is the more expansive and dynamic version of the satisficing principle that will prove useful. It is first necessary to locate the role of satisficing by describing the capability-learning situation in the terminology of the choice-theoretic framework. Broadly speaking, an 'alternative' here is a way of doing things; in particular, an *ex ante* plausible way of *attempting* to accomplish the end result at which the capability aims. To create a significant new capability, an organization must typically make a set of specific and highly complementary investments in tangible assets, in process development, and in the establishment of relationships that cross the boundaries of the organizational unit in which the process is deemed to reside. Although significant learning can certainly occur with respect to other investments, a learning perspective is most obviously relevant to process development. It is natural to focus on the process because the success of the process in achieving the desired output is the operational test for the

[4] Of course, at the philosophical level there is always the ontological option of assuming that all feasible alternatives are preexisting from time immemorial. This often seems unnatural at the conceptual level, though convenient for modeling purposes.

[5] Gavetti and Levinthal (2000) have recently proposed and analyzed the distinction between 'experiential' and 'cognitive' search. While 'cognitive' search can be conducted off-line in the sense that new alternatives can be generated and assessed without actually changing the process, choice and implementation of an alternative lead to the more conclusive type of assessment that can only be accomplished on-line.

other investments as well as for process learning proper.

A stylized view of learning

For analytical purposes, it is helpful to schematize process learning as occurring in a series of (online) trials, interspersed or alternated with variable periods of off-line deliberation and analysis.[6] That learning has such a discrete trials structure is clearly a common feature of reality. For example, in the case of CSP, there is a trial at the level of a single 'heat'—that volume of molten steel is either converted successfully to product or not. All 'batch production' processes obviously have such a discrete trials structure; in other contexts the key value creation events are trips, system conversions, consulting assignments, acquisitions, construction projects, store openings, lawsuits, *trials*, and so forth. In still others, cycles induced by clocks and calendars introduce a behavioral punctuation that structures the learning process into discrete episodes, even when the underlying work has no such character—for example, the process is periodically shut down for routine maintenance. Finally, there are admittedly cases in which production truly occurs continuously under normal conditions, but even in these there are typically episodic interventions to adjust the process—and such interventions produce precisely the sort of structure that the present stylization of capability learning presumes.

The important point for the application of the satisficing framework is that the end of a trial affords an opportunity to examine output, assess process performance, and consider various types of adjustments to the process—all in ways that are not similarly available during a trial. The focal decision is the decision on whether to make (deliberate) adjustments to the process or not; the latter choice deems the current way of doing things 'a needle sharp enough to sew with;' it satisfices, at least for the time being. Adjusting the process is looking at another needle. The question is what considerations govern the choice. For simplicity of exposition, I assume that the organization contains an effective decision locus for this choice, a 'unitary actor' who makes these particular choices.

Given this framing, it is clear that the satisficing principle does not govern all of the learning that takes place as trial follows trial; much less does it govern all the change in the process. In particular, some organizational learning is largely driven by task repetition and can occur without conscious awareness; this is particularly true when the organizational learning reflects skill learning at the individual level. Also, some change in the process occurs because of fluctuations in the context, and some 'within-trial' learning occurs as responses to such fluctuations are improvised and then practiced as similar situations recur. Further, what is identified as a 'trial' at one level of analysis may be a complex behavioral pattern involving multiple repetitions tasks at a lower level; the sort of satisficing-governed learning described here may occur at the lower levels within a single trial of the higher-level process. There are many ways to get down the learning curve of a complex process, and those just described can easily produce measurable learning within the framework of a 'way of doing things' that is constant in the sense that no deliberate process innovation is made.[7] The relevant managers would probably say, 'We are just getting better at it.' The 'covert' learning that happens in these ways is unintended or at least unplanned by top management; some part of it may even be outside the conscious awareness of all participants. Its mechanisms leave their observable traces primarily in data that support performance comparisons over substantial time intervals. Its costs, if any, typically leave no trace at all, but are hidden in the costs attributed to production.

By contrast, overt learning efforts are undertaken when the current way of doing things does not satisfice. There is (by definition) a perceived need in the organization to improve the process. Such a perception typically leads to activities and resource deployments that are observable, though perhaps only to observers who have appropriate

[6] What is here called 'off line' deliberation is concerned with the generation of alternatives and with evaluation up to the point of choice of a specific alternative; the actual value of adjustments introduced as a result of such choice can only be assessed in additional trials.

[7] On the other hand, it is clear that empirical learning curves typically describe situations where the way of doing things is not at all constant in that sense, and where deliberate change efforts persist. See Sinclair, Klepper, and Cohen (1998); Argote (1999); Mishima (1999).

vantage points on the scene. An organization that is creating an entirely new capability is obviously particularly likely to display such overt activity, since early trials are likely to yield results that are unsatisfactory, often dramatically so. The first question to be confronted by the satisficing analysis is when and under what circumstances that sort of observable activity disappears and the adequacy of the by-then-established way of doing things begins to be taken for granted. In more concise form, the question is, 'When does overt learning stop?'[8]

'Optimal' capability learning?

A brief digression into a normative perspective may serve to illuminate the interest of this question. Learning *should* stop when the incremental costs of pursuing it further begin to exceed the incremental benefits derived from it. There are, however, significant obstacles in the way of a precise weighing of this balance. Considered in fine detail, overt learning efforts have the character of investment projects under uncertainty. Some costs are incurred in the form of deliberation, training, and physical adjustments to the process; then the adjusted way of doing things is given a trial, results are observed, and the desirability of the changes is assessed *ex post*—when it is too late to avoid the costs. Thus, *ex ante* uncertainty about the benefits of further effort implies that even 'optimal stopping' cannot stop learning at the point an omniscient observer would pick. At best, optimality implies the maximization of expected benefits, calculated with reference to some probability distribution. But there are significant obstacles standing in the way of successful completion of this decision-theoretic program.

Especially in complex production systems, the possible combinations of adjustments that might be considered are enormous in number, and deficits of understanding and imagination prevent a skillful selection of the specific adjustments to be attempted (von Hippel and Tyre, 1995). Further, such systems are generally characterized by multiple strong interactions among the components, implying that simultaneous adjustments of a small number of parameters might have major effects, but also that *ex ante* assessment of such effects is difficult. The significance of this point has been illuminated by simulation studies based on Kauffman's '*NK*' model (Kauffman, 1989, 1993; Levinthal, 1997). The more numerous the interactions (K) among the available policy parameters (N), the more the performance measure forms a 'rugged landscape' over the policy space. Such a landscape displays a multiplicity of local maxima, defined as positions where it is impossible to improve performance further by adjusting any single policy parameter in isolation. Learning based on local search can, at best, reach such a local peak. Only a comprehensive understanding, of a sort that would ordinarily make search unnecessary in the first place, can clearly reveal the distant peaks and the path to them.[9] The theoretical metaphor provided by the *NK* model makes it easier to understand why boundedly rational managers might extrapolate from the experience of dwindling returns to local search and underestimate the expected returns to search in general. Finally, assessment of the consequences of specific adjustments may be difficult or slow even *ex post* if there is substantial random variation in trial outcomes.

All of the foregoing is particularly relevant in the early stages of capability learning, when accumulated data are particularly sparse and causal understanding particularly weak. Such a situation presents maximal obstacles to accurate estimation of both the actual benefits of a particular adjustment and the expected benefit of a population of adjustments. The implication is that, regardless of the subjective rationality of the participants, overt learning could easily stop at a point where a hypothetical omniscient observer could see that strong positive results were 'just around the corner,' or more accurately, just around a small number of corners. Although a small number of parameter changes might make a big difference, the diminutive number does not imply that it is easy to find those changes; there are many, many corners in such a high-dimensional space. Only an omniscient observer can easily see what a few turns in the right directions would reveal to the experimenters.

When the data that ideally would guide a

[8] I assume for the time being that there is one significant stopping point for overt learning of a particular capability. This assumption is relaxed in the final section of the paper.

[9] Gavetti (2000) explores how a less comprehensive cognitive understanding can usefully complement local 'experiential' search in the *NK* context.

decision are simply unavailable, the door is clearly open for strong influence from other considerations.[10] A number of these have been well described in the discussion of the imperfect balance that organizations tend to strike between exploration and exploitation (March, 1991; Levinthal and March, 1993). The main tendency of these influences is in the direction 'exploitation drives out exploration.' In the relatively specific context of the ending of capability learning, this translates as 'overt learning tends to end too soon;' the above points suggesting why this might happen are akin to ones that have been made in the more general exploration/exploitation discussion. For example, the idea that the benefits of a process adjustment can sometimes be assessed only by protracted on-line testing is an illustration of the general point that the benefits of exploration are often relatively remote in time from those of exploitation (understood as satisficing on the unadjusted process).

More specific insight into the suspension of overt learning can be derived by using the satisficing framework to interpret key features of the capability-learning context. That framework offers the determination of aspiration levels as a principal channel through which a number of considerations enter the picture. Some candidate sources of these influences are discussed in detail in the following section.

To frame that discussion, consider how a higher or lower initial aspiration affects the situation, taking the dynamics of aspiration adjustment and a hypothetical improving trend of potential trial outcomes as given. Set aside for the moment the complication, discussed below, that there may be a minimum level to aspirations and trial outcomes might not reach it: assume they do. Then, low initial aspirations imply an early end to learning and a relatively inferior achievement in the capability initially accepted. Should the fire of learning subsequently be reignited, there would be abundant room for further progress. High aspirations imply the opposite: protracted learning, a stronger capability when overt learning ends, and reduced room for subsequent achievement. If this logic is correct, there are immediate implications concerning heterogeneity of organizational capabilities and performance. Consider the hypothetical situation of a group of organizations that are identically positioned initially with respect to a new capability and have identical learning capacity in the sense that they would generate equally satisfactory tracks for trial outcomes in a given period of overt learning activity. Among such organizations, those with aspirations that are initially high or particularly resistant to downward adjustment will persist longer in overt learning, ultimately satisficing at higher levels of performance. Those with lower aspirations will cease overt learning earlier—but will have more room to respond effectively to a subsequent 'wake-up call,' which could plausibly be generated either by the visible example of the superior performers or by the competitive stress that they generate. Thus, heterogeneity in aspirations and in aspiration adjustment speed is a force for heterogeneity in capabilities that exists independent of differences in (technical) initial position and learning ability, though it need not be strictly additive to those other forces when the two sets coexist.

DETERMINANTS OF PERFORMANCE ASPIRATIONS

The prospects for deriving useful generalizations and explanatory power from the satisficing framework depend crucially on the ability to characterize the likely behavior of performance aspirations. In contrast to trial outcomes, which depend so heavily on the characteristics of the technology, the organization's initial knowledge endowment and its specific path of learning progress, aspirations are influenced by a set of considerations that are broadly relevant across learning situations. This makes it easier to formulate broadly relevant propositions linking characteristics of the aspiration context to learning outcomes and characteristics of the capabilities acquired.

The behavioral rule generally posited in the extended satisficing framework is that aspirations adapt to experience, adjusting downward when outcomes fall short of aspirations and upward when outcomes surpass expectations. Acceptance of this principle here is subject to the qualification

[10] I do not suggest that these other considerations are necessarily 'irrational.' For example, it is arguably rational to be guided by a remote analogy between the present situation and one previously encountered, if no better guidance is available. The point is that the tenuous relationship to what the decision-maker really needs to know renders the rationality issue moot.

that aspirations may in some circumstances remain unchanged in spite of discrepancies with realized outcomes. The downward adjustment of aspirations that typically ensues from repeated failure is a particularly significant theme in capability learning, for it must very often be the case that organizations emerge from initial learning episodes with capabilities that are useful, but not as useful as had been hoped. The following section remarks, however, that there often are practical limits to the amount of downward adjustment that can be accepted.

Threshold success

In the Nucor example, one possible trial outcome is a 'breakout.' It seems very unlikely that a long series of breakouts could reduce aspirations for CSP steel production to the point where a breakout would be considered an acceptable outcome. In this case and many others there is a lower limit of technical success for a trial, beneath which failure is unequivocal and obvious even to casual observers.[11] A significantly higher standard must typically be achieved for a capability to actually play its intended role of contributing to the overall success of the organization. For example, in the Nucor case the basic promise of the CSP technology was that it would allow them to produce flat-rolled sheet at cost and quality levels competitive with rolled steel from integrated mills. This is clearly a more demanding standard than merely avoiding breakouts, but as a standard of success it lacks the sharpness that characterizes 'no breakout.' Indeed, Nucor's success with CSP was ambiguous by the higher standard just stated.

For analytical purposes, it is reasonable to assume that there is a minimum level of output achievement below which aspirations cannot be driven. Protracted failure to achieve at this threshold level drags aspirations down toward it, but leads eventually to the abandonment of the learning effort as aspirations become resistant to further reduction. This threshold level is assumed to be at or above the threshold for technical success. An interesting question is whether it should also be assumed to be, in all cases, high enough to assure that the ongoing exercise of the capability at that level actually makes a positive contribution to the organization. The answer here is no: it is well known that a number of considerations can make it difficult for organizations to abandon activities that are actually hazardous to their long-term health, and these same considerations suggest that an organization might satisfice initially at a level of capability learning that left the organization worse off than if it abandoned the effort. One reason for doing so might be the more-or-less rational belief that experience alone would ultimately lift performance far enough to make the capability a positive contributor. There is an aphorism for this attitude that is familiar in the context of defense systems procurement and perhaps elsewhere: 'Buy it now, fix it later!'

Above the threshold success level, aspirations are adaptive. The overall aspiration level may be thought of as an aggregate of a number of different influences, which differ in origin, level, and firmness—the latter being defined as the tendency to persist in the face of results different from aspiration. Some major categories into which these influences might fall will now be discussed.

'The Book'

Sometimes an organization seeking to build a new capability is following a well-traveled path. It may, for example, be learning to operate equipment or systems from a supplier who has supplied the same thing to other organizations. The supplier may offer instruction along with the equipment and, along with the instruction, definite aspirations based on the quantitative record of the experience of those other organizations. This sort of influence is likely to be important with respect to the level of initial aspirations, but it may not be very firm. Discrepancies can always be rationalized: 'Our situation is different.' But if the influence is firm, or situations tend not to be very different, the result can be a reasonable homogeneity of achieved performance.

Needs, plans and targets

Sometimes the circumstances of the learning organization establish some particular level of performance as critical. For example, although

[11] Adner and Levinthal (1997) make a similar point about the 'minimal threshold of functionality for a technology' and offer the following in explication: 'A horseless carriage that is likely to break down after a quarter of a mile is a novelty, not a substitute for a horse.'

there proved to be some 'give' in Nucor's aspirations, it would not likely have satisficed at a level of CSP performance significantly below what was required to sell the resulting steel products at a price in excess of variable cost. If (counter-factually) the company had been running a loss overall at the time of the CSP adoption, it might have 'pinned its hopes' on the innovation and aspired to a greater success—a large enough profit to bring the company as a whole out of the red. More generally, the strategic objectives surrounding the effort to acquire particular capabilities may entail relatively firm performance aspirations related to those objectives. And, quite apart from objective considerations that might lend significance to a particular performance level, any performance estimate or target that gets developed early in the process is a candidate for becoming a 'focal point' or 'anchor' to which aspirations attach. Research in decision making suggests that human beings are prone to establish anchors for their expectations even when the objective basis for the anchor value is very slim (Tversky and Kahneman, 1974), and many managers seem to believe in the value of establishing definite targets even when there is little basis for the specific target values set. These considerations suggest that decision processes that create performance estimates or targets at an early stage in the learning process may have a strong influence on aspirations, even though early trial outcomes deliver vastly more information about the actual possibilities than was available for the early estimates.

Related experience

Ideas about what can be learned, and how fast it can be learned, are undoubtedly influenced by the organization's previous experience. This effect is presumably stronger when the new capability 'closely resembles' something the organization attempted and learned previously. However, the problem of providing a nontautologous answer to 'How close is close?' is a difficult one. In an information vacuum, remote analogies can seem persuasive. Assessing the strength of rival influences on aspirations may therefore be a more promising way to assess this factor than actually trying to calibrate the quality of the analogy to previous experience.

When it undertook the CSP innovation, Nucor had a good deal of experience with bringing other steel-making and steel fabrication plants on line, and those experiences endowed it not only with relevant capabilities and confidence, but also with ideas of what a successful start-up would be like. The extent to which that experience was 'really' relevant to the CSP innovation is not easy to assess, but it certainly contributed some specific skills and some general confidence. Although Nucor experienced substantial difficulties in mastering the new technique, those difficulties were overcome more promptly than its plans anticipated.

Vicarious experience

It may be that other organizations have undergone experiences that are more obviously analogous to the current one than anything in the organization's own past. If information about what the others achieved is available, it is likely to have a strong influence on aspirations. This is particularly true when the new learning effort is construed from the start as imitative of, or responsive to, the accomplishments of others, and still truer when those others are rivals and their achievements are relevant to the competitive threat they represent.[12] For example, the learning response of U.S. automakers to the Japanese challenge in the 1980s was influenced at an early stage by independent assessments of the quality of Japanese cars, and then profoundly shaped by the example of the Japanese transplant assembly plants in the United States. Whereas the early information was subject to various forms of discounting and 'denial', the transplants delivered a clear message about what was possible with 'lean production' and quality management (MacDuffie, 1996; Pil and MacDuffie, 1999; Cole, 2000). As this example illustrates, the 'firmness' of this sort of influence is affected by the amount and quality of the information available, including the degree to which comparison is complicated by contextual differences.

[12] This influence differs from that of 'The Book', in which there is not only extensive experience elsewhere, but a codification of that experience. The competitive threat of rivals supports the informational influence of rival experience with a 'need' influence.

Costs of learning

Since overt learning activity requires some deliberate resource allocation, its continuance involves at least a passive acceptance of the proposition that its likely benefits cover the costs of the resources devoted to it. Such costs are not strictly a determinant of aspirations as such, but they are a determinant of the satisficing level of performance: the higher they are, the lower the level of performance that is satisficing.[13] There are obvious costs to such learning activities as off-line analysis, consultations, experiments, or simulations, or making process adjustments that involve changes in equipment, training, or configuration and layout. Perhaps less obvious are the opportunity costs represented by downtime in the production process: a major reason to stop overt learning is to graduate to 'real life,' i.e., production. This factor obviously is not relevant when learning has not yet reached the technical success threshold; at that stage there is no output to forego. But when inter-trial pauses for learning mean foregoing a profitable output stream, that sacrifice has to be weighed against the benefit of cost reductions and the more conjectural benefit of further improvements in quality parameters. When the foregone sales also may mean the sacrifice of lead-time advantages and longer-term market share, the urgency of stopping the 'tinkering' and getting on with production is even more apparent. Although this impatient viewpoint has at least a superficially rational basis, its advocates in an organizational context may be from higher organizational levels, or perhaps from marketing, and be uninformed or insensitive regarding both the shortcomings of the achieved performance and the promise of the remaining learning opportunities. They may also be frustrated because at this point the schedule has (most likely) already slipped a good deal. And their case is built on the usual argument for getting on with the 'exploitation'—the benefits of the prospective sales are near term and relatively certain, while those of the learning are long term and conjectural. Thus, the superficial rationality of the impatient view should not lead us to imagine that it is always correct.

Subtler opportunity cost issues arise at the level of individual participants. Some members of the team assembled to support learning may not be hierarchical subordinates of the manager chiefly responsible for the progress of learning. They are *de facto* volunteers, either as individuals or because they have been 'volunteered' by their bosses. Volunteer workers tend to disappear when other priorities seem more urgent to them (or their bosses). Thus, overt learning may falter, pause, or stop because of implicit cost–benefit calculations by individual participants—calculations that are partly based in considerations remote from the learning effort itself.

'Stretch goals'

It is not a secret that high aspirations can often contribute to high achievement. Indeed, this observation has congealed into managerial doctrine, perhaps most obviously in the notion of 'stretch goals' (Hamel and Prahalad, 1993), but also as 'strategic intent' (Hamel and Prahalad, 1989) and in the high aspirations expressed in mission statements. Top managers differ in their devotion to these ideas. It is probably a reasonable conjecture that initial aspirations tend to be higher, other things equal, where leaders talk more about high aspirations. How firm this influence might be, especially when set against the costs of learning, is not so clear.

Empirical evidence: 'Windows of opportunity'

An empirical study by Tyre and Orlikowski (1994) provides powerful examples of some of the foregoing points. Though focused at a more micro level than the learning of a capability (as defined above), it examines organizational events of much the same kind. The authors report on the adaptive activities that were undertaken in response to the introduction of new technology in three organizations, one of which was a manufacturer of precision metal components dubbed 'BBA.' Multiple projects were examined at each organization, including 41 examples of new process technology at BBA. Adaptation activity was found to be particularly intense for a period of a few months right after the change and declined thereafter, but was sometimes resumed in brief bursts. Four organizational forces were found to

[13] This is fully consistent with the modeling of satisficing as a rational search or 'optimal stopping' problem (Simon, 1955: appendix). (As discussed above, that model misleads to the extent that it suggests that the data required for the optimality analysis are available.)

depress adaptation effort, each of which is illustrated here with one of the many striking quotations the authors report from their interviewees at BBA:

(i) Pressure to produce instead of continuing adaptation. 'Once we got the equipment into the factory, time to do important engineering work was squeezed out by everyday work to keep things running' (Tyre and Orlikowski, 1994: 107).
(ii) The tendency for patterns of use to congeal into routine operations in which users adapted themselves to the technology instead of the reverse. 'The idea was that we would get back in later to do the fine tuning. But now the operators depend on the machine—it's built in, they don't want to change. So the fact is we haven't gone back' (Tyre and Orlikowski, 1994: 109).
(iii) The tendency for expectations to converge to actual achievement. In a project involving a high-end precision grinder, users were having trouble getting correct dimensional finishes. 'But once we decided that the finish was OK as it was, then we figured that we need not and in fact could not improve beyond what we were getting!' (Tyre and Orlikowski, 1994: 110).
(iv) The tendency for the relevant teams to dissolve and lose momentum. 'Since the major problems were solved, there was no impetus for engineering support to help on other improvements—and once (they) left, a lot of effort just never got done' (Tyre and Orlikowski, 1994: 111).

As this last comment indicates, it was not the case that adaptation efforts stopped because *all* of the problems had been solved. In fact, some of the things left undone were in some cases considered high priorities when the projects were initiated. Further, the BBA projects took an average of 14 months to get to the point where they produced parts on a consistent basis, and another 8 months to be 'fully integrated' (Tyre and Orlikowski, 1994: 105). The authors do not indicate how much performance improvement and how much aspiration adjustment went on in the latter part of the 22-month period, but their data clearly indicate that the level of adaptation effort was low. The data also seem to suggest a role for the calendar in igniting bursts of renewed learning. Looking at it, one can almost hear someone saying, 'Do you realize that it is almost (6 months, a year, 2 years) since we installed that equipment, and we still haven't straightened out the (whatever)?'[14]

Review

Since the actual pay-off to continued investment in learning is unknown when the investment is made, there is no reason to expect overt learning to stop at the point that an omniscient observer would pick. The above discussion identifies a number of plausible influences on this decision that are not grounded in the specific reality of the learning effort but rather reflect contextual factors. In many cases, the influence of these factors is clearly mediated by contingencies of exposure to relevant information, by managerial judgments, and by organizational politics. Thus, there are sources of heterogeneity in achieved performance levels that have little to do with the technical difficulty of raising the capabilities to a higher level.

Although these various influences can push aspirations in different directions, there is one systematic tendency that is worthy of note. More radical advances, representing a greater disconnect with the previous activities of the focal organization and others, have a distinctive profile in terms of the level and firmness of the influences identified above. In such cases there is no 'Book' and no comparable experience of other organizations, and any analogy with previous experience of the focal organization is remote. Thus, these influences are either nonexistent or soft. There may well be plans and targets for the learning effort, but the weakness of the factual basis is likely to soften these influences. In many cases, considerations of need and cost will begin to point to an early stop as soon as production and sale promise a return over variable cost, yielding some relief from cash flow problems. If the capability yields an innovative product that represents a sound concept for meeting a newly identified need, and the effort is appropriately directed toward a niche market that places a high

[14] The four points above illustrate previous remarks about opportunity costs at the organization level (i), at the individual level (iv), and the related facts that aspirations adjust and overt learning ends with visible lines of improvement still visible ((ii) and (iii)).

value on the concept, revenue opportunities may be substantial even for primitive and costly versions of the product. Indeed, the 'need' factor can take the form of a need for cash to continue the work, and the decision to satisfice temporarily on a primitive version of the product may coincide with the identification of a niche willing to put up with it (Levinthal, 1998).

Thus, the satisficing principle helps to explain why new capabilities are so often born in forms that are primitive (and thus more easily achieved) and improve from there. At a finer level of analysis, it suggests the sorts of capabilities for which this is likely to be true, or what attributes are particularly likely to appear in primitive form. At one level, of course, the explanation is the obvious technical one, a matter of 'not knowing how to do it better.' But more learning would generate more knowing, and the question of how much of the learning gets done before any output appears needs an answer.

As a sobering exercise, consider what this sort of analysis implies for the significant performance attributes associated with the capability of operating a nuclear reactor to generate electricity, in the historical context in which such operations developed in the United States. The signal virtue of nuclear power is its very low variable cost. Therefore, to leave an operable reactor shut down is to incur a large opportunity cost. The context was one in which government policy strongly supported and promoted the nuclear power technology, but did very little to subsidize individual reactor projects or otherwise soften the market test that the innovating utilities faced from established modes of power generation—thus leaving the utilities to bear the full weight of the opportunity cost of an idle reactor. Neither did the government complement its R&D on nuclear power with comparably serious efforts on safe reactor designs, human factors analysis, and other components of the safety problem. Viewed against the ominous potentials of that background, the Three Mile Island episode looks like good luck.

RE-IGNITING LEARNING: CRISIS RESPONSE AND CONTINUOUS IMPROVEMENT

For simplicity, the above discussion has proceeded as if, in the learning of a given capability, overt learning would ordinarily stop once and for all. This is certainly not the case. Even when there is a single major transition from a learning mode to a routinized production mode, the transition is not likely to be very sharp. A more plausible pattern is one of waning efforts and gradually lengthening pauses. The satisficing principle suggests that such pauses are likely to be systematically related to performance fluctuations, being triggered by episodes of relatively good performance and terminated with the recurrence of difficulty. There may be no identifiable decision that marks the transition as routines stabilize; learning may simply fade away. Difficulties with the process may continue to occur and be dealt with, but the manner of dealing with them no longer produces a trend of improvement in the process. Alternatively, a more decisive end to the 'tinkering' may occur in response to the difficulty of maintaining coordination among different parts of the process when they are in constant flux, or to the need for standardization of the output.

There are a number of reasons why the learning flame might be re-ignited at some later date, after it had definitely been out for a substantial period. The categories identified in the previous section remain relevant; they suggest the sorts of events that might produce an up-tick in performance aspirations that would lead to a renewal of overt learning efforts. New targets may appear when customers express unusual output demands, requiring that some performance attributes take on values not attainable with the capability in its previously stabilized form. New personnel may introduce new sources of vicarious experience, leading to the importation of higher performance standards from other organizations. New problem-solving resources may be acquired, suggesting that advances can be made more speedily and hence that the opportunity costs of learning have fallen.

A general issue that is particularly significant here is the degree of specificity or localization of these sorts of effects on aspirations. An organization may command several major capabilities, which in turn can be thought of as a hierarchically organized structure that is decomposable into routines, subroutines and so on. The stylization of the learning process introduced earlier in this paper is relevant at multiple levels of this hierarchy, and so are the various influences on aspirations. For a performance improvement to register at a given level of the hierarchy, there generally has to be improvement in some of the constituent processes at a lower level.[15] Hence, whatever the hierarchical level at which a particular influence on aspirations makes its initial impact, it tends to 'decompose' and trickle down the hierarchy of routines from there. For example, aspirations affecting learning in Nucor's implementation of CSP might reflect influences relating to casting specifically, or alternatively to the trickle-down of strategic aspirations relating to the quality of Nucor's flat steel sheet. The latter aspirations, however, could equally well be 'allocated' to the operations of the rolling mill. In the absence of specific information linking the higher-level aspirations to potentials for improvement in a particular constituent routine, the effect of the higher-level aspiration tends to be diffused across the lower levels. This likely means that the effect on a particular lower-level routine tends to be soft, i.e., aspirations will reconverge with actual performance if improvement is not quickly forthcoming. Influences specific to a particular subprocess would tend to create firmer aspirations there; a perceived shortfall in the operations of the caster implies a quest for improvement there, not elsewhere.[16]

The possibility of the converse pattern is also worth remarking. If prevailing ways of doing things are satisficing at a higher level, there are no unattained aspirations trickling down from there. In fact, satisfaction at the higher level may even reduce the salience of influences that suggest shortfalls in particular constituent processes, softening the aspirations induced by those influences. This can readily happen when the performance criterion in focus at the higher level is one to which the constituent processes relate in an additive way, such as unit cost or overall return.[17]

Two major classes of scenarios for the re-ignition of learning provide contrasting illustrations of the observations just made about specificity. The first class involves cases where the organization is in a crisis induced by sustained competitive pressure. There is a clear 'need' for better performance; the survival of the organization, or at least top managers' jobs, may be at stake. This influence relates to the overall performance of the organization and thus impinges on the structure of capabilities and routines from the top; it relates to the big 'how we make a living' capability of the organization as whole. Such an influence is not (as such) diagnostic of any particular shortcoming; it is entirely nonspecific. It may raise aspirations for constituent processes temporarily, but the effect tends to be soft and temporary because the hypothesis that 'the real problem lies elsewhere' is available everywhere. For renewed learning to make a contribution to the resolution of the crisis, it is generally necessary for the survival threat to be supplemented by influences that are more diagnostic of specific and correctable deficiencies. Numerous examples suggest that the search for a diagnosis can be protracted, and of course the crisis tends to deepen while it goes on. It can be particularly protracted when the basic problem is that a needed function or capability is entirely absent—higher-level aspirations then have no helpful place to which they can trickle![18]

The quality management doctrine of continuous improvement (*kaizen*) illustrates the opposite class of scenarios. The practice of continuous improvement amounts to an effort to re-ignite learning so frequently that the flame burns pervasively and, so to speak, continuously. A key part of this effort is the institutionalization of multiple means of strengthening influences that create higher and firmer aspirations for specific processes. Benchmarking, for example, is a method for accomplishing this by drawing more systematically on vicarious experience; internal bench-

[15] An exception might be when improvement at the original level can be achieved by improving, at that same level, the coordination of constituent routines, without affecting their inner workings significantly.

[16] The foregoing paragraph is essentially a variation on the insight-laden theme that Cyert and March introduced under the name 'problemistic search' (Cyert and March, 1963).

[17] Tyre and Orlikowski mention an example of this kind where one project engineer confidently declared, 'The fact that this is an optimized system was proved by the corporate post-project audit—it showed that we are getting 138% payback.' This, notwithstanding the fact that one system originally considered a major feature of the new tool had not been debugged and was not in use (Tyre and Orlikowski, 1994: 110)—the major misunderstanding of the concept of optimality implied here is commonplace. In fact, this 'optimized system' is about as clear an example of Simon's 'needle sharp enough to sew with' as one could imagine.

[18] One of the crisis situations described in Starbuck, Greve, and Hedberg (1978) is of just this kind. Kalmar Verkstad, a Swedish manufacturer of railroad rolling stock, almost succumbed due to the misperception that it needed new product lines when it fact it needed a competent sales capability for the products it had.

marking does the same thing with respect to the organization's own experience. (Of course, benchmarking efforts seek to transfer know-how as well as aspirations—but without the heightened aspirations, the chances of effective utilization of the know-how would be slim.[19]) Similarly, efforts to attend closely to the sources of defects and difficulties, as in root-cause analysis, can be viewed as an active promotion of the influence of 'the process when it is working well' on aspirations for its average performance (MacDuffie, 1997; Flaherty, 2000).

Thus, analysis based on the satisficing principle makes a dual contribution to understanding of why and when quality management efforts make sense.[20] Its implications for the cessation of overt learning help to explain why valuable opportunities to renew learning can be abundant. And, as just explained, many of the specific techniques of quality management can be broadly understood as involving efforts to strengthen types of influences on aspirations that are generally operative, creating higher and firmer aspirations as a result.

SUMMARY AND CONCLUSION

As they learn new capabilities, organizations draw on the society around them for both means and ends. The means include the multiple sources of knowledge that are drawn upon in solving the long series of individual problems that arise in the course of such an effort—the technical training of employees, the sophisticated equipment, the more-or-less accurately perceived solutions that other organizations have developed for similar problems. The ends include, at the highest level, socially legitimated organizational goals. But the ends also include more proximate aspirations that guide learning and define its 'success,' both for process details and for the capability as a whole. Heterogeneity in aspirations thus joins many other causes as a potential explanation for why organizations wind up doing similar things in different ways and with different effectiveness. Other things equal, low aspirations mean an early halt to overt learning and more improvement opportunities 'left on the table,' while high aspirations imply the opposite. But covert learning likely continues after overt learning stops; besides that, the opportunities 'table' tends to be refilled from external sources while overt learning is halted.

The perspective offered by the satisficing analysis of capability learning has broad and profound implications for the conceptualization of production methods. In mainstream economics, the standard conceptualization of production ignores the fact that production methods have emerged from a historical process and presumes that the limits of the feasible are sharply defined.[21] Ignoring the historical origins is viewed as a legitimate simplification, while the idea that technical feasibility is sharply defined is taken very seriously—probably because it is necessary to the conception of optimal behavior, which itself is taken very seriously. The foregoing analysis shows, however, that these two aspects of the standard conceptualization are closely connected. Acknowledging the historical and evolutionary origins of capabilities leads us to consider what is happening in real settings when overt learning stops. Such consideration reveals that the sharp edge of the technically feasible world is a myth; what the explorers discover is not an edge but a gradually thickening fog bank. When the fog is discouragingly thick, exploration stops—but it might resume later either because the fog lifts or because the incentives to press further increase. This means that subsequent analysis—for whatever descriptive or normative purpose at whatever level, from the shop floor to national economic policy—cannot safely assume that prevailing routines mark the edge of the feasible. They only mark the place where learning stopped, and perhaps it stopped only temporarily.

When viewed in a broad historical context, the plausible range of aspirations for a given organization at a given point of time seems quite narrow. When Boeing developed its 247 aircraft in the 1930s, it could not plausibly have come

[19] Recent empirical work by Szulanski (2000) generally confirms the positive role of motivation in facilitating internal transfers—with the interesting exception that the *lack* of motivation in the recipient significantly facilitates the 'ramp-up' phase of the transfer. This is consistent with other evidence *suggesting* that too much eagerness in the recipient can cause problems.

[20] I have explored this at greater length in Winter (1994).

[21] Winter (1982) provides a more extended analysis of the impact of a knowledge/learning viewpoint on the standard economic theory of production and offers suggestions for reform. These objections to standard production theory are a key issue for the evolutionary theory that I developed in collaboration with Richard Nelson (Nelson and Winter, 1982).

up with the 707 or the 747 just by raising its sights. In a more microscopic view, however, significant ranges of discretion appear. At a particular time and place, an incremental dose of resources devoted to learning would ordinarily (or on the average) produce an increment of learning and a superior capability. (If the 247 could not have been the 707, it might plausibly have been sufficiently better than it was to earn the accolades that history instead bestows on its rival, the DC-3.) In their role as regulators of learning investments in the small, performance aspirations partially determine the new capabilities that emerge. By many branches from that early path, they influence the levels of performance aspirations a bit farther down the road, both in the same organization and elsewhere. In the evolving capabilities of the social system, therefore, what it is possible to accomplish is much more responsive to what people are generally trying to accomplish than might appear at first sight.

It has been well said (by Keith Pavitt), that 'Nobody wants to fly the Atlantic in a socially constructed airplane.' On the other hand, we can be grateful that the social mechanisms governing aspirations for such flights have helped to move the available capabilities beyond the performance level of the *Spirit of St Louis*.

ACKNOWLEDGEMENTS

This paper was prepared for the conference on Evolution of Firm Capabilities held at the Amos Tuck School of Business Administration, September 24–25, 1999. I am indebted to Connie Helfat, Richard Rosenbloom, John Paul MacDuffie, and Dan Raff for helpful comments on an earlier draft.

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