

PART **One**

The Game of Technology Transfer

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The Pieces

INTRODUCTION

In this part we introduce you to the cognitive framework for understanding and doing technology transfer. We use a game metaphor, as that is the easiest way to understand the model. As with other games, there are pieces and there is a board. In this chapter we introduce some of the key pieces. In the next chapter we explain the board. In Chapter 3, we discuss strategy.

Technology is simply an aid for conducting an activity which is repeated time and time again. It may be a tool, a technique, a material, etc. Because humans engage in activities that are repeated over and over again, it makes sense to build tools and other useful aids so we can do this activity more effectively and efficiently.

Consider a game in which the object is to move a technology out of the hands of one player into the hands of another in such a way as each player is better off after the technology has moved than before. In plain English: You win when you do a good deal. You lose if you do a bad one or do not get one at all. Since you have two ways to lose and only one to win, all other things being equal, simply relying on luck should lead to a loss.

Now, what makes technology-based aids different from those developed on the basis of experience or Eureka bursts of inspiration is that we can explain why we built the tool the way we did. Technology occurs where thought precedes action and is applied to the improvement of that action. In modern times, this thought is usually a scientific or engineering finding that explains why if you do X, you will get Y with some degree of confidence.

It is these aids we are trying to move from one player to another. Our game board is a geophysical-temporal space on which are laid out a series of channels. Players move messages, goods (including technology), and themselves through these channels. The channels run between nodes or arenas where the players live and work. If a channel does not exist, the players are allowed to construct one.

Players, messages, and goods can only be moved where relationships exist. Relationships exist where the players develop predictable patterns of behavior that is patterns that have some probability of occurring. These patterns involve interactions between two or more players.

Rules govern how you can bring players, messages, and goods into relationships by defining what constitutes coherence between attributes of those entities. By defining what constitutes coherence, that is, a permissible relationship, the rules also de facto define what is impermissible. The rules can change over time. By changing a coherence between attributes into an incoherence, players can block the movement of their opponents' players, messages, and goods.

Relationships can be described via equations. These equations use terms like “*constrains*” (\rightarrow), “*equals*” ($=$), or “*approximately equals*” (\approx) to describe how an attribute of one entity coheres with the attributes of another entity. For example, an equation can express the equivalence in value between a technology that is being offered to other parties and what other parties are seeking to exchange for technologies.

When players interested in a deal agree the values are equal (or close enough to equal), technologies can be moved from one party to another. This part of the book explains the game. The rest of the book is about how to win this game.

THE PROBLEM WITH MODELS ABOUT HUMAN BEHAVIOR

Like Monopoly™, this game purports to reflect certain aspects of reality. However, social science requires abstracting essential features out of the flux of everyday life. Just what is essential depends on what is being studied. Here we are studying human behavior.

Social scientists will tell you building models about human behavior is fraught with problems because the object of study is active, dynamic, and intelligent. There is a famous debate concerning the anthropologist Margaret Mead, who studied the differences between adolescent sexual behavior in South Pacific and Western cultures. The debate centers on whether Mead was subject to a hoax pulled by the Samoans she interviewed.¹

According to Derek Freeman, two of the people Mead relied upon, Fa'apua'a and Fofoa, were kidding when they said they spent their nights

¹ See Bender, Humphries, and Michal, “The Margaret Mead and Derek Freeman Debate,” n.d., <http://members.fortunecity.com/dikigoros/meaddebate.htm> (accessed September 11, 2004).

with boys. Freeman said Fa'apua'a told him that she never thought Mead would have believed them because it is a Samoan custom to joke and exaggerate about sexual behavior. For our purposes it does not really matter what was the truth. We just need to be aware that asking people about what they are doing or thinking does not necessarily lead us to the truth.

Unfortunately watching people may not be any better. Observation does allow us to develop statistical probabilities for behavior. But without an understanding of what motivates people, we have no way of knowing with any certainty if the behavior will continue. For example, in a study of workers at the Western Electric Company's Hawthorne plant in Chicago, various factors were changed to see if they had an impact on productivity. The factors were things like pay, light levels, and rest breaks. Curiously, every change brought productivity increases. Then, over time, in each instance the productivity increase dissipated. Finally the researchers came to the conclusion that it was not the factors being manipulated that led to the increase in productivity. Rather, it was the workers' awareness that they were being studied. As the studies wound down, so did the productivity gains.²

A third path is called *participant observation*. In this method, the scientist uses a carefully structured research protocol to analyze a situation in which the researcher is also a participant. The idea is that by participating, you share in the intersubjectivity of human experience and thereby are able to combine both the "ask them" and the "watch them" approaches. The problem is the tendency to "go native" and lose objectivity. Even if this problem can be avoided, by becoming a participant, the researcher can never be sure his or her presence has not skewed behavior and views from what they would be in the researcher's absence. It is the social scientific equivalent of the Heisenberg uncertainty principle.³

What this brief digression demonstrates is that any scientific method for collecting data on which to build a model has problems. So, I hope the reader will be sympathetic when I acknowledge this model is based on none of these approaches. Instead my approach is philosophic in the Platonic sense. This model is based on contemplation: reflection on my experiences, reflection on what I have read, and thinking about how to systematize the data.

² See Stephen W. Draper, "The Hawthorne Effect and Other Expectancy Effects: A Note," June 1, 2004, <http://www.psy.gla.ac.uk/~steve/hawth.html> (accessed September 12, 2004).

³ See Sociology.org, "Participant Observation: Overview," n.d., <http://www.sociology.org.uk/mpop.htm> (accessed September 12, 2004).

CONSTRUCTS

Following Max Weber, I have created constructs or ideal types, which are then explored to create the model.⁴ Constructs are objects (entities, model elements) that carry attributes and can be placed into relationships.⁵ The attributes define (when instantiated) entities. The relationships use these attributes to link one contract or entity to other constructs. The constructs have no intrinsic merit. They merely are more or less useful, depending on how well they help us understand the phenomenon being modeled.

Science is premised on the assumption that with the right knowledge, we can form predictions of the form “if X then Y” with a reasonable level of confidence. If we can do that, then we can combine this knowledge of X and Y with other knowledge and know-how and end up with technologies of the form “do X and Z will result” with some level of confidence.

Assuming we want Z, then the ability to use X to get Z is useful. For example, I supported initial commercialization of a barnacle protein-based technology for Tufts University, based on a breakthrough by David Kaplan. The university’s invention disclosure states:

*The proteins involved in barnacle adhesion are useful in devising high-strength protein-based adhesives capable of curing under water, coating for prosthetic implants to serve as an interface between the prosthetic and the bone or other tissue, and methods of preventing biofouling of underwater surfaces. DNA and amino acid sequences of the adhesion proteins are provided and isolated nucleic acid sequences as well as microorganisms comprising such vectors and capable of expressing a barnacle adhesion protein are also provided.*⁶

As the above summary highlights, if we know specific proteins are involved in barnacle adhesion, (our “if X then Y”) then we can use that

⁴ For an overview of Weber’s ideal type, see Coser, “Ideal Types,” 1997, <http://www2.pfeiffer.edu/~lridener/DSS/Weber/Weberw3.html> (accessed September 25, 2004). Note that for our purposes, we need not worry if our constructs are rooted in the current historical period and in modern socioeconomic systems since that is where technology transfer occurs.

⁵ The entity, attribute, relationship approach has its root in Peter Chen’s Entity-Relationship approach for unifying network and relational data base views. For an overview see University of Texas, “The Entity-Relationship Model,” February 29, 2004, <http://www.utexas.edu/its/windows/database/datamodeling/dm/erintro.html> (accessed September 25, 2004). The E-R basis is important because ultimately we want a way to model technology transfer that is programmable. As we shall see, the E-R approach is one leg. It allows us to collect and store relevant data. The other leg is how we analyze, and thus make useful, the data. The methodology for that is coherence, which is discussed in the following paragraphs.

⁶ Tufts.biz, “Novel Kinase and Mechanisms of Curing of Barnacle Adhesives,” September 11, 2002, http://www.tufts.biz/cgi-bin/tech_search.cgi?full_report=1&case=37 (accessed September 11, 2004).

knowledge to invent a set of technologies (our if “X then Z” where X is our knowledge of the protein, and Z is some desired end, such as making glue, making a coating, or making antifouling paint). To make glues, we combine our knowledge of the amino acid sequence (X) with tools for synthesizing sequences. To make antifouling additives we combine our knowledge of those same sequences with knowledge of how to cut them or inhibit their formation and with tools for making those enzymes and chemicals. Assuming we want either under-water curing glues or antifouling coatings, knowing the amino acid sequences is useful. In other words, we can design “*how-to*’s” if we have a reliable and replicable understanding of “*what-is*.”

Carrying this instrumental orientation back to our model, if we want to build a technology for technology transfer, one beauty of constructs is that they can be sustained or falsified empirically. You can go out and test to see if the attributes and relationships actually exist in the phenomenon being modeled, to see if they accurately reflect “*what-is*.” A sustained construct is called valid—that is, to the extent we have tested, it is a fair abstraction of “*what-is*.” If we create valid constructs, we should be able to improve the “*how-to*” involved in technology transfer.

PORTRAYING CONSTRUCTS

Before continuing, I need to take care of a housekeeping chore. I am going to use graphics to portray constructs. The graphic in Exhibit 1.1 is the legend for understanding the portrayals.

Note that to be included in a construct, an attribute must be capable of being measured. At least a yes/no, 0/1 scale must be conceivable. For us, technology transfer is a quantitative interdisciplinary social scientific field.

Also note that defining a relationship is never enough. There must be a special-temporal path, which, following the marketing and communication literatures, we call a *channel* through which the relationship can be formed and endure. While the ideas behind inventions and creations are critical, we always have to remember technology is embodied ideas. It is as physical as the people who sign the deal.

DEALS

We start with the basic assumption of transactions in market economies: Deals take place where the goods bought are (at least roughly) equal to what is given to obtain them insofar as the parties to the deal are concerned.

In technology transfer, the goods being sold are intellectual property—

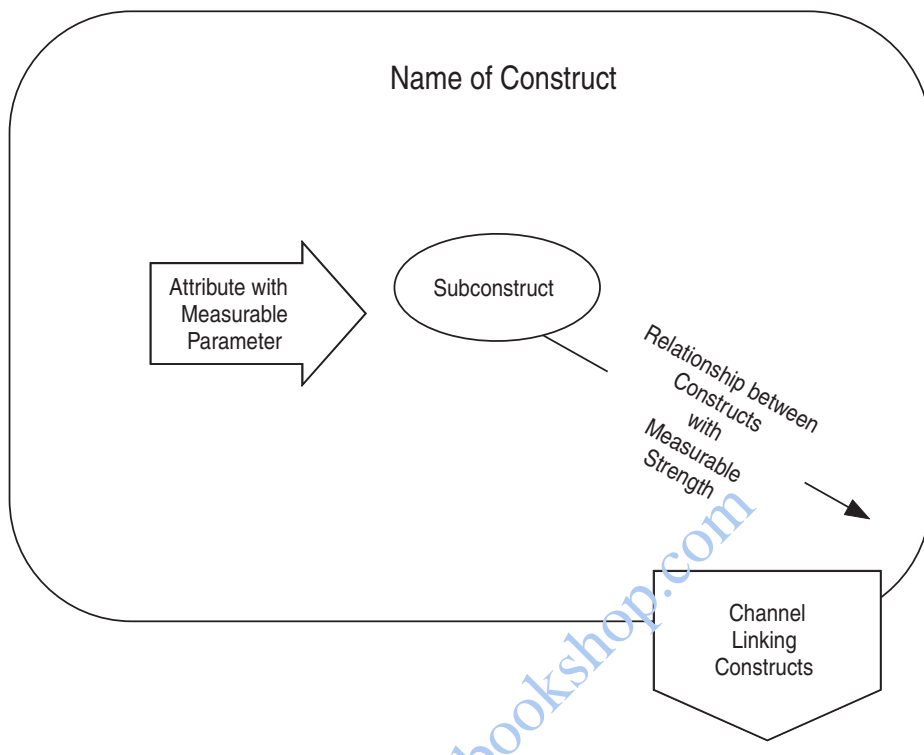


EXHIBIT 1.1 Components of a Construct

that is, ideas that have been reduced to an embodied format (paper, products, etc.) and that can be legally protected (patented, trademarked, copyrighted, covered by trade secret, etc.), so the coercive power of the state can be used to punish any party breaking the deal.

In market transactions, what we are saying is so much of X equals so much of Y. Where two things can be put into this market equation, we say they have equal value.

One way to visualize value is to think of breakfast cereal. How many bowls of cereal would you want to sell your hat? How many bowls to sell your car? How many to sell that great idea you had last night? Technology transfer can be modeled as trading ideas for bowls of cereal. Using money makes the calculation easier but changes nothing in the basics of exchange. Return on investment is like a potlatch. When the deal is signed, it's time to celebrate.

Now, how many bowls of cereal you want for your idea probably depends on all sorts of things. Three factors often involved are: desirability, attachment, and available substitutes. Each of these is a relationship between a player's needs and attributes of a technology.

Desirability measures how well your technology meets a player's criteria

for acquiring it. What makes a laptop computer desirable may be its portability. But we can operationalize what portability means into a set of metrics. Operationalization leaves us with metrics for price, performance, and/or ease of use of a technology. These metrics reflect the preferences of the buyer.

Sometimes we need to add an additional set of criteria: aesthetic. Taste is an example. If you like sweet and nutty flavors, you will look forward to eating to your honey nut cereal more than your oatmeal. Such criteria are most commonly found where consumer goods are involved.

Where taste enters into buying decisions, variation between goods often increases their value. Where taste is not a factor in decisions, variation almost always reduces the value of a good as it indicates a defect. The only question is what the acceptable range for variance is. Let's compare two process technologies. We did a project on introducing new manufacturing methods for near net shape forming making vanes inside jet engines. Here the issue was tolerance. Because the technology could eliminate a processing step while maintaining tolerances, it was a winner. In aviation, where variation can mean a plane falls out of the sky, increasing variation was a "no no" for new technology. Now compare that aviation technology to the introduction of new curing techniques for leather. In the Indian leather industry, tanning used to be accomplished with the aid of vegetable tanners. Today chromium salts are used. The adoption of salts required consumer education, which consisted primarily of adding a label that says "range marks and variation are signs of quality." (I guess consumers could not be trusted to understand each cow is a bit different from every other cow.) Variation in hand-made leather finishes is a "yes yes." Ideally, and perhaps ironically, what is wanted is controlled variation. That suggests sewing, design technology, information technology, etc. are likely to be more attractive to leather manufacturers than inspection or material handling, which have a higher likelihood of damaging the finish. It turns out that is the case.⁷

⁷ See Sanbord and Becksted, "Technology Adoption in Canadian Manufacturing," August 1999, <http://www.advancedmanufacturing.com/pdfs/technology.pdf> (accessed September 25, 2004). The information on Indian leather tanning technology is from "Leather Technology," *Times Internet* (2002), http://learning.indiatimes.com/career/car_options/engg/leather.htm (accessed September 25, 2004); and an example of the plebeians' notice for leather buyers is at "A How-To Guide To Purchasing Leather Clothing at Leather Lollipop," n.d., http://leatherlollipop.com/leather_howto_buying_guide.cfm (accessed September 25, 2004).

For our purposes here it suffices to note that, all other things being equal, the more your technology is perceived as desirable, you are more likely to be able to charge a premium price. Alternatively, for any given level of desirability, the cheaper your technology, the more likely you are to sell it. Economists discuss this factor when talking about the elasticity of the demand curve, that is, how much shift in demand occurs per shift in price.⁸

An example helps. Bob Jaffee, as a young post-doc research scientist, discovered that by observing the growth rates and swimming behavior of single cellular organisms he could create a near real-time assay for non-specific toxic agents in water and air. (The organisms function like canaries in a mine. They die or get damaged before people do.)

Bob developed a field deployable unit. For years no one cared. After all, who needs quick analysis when you can collect samples and send them out to an analytical chemistry lab. But Bob believed in the significance of his work, even after his National Institutes of Health funding ended. He drove a taxicab in New York City to subsidize his research, conducted in a small lab in his apartment.

Shortly before 9/11 we met. I thought the work was pretty cool, and on investigating it further concluded it was good science. I found some folks at the Department of Defense who feared there was a coming terrorist storm. They were funding research and development on a new generation of tools to monitor and protect water supplies for troops in the field and people at home.

What Bob needed was someone who could build a machine he had conceived that did automated analysis of single celled organism swimming behavior. We contacted Woods Hole Oceanographic Institute because they had built equipment to study swimming behavior of plankton in the ocean. They agreed Bob had a good idea and together Jaffee and Woods Hole submitted a proposal to DoD that won a big slug of money. Shortly thereafter 9/11 occurred and no one questioned why we would want a near-real time way of determining the presence of nonspecific toxins in water or air. What had been undesirable was now very desirable.

Never value a technology on why it is desirable to you. If the other party is clever they will point out they do not care. They only care about why the technology might be attractive to them and your focus

⁸ For a quick tutorial on how quantity demanded changes in response to a change in price, see Neil Skaggs, "Price Elasticity of Demand," n.d., http://www.econ.ilstu.edu/ntskaggs/ECO%20105/readings/price_elasticity_of_demand.htm (accessed September 25, 2004).

on yourself indicates you have no real idea about that. “Green” technologies are commonly prone to this problem. For example, we assessed a nonvolatile organic compounds glue for bonding metal to rubber—something done frequently in the auto industry. But the non-VOC aspect had little interest until our customer produced test results demonstrating that the glue actually made superior bonds. Sounds silly but the key challenge for auto manufacturers is getting better bonding of rubber to metal, not removing the VOCs. The reason is that infrastructure is already in place to suck up and dispose of VOC fumes. The disposal cost is minimal and the infrastructure is sunk cost. Without the superior performance no-VOC just won’t sell till that investment has been amortized.

Attachment measures how easily you will part with the good or how badly you want it. We assume the more emotionally difficult it is to part with the good or the more imperative its acquisition, the higher its attachment. Attachment thus links the relative importance of a player’s needs with the performance, ease-of-use, or aesthetic features of a technology. Attachment weights the metrics of desirability

If you have a car and someone asks to buy it, you might think, well, if the price is above what it would cost you to replace it, why not sell? On the other hand, suppose the car is a 1971 silver blue Shelby Mustang that you have lovingly restored after finding it three years ago in a farmer’s shed outside Oshkosh, Wisconsin? That car is *your* car, not just vehicle ID # so and so.

Now think about living in Manhattan where no-one needs a car and suddenly there is this 1998 Ford Escort you inherited from Aunt Jeanette, and it’s parked outside on the street where every Tuesday that dang parking enforcement officer gives it a ticket because you do not have a garage and work late Monday night and somehow never wake up in time to move it to the other side of the street before the street cleaning machine comes down the road. The point is that replacement value only matters if you want to, and are willing to, replace the good. Or as Art Butler, a retired economic professor at the State University of New York at Buffalo likes to say: “My house is always for sale. It’s just a matter of the price.”

Never value technology on its development costs. If the other party is clever, they will tear you apart by exploring how you stupidly wasted money developing the technology, thereby artificially inflating your price.

Attachment is one factor for figuring out whether it is better for a company to license or buy from you as opposed to developing a competing product. One of our projects was for Aerodyne, a well-respected developer of advanced scientific instrumentation for atmospheric research. The company was one of the first in its niche to market with a quantum cascade laser based spectrometer. The market is small for this kind of specialized atmospheric chemistry instrumentation and part of the key competition is in-house development by research teams. What matters to these buyers is getting a unit quicker and cheaper than they can develop it themselves, that is, they have negligible attachment. The appropriate method for pricing the unit was to determine the buyer's in-house development costs and beat it. That method placed the price below the value of substitutes for the buyer. The pricing is feasible because the development costs are being amortized over tens of units rather than a single unit.

We can even go further. Suppose our developer wants to form original equipment manufacturer (OEM) arrangements to sell their unit through vendors who would otherwise be competitors. For the developer, (e.g. Aerodyne in our example) OEM agreements enable increasing the number units sold, thereby increasing the base for amortizing costs, thereby effectively cutting the cost per unit. So long as an increased economy of scale can be attained, each additional unit produced should cut per unit cost, which will increase the profit on units the developer sells. Selling more increases gross revenues; earning more per unit increases net revenues. Profits rise. This is definitely a good thing for a company. Heck, even universities and government labs like money.

We can conclude it should be in everyone's best interest to enter such an OEM agreement so long as each competitor can beat the anticipated per unit profit margin it would have earned, had it run an independent development program, or partnered in a development program with someone else. No strategy a competitor might adopt would leave them better off. But, this conclusion only holds if we can assume attachment away. If the competitor feels demonstrating technical prowess or leadership is critical for long term success, it will be attached to its own technology, changing the calculus.

Attachment is a two way street. Maybe 30 years ago I was in London and walked into the Tate Museum and saw the Turners. I was knocked off my feet. The play of light in which the world dissolved; the use of water and sky as fluids that metaphorically danced with the fluidity of light. This year I was back in London again. The first place I went was to the Tate to see them again. And this time, being an older

and wealthier person, I looked for an affordable Turner for sale in the galleries. In art there is an aesthetic attachment not found in most technology transactions. But the dynamic is the same. The more someone wants it, the more you can usually charge. If you don't believe this, Google Jerome Lemelson. You may have to drag them to the table kicking and screaming, but if they are really attached to what you are selling, they will buy it rather than not have it.

The final factor is the availability of substitutes. Substitutes create a benchmark for a technology's fair market value, or to be more precise, a market price range likely to be perceived as reasonable or fair by buyers. (Attachment can be used to suggest where in that range you should price your goods.)

The substitutes need not be direct replacements for what you have. All other things being equal, the value of a new sensor for detecting mercury emissions from coal power plants is likely equivalent to the value of a sensor used to detect equivalent parts per whatever of mercury being emitted from an industrial incinerator. Wander through the cereal aisle in the supermarket. The price of any vendor's cereal is constrained by the other cereals being sold, with the range smallest when comparing cereals with similar ingredients and taste.

Never value a technology above its substitutes unless you have brand loyalty. If the other party is clever they will make you feel stupid by pointing out they can buy an equivalent good for less. Now you have to come back cheaper or there is absolutely no reason to buy from you because you just got caught gouging.

Brand loyalty changes the equation because it enables you to price above substitutes for the same product. It is why people buy Honey Nut Cheerios rather than the store brand even when they taste the same, have the same nutritional value, and so forth. But, even brand loyalty can only take you so far. As Abe Lincoln said, "You can fool some of the people some of the time but you can't fool all of the people all of the time."

Substitutes create a framework for sticker shock. Because we want to avoid "You Want How Much!" when we go to enter the market, we can use the pricing of substitutes that adequately meet end-user needs to eliminate potential market entry niches.

Under contract to the U.S. EPA, we did a market analysis for a hand-held explosives detector designed for military use in Iraq. The EPA was funding the company that developed the unit to adapt it to sense biological toxins as well. The company thought they could commercialize the device, which cost around \$26,000 for landfill use. Two problems: First, substitutable technology only cost a few thousand dollars. Second, landfills do not get the kind of budgets that an army at war can obtain. Our research indicated the focus of commercialization should be an industrial biotech, where buyers were used to paying prices in the \$20 thousands. (Although sensing toxins was not needed, users did want a better way to detect closely related chemical compounds, making market entry contingent on one of those proverbial “simple matters of engineering.”)

Substitutes also set a baseline for general acceptability. People normally make decisions on only a few criteria. You are buying a car. You want good fuel economy, comfort, and a price below \$15,000. You do not specify what you want for tires or the lock on the trunk. These are important, in that a car without tires would not be very useful. But basically all you care about is that the tires be good enough, that is, within the general range of acceptability.

Now, the whole reason for this discussion is to point out we have to understand what people want to write an equation that works for a deal. Value is always the middle term in a market equation. This value presumes that the attachment to the good by the seller and buyer do not make a deal impossible, that it can be sold for a price within the range of substitutes (or if there are no substitutes for a price seen as reasonable), and that it is desirable enough that someone wants to buy it. Given such assumptions, the seller and buyer can agree on a price and you have a deal.

From this perspective technology transfer can occur where an attainable equation can be created, that is, you can define a transaction that both parties to the deal will find fair. That is the art and science of technology transfer: making sure the equation happens at the right time, in the right place, for you and your customer. All deal makers do is create attainable equations. These equations look something like this:

Royalties (x) = Some Percent of the Value of Technology for
Generating Savings or Profits (v) = Rights (y) Transferred via License

Capital (x) = Some Percent of the Value of Technology for
Building a Company (v) = Equity (y) Transferred

Cash (x) = Some Percent of the Value of Technology (v) for
Providing Services in this Context = Know-How (y) Transferred
in Consulting Contract

Now, implicit in these equations is the fact that the value received with a technology *is not* simply equal to what a buyer will pay:

$$\text{Value } (v) \neq \text{Cash } (x) = \text{Price } (\$)$$

The value of a technology has to be more than they will pay for it, or there is no reason to enter the deal. At best the buyer ends up running in place financially.

Be aware. Not everything will sell. Sometimes a technology is early, sometimes it is too late, and sometimes it is just irrelevant because no one wants it even though it's brilliant science. But if you have a portfolio to move, you will almost always have some winners.

TECHNOLOGIES

Now that we know what a deal is, we can focus on what is being traded. To say we are trading embodied ideas is not precise enough. There are all sorts of ideas and all sorts of ways to embody them (see Exhibit 1.2). What makes a technology suitable for use in a deal?

Plato, in *The Republic*, says ideas are the essential core of reality. In the myth of the cave, he has Socrates describe a group of people chained in place. Behind them is a fire. Another group of people carry cutouts in front of the fire, but behind the backs of the chained people. That creates shadows on the cave wall. The chained people watch these shadows. They see birds, chairs, trees, and shadows made by whatever silhouettes are carried in front of the fire. They think what they see is the actual object, but it is just a representation. This representation is a metaphor for the idea of the object being carried.

In Plato's myth, the people are unchained and realize all they have seen are shadows. They think the silhouettes (these embodied ideas) are the real objects until they wander outside the cave into the sunshine and see the "real world." Plato's point is that even the objects in the real world are just embodiments of the eternal ideas of bird, chair, tree, etc. He wants you, the reader, to realize that there is more to life than what you can see and touch. He believes there is something outside any embodiment—the pure idea. Because it is outside any embodiment it is eternal. He believes what really matters is knowing those eternal ideas.

Whatever the merits of the Platonic argument, our concern in this book is more instrumental. For us, what matters is not the idea per se,

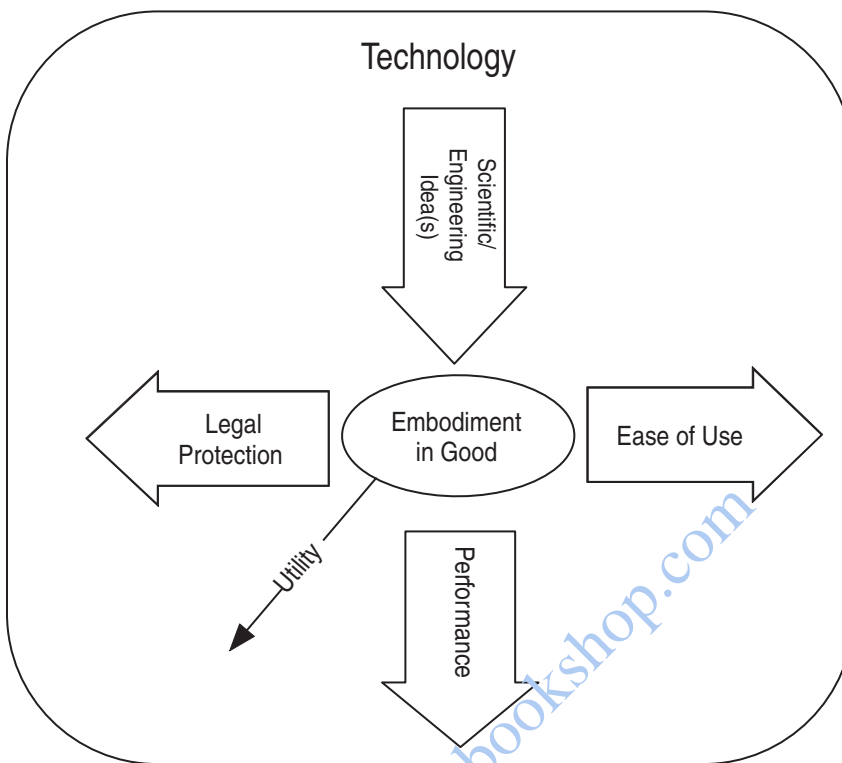


EXHIBIT 1.2 Attributes of a Technology

but its embodiment. It is the process of embodiment itself that concerns us—how an idea is made into something we can see, touch, feel, hear, or taste. The ideas that interest us are ideas that can become things we can sense. Technology transfer occurs down and dirty in the mud of human existence.

In this life, we wake up in the morning and are hungry. We want that bowl of cereal, and we want it without working too hard to get it. Suddenly we understand why technology transfer is important. It is important because we want to get our hands on tools that make it easier to get that cereal. We want combines to harvest wheat in Nebraska. We want ships to carry the sugar from Hawaii and ways to produce it out of sugar cane. We want trucks to deliver milk to stores in New York from farms in Wisconsin and refrigerators to keep the milk cold. We want bowls and spoons to eat with.

When we think about a way to satisfy a need, like eating, we can usually refine it into an ordered set of tasks. A task is one or more activities focused on accomplishing a specific goal.

When tasks are linked together in a particular order to conduct goal-directed behavior, we call that set of tasks a task sequence. Practices are made up of one or more task sequences. Dribbling a basketball is a task. The fast breakaway into a lay up is a task sequence. Playing basketball is a practice.

Technology is a physical embodiment of an ideal that is helpful for accomplishing a task. Technology can be tools, techniques, or materials. The kinds of tasks where it applies are almost always repeated tasks. After all, why buy or learn to use a technology for one time only. However, if the task is repeated, it makes sense to adopt a more reliable, most effective, and/or more efficient way for doing that repeated activity. Technology helps us manipulate the physical world to accomplish a pre-determined end that is instrumental for fulfilling the reason for doing a repeated task.

Technology gets applied in task sequences in order to move the physical world in a manner that makes our life better. Our friend Plato would tell us there is an eternal definition of what makes life better. He calls this idea “*Good Life*.” Given the idea of the good, its embodiment in life is the Good Life.

Markets are not so contemplative. In a market, it is just about goods. Goods are anything that anyone believes facilitates living a good life, however they define that. The ability of the good to contribute to that good life is measured as utility. But since what is the good life is entirely subjective, that definition does not help us very much.

We need a way around that problem. Recall we do tasks to meet our needs. It seems reasonable to assume meeting our needs is part of living the good life. Since tasks and task sequences are goal directed, once the goals are stated, we can define objectives. Once the objectives are defined, anyone can assess how well a tool, method, material, etc. contributes to attaining the objective(s). More contribution equals more utility. Technologies have utility if they are used in tasks that someone believes facilitates living a good life.

Not surprisingly, just what makes a good “*better*” is an empirical question. We cannot know what “*better*” means until we look at what specific people want to accomplish. Better measures the incremental utility that the technology provides. This incremental contribution is measured on some dimension relevant to that end user who defines the goals and objectives of the task.

We can summarize our discussion as follows: If we want to know if a technology is commercializable, we ask how it helps conduct one or more tasks that satisfy particular needs for specific end users. Deals are made where technology creates superior net utility for buyers.

People almost always assess utility on just a few criteria. The trick is to identify just what those criteria are and to be better than them. For the rest of the potential evaluation criteria it is usually sufficient to be as good as the competitors. An example is a non-skid surface for aircraft carrier landing decks. On a key criterion, resistance to tail hook strikes, a new technology for these surfaces underperformed. When struck, it created a shower of splinters that could endanger the eyes of unprotected sailors, and aircraft if sucked into engines. Nothing else mattered with that technology unless tailhook strike could be endured. The solution for commercialization was to shift the technology to an application in which the strike impacts were not important. We thus focused on ships with helicopter pads, where the key issues are durability and time to apply; secondary criteria for aircraft carrier landing strips. On these criteria the technology shined.⁹

Again just *what is* superior utility is an empirical question. The metrics measuring better can be classified into two broad categories: performance and ease-of-use.

Performance is a measure of functionality. It addresses how the end user actually completes the task with the aid of this technology. Performance is usually measured on interval scales in standard international units (SIUs) and key units outside the SIUs.¹⁰ The battery in my laptop provides so much power at such a rate and weighs so much. That means it is useful for working at the beach.

Ease-of-use is a measure of the difficulty an end user will experience when using the technology to attain the promised performance. It is usually measured in ordinal or cardinal scales using characteristics and features of the technology. Ease-of-use is determined with the aid of two sets of criteria: characteristics and features.

Characteristics measure how well our technology maps to the skills, capabilities, and resources of, or available to, end users. Adaptability is an example of a characteristic. Because I can stick a CD into my laptop and

⁹ For an analysis of why people use limited criteria, see Legrenzi, Girotto, and Johnson-Laird, "Focusing in Reasoning and Decision Making," in *Reasoning and Decision Making, Cognition Special Issue* (New York: Elsevier Science, 1993). For evidence this is the case in purchasing decisions see Ozanne, Brucks, and Grewal, "A Study of Information Search Behavior during Categorization of New Products," *Journal of Consumer Research* 18 (March 1992).

¹⁰ For these units, see the descriptions at the National Institute for Standards and Technology at <http://physics.nist.gov/cuu/Units/index.html> and <http://physics.nist.gov/cuu/Units/outside.html> (accessed September 25, 2004).

load a new software program, my laptop can be a publishing system, a word processor, an Internet telephone, a DVD player, or any number of other things. My laptop is a lot more adaptable than my cell phone, say, for sake of argument, five levels higher on a scale of one to ten.

Features refer to the interfaces end users utilize to access and manipulate the technology. Mismatch between characteristics and end-users are barriers to entry. Features can be used to mitigate these barriers. The fact I can load software does me little good if I cannot figure out how to use it. But if the desktop publishing software can be accessed through the same drop-down menu structure as my word processor, I probably can figure it out.

Together these metrics define the utility of a technology. Ideally, for both performance and ease-of-use, we would weight the specific metrics to reflect their importance to end users.

Better does not always mean more. Over-performing can be as bad as under-performing, especially when there is a cost penalty to get the performance. Many years ago I supported commercialization of a new magnet technology for magnetic resonance imaging (MRI) machines. The inventor's father had been a grain farmer. His preferred application for his technology was in high throughput machines for measuring moisture in grain. The grain would be measured as it ran along the conveyer into the grain elevator, providing a precise measure for the amount of crop versus water. Unfortunately, precision came at a significant cost increment. Market research established that moisture was currently determined by using low cost capacitance probes that were stuck several places into a truck load of grain before loading it into the elevator. Sometimes you won, sometimes you lost, when the money paid for your grain was determined by the weight of product going into the elevator. Overall people believed it averaged out even though moisture measurement could be more accurate, but both farmers and elevator operators felt the current technology created fair results. They had no incentive to pay a premium for a high precision system and the technology could not be commercialized in that application.

OK, lets return to equations and see if we can describe a fair deal. My buyer wants:

$$\begin{aligned} \text{Performance } (\sum p_{1\dots n} \times w_{1\dots n}) + \text{Ease of Use } (\sum e_{1\dots n} \times w_{1\dots n}) \\ = \text{Utility } (u) \end{aligned}$$

where w is the weighting, and there can be multiple metrics.

Obviously, if we can put a price on utility, we have a basis for doing deals:

$$\begin{aligned} \text{Performance } (\sum p_{1\dots n} \times w_{1\dots n}) + \text{Ease of Use } (\sum e_{1\dots n} \times w_{1\dots n}) \\ = \text{Utility } (u) \approx \text{Value } (v) \end{aligned}$$

Value is just the expression of utility in money. Note that in the above equation we use an approximately equal sign rather than an equal sign. Value, an objective metric, is never a perfect substitute for utility, a subjective one. But we can ask a person to set a dollar value on the utility, establishing a rough correspondence.

Note that once we know what end users want in terms of performance and ease of use we can predict the utility of different technologies and thus we can compare them and determine who has a competitive advantage. Competitive advantage means your technology meets end-user needs better than any substitute. That makes it more desirable, and thus worth more to the end user.

Using value, which is expressed in dollars, also allows us to compare the relative utility of different technologies for widely divergent tasks. For example, we can compare the relative advantage for any individual of a new biocide for drug resistant staff infections in hospitals with the relative advantage of a new way to stop spam in email. All we need to do is ask that person to express the utility in dollars, that is, to define each technology's value to them.

We cannot, however establish value by asking someone, "What will you pay for it?" Value only exists where benefits are obtained, that is, to be useful a technology has to lead us to the task "better" than we did before. We want some improvement net utility. Charlie trades because he thinks "This year I am going to be a babe magnet" so he trades his Dodge truck for Harry's classic Harley motorcycle.

$$\text{Value} \approx \text{Net Utility } (nu) \approx \text{Benefits } (b) - \text{Costs (Price } (\$) - \text{Other Costs } (c))$$

What goes in other costs? Other costs include the costs of acquiring, implementing, and using a new technology. You buy your son his first two-wheel bike for Christmas and next thing you know you are putting up with your husband's grumbling while he reads the instructions and puts the darn thing together. And then "Ouch" that was his finger he squished and now you are running upstairs to get him a bandage. But there are none so you have to run out to the store while he holds a tissue against the wound to keep from dripping blood on the living room carpet.

Usually when a new technology is implemented there is a need for

training, some revisions to procedures, maybe improvements in physical plant, etc. All of this takes time and money to accomplish. These labor and other expenses are called “*changeover costs*.” There are always changeover costs; the question is: When can we assume they are insignificant enough to be set to zero?

Large change-over costs make it more difficult to make the case for a deal because the changeover costs for the current technology, having been spent in the past, are now sunk costs. That means they are not included in calculations comparing the value from implementing the new technology to continued use of the current technology. For this reason, new technology is often readily adopted after the current technology has been fully, or sufficiently depreciated.

To highlight the significance of sunk costs: Changeover costs are a major factor in the continued dominance of Microsoft operating systems for servers. At the heart of these costs is the client-server model built into the Microsoft architecture. In the Microsoft world, the client is often a key processing center. In the Unix world, the server is the key processing center. Thus, changing over is not simply a matter of swapping operating systems on the server but of rethinking the functionality across the network, rebuilding the client-server relationships to reflect the new architecture, and learning how to manage and support a new set of interfaces.

In *Productivity Dilemma: Roadblock to Innovation in the Automobile Industry*, William Abernathy examined why the U.S. auto manufacturers took so long to respond to the Japanese import threat during the 1973 oil crisis.¹¹ He found that the American automobile manufacturers were locked into a dominant design in which cars kept getting bigger. That made it difficult to see the impending collapse of the large car market. To make matters worse, they had just invested in new factories to build larger cars. So they were locked in, having spent their cash, and could not reinvest in designs and factories for fuel efficient cars. They had to tough it out till large car sales recouped the costs of building and operating the factories. By that time, the Japanese were able to establish a firm beachhead in the U.S. market.

¹¹ William Abernathy, *The Productivity Dilemma* (Baltimore: Johns Hopkins University Press, 1978). For more on the oil crisis see Wikipedia, “1973 Oil Crisis,” n.d., http://en.wikipedia.org/wiki/1973_energy_crisis (accessed July 18, 2005).

How much net benefit or profit is required to make a deal happen is another one of those empirical questions. All our model says is that:

$$\begin{aligned} \text{Net Utility } (nu) \approx \text{Net Value } (nv) \approx \text{Net Benefits} = & (\text{Performance } (p) \\ & + \text{Ease of Use } (e)) - (\text{Price } (\$) - \text{Change over Costs } (cc) \\ & - \text{Operating Costs } (oc)) \end{aligned}$$

where $\text{Net Benefits}_{t1} > \text{Net Benefits}_{t0}$.

Where economic transactions like most technology transfer are involved, we can simplify the net benefit calculation by simply measuring the profit.

$$\text{Net Utility } (nu) \approx \text{Net Value } (nv) \approx \text{Price } (\$) + \text{Profit } (p)$$

Bottom line: Technologies suitable for deals have to offer net utility for the end users that acquire them and net value is never a perfect substitute for net utility. Let's return to the guy putting together his son's bicycle. Suppose he is a professor of theoretical particle physics. Now suppose he is an auto mechanic. The professor probably does not spend most days taking apart and assembling machinery. The auto mechanic probably does. When the professor squishes his finger, he may think, "dang bike." The auto mechanic is more likely to think, "that was silly of me." The out of pocket costs are the same whether a professor or mechanic buys the bike. But the hassle factor is probably different, and thus the value of a self-assembly bike will differ when these guys go shopping for bikes for their younger children.

Of course, deals are more than just equations. The deal is a social relationship. On the one hand, the establishment of an enduring relationship (a pipeline) is often part of the motivation for doing a deal to move technology. On the other hand, since all people are not of noble character, you have to worry about being ripped off.

If you want to sell technology, you must be able to stop people from just taking them for free or they have no economic incentive to deal with you. Like any other kind of property, intellectual property is a social artifact. Once an idea becomes property, one party can exclude others from accessing or using it, that is, the rights to use become attributes of the technology. In market economies, technologies are associated with a bundle of rights related to control of the object(s), which is (are) the goods that constitute the technology. What deals do is transfer part or all of these rights from one party to another in exchange for consideration. The value of that consideration is defined by the equations underlying the deal.

PRACTICES

The context in which utility is determined is a practice. Practices are structured sets of activities that are repeated in order attain some end (see Exhibit 1.3). Practice makes perfect: the practice of law; medical practice; baseball practice.

Understanding practices is critical in our model of technology transfer so let's be sure we understand what we mean by the term. Let's say I want to shoe a horse in the era before the industrial production of horseshoes. I measure the horse's hoof. Then I make the horseshoe.

1. I buy an iron bar with the holes already punched in it. *Task.*
2. I build a very hot fire. *Task.*
3. I heat the bar in the fire to make it malleable. *Task.*
4. I take a hammer and pound the bar into the right shape on an anvil. *Task.*
5. Iterate 3 and 4. *Task*
6. Quench the metal. *Task.*¹²

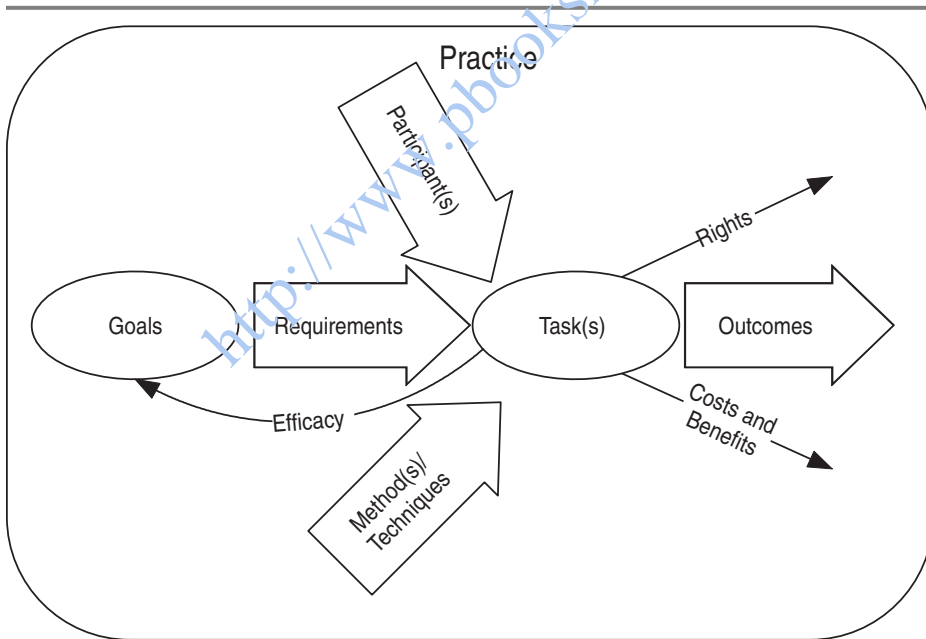


EXHIBIT 1.3 Attributes of a Practice

¹² Adapted from *Fremline's Forgery*, "Tutorial: Constructing A Fullered Straight Bar Shoe," 1996, <http://www.horseshoes.com/advice/fremlin1/cnastbrf.htm> (accessed September 18, 2004).

The specific procedure for making horseshoes listed above is a *task sequence*. There is a separate task sequence for measuring hoofs. Shoeing horses is a *practice*.

Note that practices are not dependent on any specific task or task sequence. Prior to 1857, when the first machine for making horseshoes was patented, I only had the option of making them myself. When the Civil War broke out, demand for machine made horseshoes skyrocketed as horseshoes were needed for the Union Army. By the 1870's, H. Burden and Sons had forging machines that produced six shoes per second.¹³ In less than 20 years, the task sequence for making horseshoes went from artisan production to mechanized batch production to mass production. But I can still hand make a shoe if I choose.

I want to highlight four aspects of practices important for technology transfer: goals, outcomes, dominant designs, and participants.

Because practices are repeated sets of structured activities, the goals of, or motivations for, each practice can be described. As we have indicated, given any specific set of goals I can:

1. Define what constitutes acceptable performance for the tasks and task sequences used to conduct the practices, and
2. Compare partial or complete alternatives for conducting those tasks to see which is superior.

The task sequences in practices exist to create a narrow set of outcomes. There are only two major reasons for making horseshoes: Either you want to shoe a horse or you want to play horseshoes. Different goals will set different constraints on what makes a good shoe and thus lead to different definitions of acceptable outcomes. I either want a shoe to fit well for the horse I am riding or I want it balanced well for tossing. These desired outcomes can be redefined as the objectives for successful horse-shoe making.

The same can be said of doctoring. We either want to maintain our health or we want to heal. Within our model, it makes no difference if you are making horseshoes or making people well. Given any set of objectives for a repeated activity, I always have the possibility of developing new techniques and goods for accomplishing those objectives.

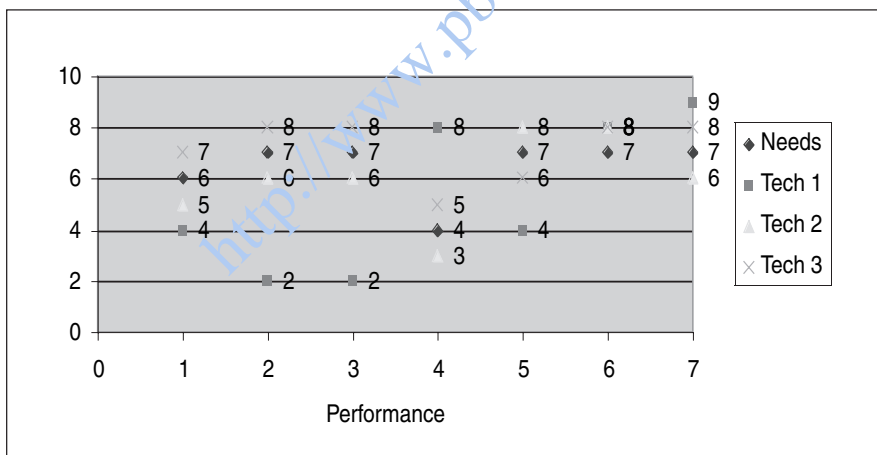
Our job in technology transfer is obviously simpler if these objectives have been defined in advance, because then I can operationalize the objectives to develop desired requirements for technology (see Exhibit 1.4). These requirements provide a baseline against which I can compare my

¹³ Pacific Horseshoeing Company, "Trivia," n.d., <http://www.farrierschool.com/trivia.shtml> (accessed September 18, 2004).

technology’s functionalities and interfaces. I can also compare how well my technology performs with substitutes for meeting the requirements. I can rapidly determine if I have a competitive advantage. Exhibit 1.4 provides an example. It is based on data I collected during a project for General Dynamics on electronic controllers for electric motors. (Because almost everything we do in technology transfer involves proprietary data, what you see is dummied data.)

Over time, as people opt for better ways of conducting practices, one (or no more than a small number) of combinations of labor, techniques, and goods emerge as the dominant way for conducting each task within that practice.¹⁴ The result is that after a period of product innovation and experimentation by end users, their expectations for goods tend to coalesce around a set of functionalities and features. The result is the emergence of a dominant design for that good.

Once a dominant design does emerge, there are sound reasons to figure out how to make it as efficiently and effectively as possible. The reason has to do with the advantages of attaining economies of scale and scope and with the benefits of moving down the learning curve. In economies of scale and scope, the average cost of production decreases as



- 1. Power Density 3. Volume 5. Power Consumption 7. Mean Time between Failure
- 2. Weight 4. Voltage 6. Speed

EXHIBIT 1.4 Competing Technologies

¹⁴ I first ran across the concept of a dominant design in Abernathy’s *The Productivity Dilemma*. The concept of dominant design has been explored in James Utterback’s *Mastering the Dynamics of Innovation* (Boston: Harvard Business School Press, 1996).

output increases, thereby cutting unit costs. In economies of scale this occurs by doing or making the same thing many times, allowing specialized equipment and techniques to be used. The higher the rate of production, up to some limit, the more efficient the operation. In economies of scope, the benefit comes from using the same equipment and techniques to make a family of related products or services. Again, up to some limit, cost per unit is reduced as the number of units increases. Learning curves operate differently. Here know-how and expertise is gained as a process is repeated. Thus, productivity grows over time, again to some limit. Other learning curve advantages come as systems are debugged and optimized.

Where a dominant design does exist, by definition end users expect vendors will sell them a specific bundle of functionalities and features (see Exhibit 1.5). The functionalities constrain the performance expectations. The features constrain the end-user interfaces used in the good, and thus its ease of use. When these expectations are rigid enough, the constraints can be codified as standards. The result is, where dominant designs exist, we can quickly determine if a technology likely will have utility in the eyes of end users by comparing the technology's performance and ease of use with the likely feature and functionality expectations of participants in the relevant task(s) given the dominant designs in place. We can even make a pretty good educated guess as to what price will be acceptable for a new product based on the pricing of equivalently functioning and feature laden goods. The reason is the equivalents provide the context for "sticker shock."

It doesn't matter if your technology outperforms and outshines anything on the market: if it is viewed as falling in a shopping cart filled with low priced goods, no one will pay a premium for it. You want to position it in the shopping cart that allows the best comparison on price. The worst thing is to position your product in such a way as to have a buyer tell you: "I could buy a year of college for my kid for what you want to charge me."

We had to figure out a price for a break-away guy wire for utility poles. Guy wires can be a significant hazard when drivers lose control as cars frequently run up them and flip over, causing death and injury. We concluded that \$200 was a feasible price, as follows. Our analysis suggested that a breakaway base (\$120) made the cost of a wooden pole about 160% more expensive than a basic pole (\$200). We believed that this technology would be viewed by end-users as a similar safety improvement for the standard wooden pole. Since it fell in the same shopping cart,

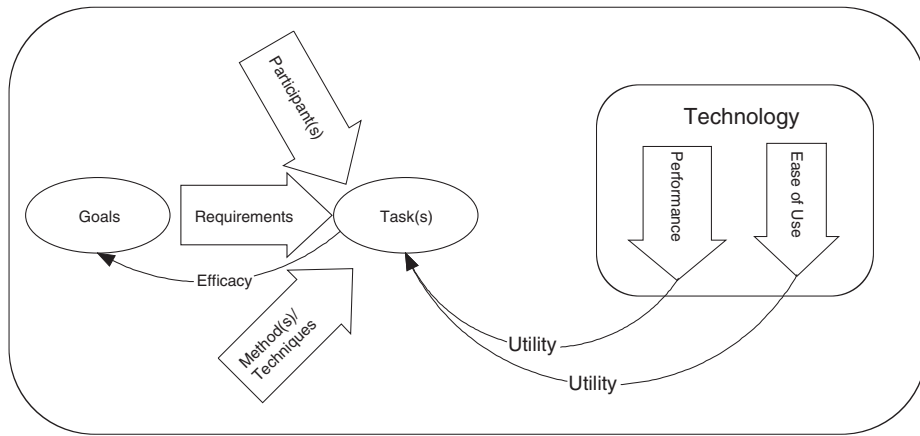


EXHIBIT 1.5 Practice with a Dominant Design

a similar price incremental should be seen as reasonable. So we set the price 200% over standard guy wire pricing. To confirm potential reasonableness, we made another comparison to breakaway metal poles (which do not require guy wires). The least expensive breakaway metal pole at that time was \$1260, an increase of 630% over the standard wood pole. Using this technology with a breakaway base provided a much less expensive alternative to a breakaway pole, while providing the same safety benefit. Our analysis further suggests that labor costs are smaller when using this technology on breakaway base wood poles and for installing breakaway poles. So we could ignore that cost. By putting our solution in the same shopping chart as the breakaway poles we ended up with very favorable pricing—\$520 for a wood pole modified to breakaway to \$1260. We now had a starting point for surveying end users to see if they agreed \$200 was a reasonable price, which they did.

The more a dominant design is solidified, the more likely it is that the current task sequence for accomplishing the objectives has been documented and thus the easier it is to assess our competitive advantage. We now have a more solid set of outcome requirements (performance). We also have a pretty good idea of the skills, habitual behavior, and expectations participants will bring to the task, and thus can better understand what constitutes ease-of-use.

The people who shoe horses are called farriers. That person has a skill set. This skill set changes over time and sets constraints on what is and is not an easy to use method/technique or tool. Go back several decades and there was no source for high quality manufactured horseshoes in the United States. The general used steel shoes that were sold had a variety of

design flaws. Some had a web that was too narrow. Some had the heel nail located too close to the heel. Others had too shallow a nail pattern. The consequence was that farriers had to make shoes in order to have shoes that fit the horse's foot.

By the 1980's things changed. European manufacturers flooded the American market with well designed, well made shoes that came in enough sizes to fit most horses. As the shoes gained popularity, other vendors began to supply the E-type nails that the European shoes required. Then North American manufacturers began to emulate the Europeans and made better shoes. A core task sequence for the practice of shoeing horses was disappearing: making shoes. The result was farriers no longer needed to lug around coal forges, coal, and iron to do their job. The forging skill was no longer essential for being a farrier. However, that meant a generation of farriers emerged with a different skill set.¹⁵

Now, let's return to the reason for shoeing horses. Let's say our goal is to give a horse a well-fitting shoe. Because switching to manufactured shoes enables getting rid of the forge, hot shoeing has been generally replaced by cold shoeing. However, there are situations where hot-fit shoes are better. One situation is where clips are used.

Clips are the flat projections that extend upward from the outer edge of a horseshoe. They are usually round or triangular. They create a small lip at the edge or wall of the hoof.¹⁶ A hot-fit shoe fits better and is more stable than a cold-fit shoe so long as it is nailed on where the shoe was originally fit for the same reason that a custom tailored suit will almost always fit better than a manufactured one bought in a department store.

Although hot-fit horseshoes have higher utility than cold-fit shoes in certain circumstances, like perhaps horse racing, in general cold-fit shoes are just as good. So now a farrier has a choice to make. Should she learn how to run a forge and make shoes with it, buy a coal forge, and lug it around for those limited situations where a hot-fit is better or should the farrier leave those jobs to a "specialist?"

It is situations like this that are the necessity which mothers invention. Ken Mankel invents the portable liquid propane fired forge. This product greatly simplifies the decision because the LP forge is cheaper to operate, lighter and smaller, and easier to use as it does not require the skills for tending the coal fire.

As we saw earlier, we can ask people or we can examine what they do

¹⁵ The example is based on Stovall, "Hot Shoeing: Pros and Cons," n.d., <http://www.horseshoes.com/advice/stovall5/hotshoeing.htm> (accessed September 18, 2004).

¹⁶ See Pollett, "Anatomy of the Inner Hoof Wall," n.d., <http://www.horseshoes.com/advice/anatomyandfunction/anatomyofinnerhoofwall/anatomyofinnerhoofwall.htm> for a discussion of hoof walls and related graphics (accessed September 18, 2004).

when we try to understand their behavior. The first method taps subjective insights. The latter is based on objective observations. By focusing on the practice, that is, on the goals, outcomes, tasks done, and participants, we can define what is “better” without relying on the subjective opinions of people. We really can explain why Mankel’s LP forge is better than a coal forge. The practice provides an objective basis for predicting whether a technology will create net utility for participants in that practice.

I would be remiss if I did not mention the horseshoe nail. “For want of a nail, the shoe was lost. For want of a shoe, the horse was lost. For want of a horse, the battle was lost. From loss of the battle, a war was lost.” The nail is actually more complicated to manufacture than the shoe. For around 3000 years, nails were made by hand. In the mid-1800s Daniel Dodge, Silas Putnam, and George Capewell each patented nail-making machines to mass-produce horseshoe nails.¹⁷ The Putnam Nail Company began to manufacture nails in the 1860s, By the 1890s the firm had 400 to 500 workers who each produced around ten tons of nails per day.¹⁸ In other words, it was once again the creative burst created by Civil War demand that spurred innovation. As the adage goes: “Necessity is the mother of invention.” In our terms, understand what people need to do their jobs better and you can have a pretty good idea as to what technologies you can sell them.

This ability to predict utility on the basis of observation is found wherever thought precedes action. By definition, thought-based activities presume thought can be used to make the activity better. Practices provide a context in which to apply relevant scientific/engineering knowledge and experiential know-how. For such practices we can manipulate syllogisms like:

No germs no bad breath
Swish with hydrogen peroxide no germs
Therefore swish with hydrogen peroxide and no bad breath

Implicit in the ability to make the syllogism is the ability to compare mouthwashes, toothpastes, peroxide, etc. on the dimensions of (1) number

¹⁷ Breninstall, “Horseshoe Nails,” *Rural Heritage*, n.d. found at [http://inventors.about.com/gi/dynamic/offsite.htm?site=http://www.horseshoes.com/advice/nails/horseshoe nails.htm](http://inventors.about.com/gi/dynamic/offsite.htm?site=http://www.horseshoes.com/advice/nails/horseshoe%20nails.htm), accessed December 18, 2005.

¹⁸ Taylor, “Town History, Dorchester Athenium, December 7, 2004, <http://www.dorchesteratheneum.org/page.php?id=52>, accessed December 18, 2005.

of germs or nastiness of breath, and/or (2) cost to obtain some threshold of germ reduction or nastiness reduction. We can always ask: “How I can improve efficiency or efficacy?” “How can we cut the cost per unit or improve the utility per unit?”

Our ability to use this kind of analysis is limited wherever taste or lifestyle considerations enter as a major criterion. As another old adage goes, there is no accounting for taste. Sometimes people even seem to act stupid. For example, cigarette sales in the U.S. are estimated to be at about \$81 billion in 2004, despite the fact that cigarettes are dangerous, addictive, and likely to kill you. They are sold by tobacco companies that, under the 1998 \$206 billion Master Settlement Agreement, all but admitted they knowingly sold products with these traits. So why do hip young college students smoke?¹⁹

Let’s look at one more example. Suppose my practice is cooking. Suppose I want to cook Toll House cookies. I look up a recipe and find the oven has to be preheated to 375 degrees Fahrenheit. Depending on whether I sit the cookies on baking sheets or in pans, I need the oven to hold that temperature from 9 to 11 or 20 to 25 minutes.²⁰ Because I just looked up this information, I am engaged in a practice in which thought precedes action. Bingo!

I have two parameters on which technologies may be evaluated for suitability: temperature and time. The parameters define efficacy, the performance I need to attain outcomes.

I can compare ovens on these parameters to see how well they can do the job. Clearly the acceptable ovens will have performance at or above my requirements. If an oven performs more poorly than I desire, the only question is can it be adapted somehow to make it acceptable. If not, it is not a candidate for baking my cookies.

In general, the ovens whose performance clusters most tightly to my requirements will be most attractive. Why? Because I am looking for a particular outcome: cookies. Attaining that outcome creates a benefit for me: the satisfaction you get from eating chocolate chip cookies still warm

¹⁹ See Mintel International Group, “Cigarettes—US—April 2004,” http://www.the-infoshop.com/study/mt19265_cigarettes.html (accessed September 18, 2004).

²⁰ Well.com, “The Real, the Original, the Authentic Nestle Toll House Chocolate Chip Cookie Recipe,” n.d., http://www.well.com/user/ward/cooki_recipe.html (accessed September 18, 2004).

from the oven. At the same time, as we saw, there will be costs. Not only must I buy the oven and the ingredients; there also is time it takes to cook the cookies. If my son or daughter is in the house, they may want cookies too. Then I have to decide whether to share or not. That increases the costs for me as I have to make even more cookies or eat less.

(Of course, being kids, for them, however, the cost-benefit calculus is different. They are just eating cookies. The point is that both cost and benefit can only be calculated with reference to some player or situation. They are intrinsically referential.)

Now I am writing this book and I am getting hungry. I want some cookies. I want to bake about 3 or 4 cookies on a 10" x 8" sheet. (Don't want to pig out too much or I will spend all my time eating rather than writing and besides the Surgeon General is warning us about how Americans are getting too fat. Fat is associated with higher risk of diabetes. Get diabetes and you can kiss your cookie eating days good-bye. More thought-preceding action. See, it is a very common experience which helps explain why technology is so ubiquitous in today's world.)

Now I am torn. I am hungry but I have to finish this book. Because I have a deadline for the manuscript, I do not want to sit by the oven. I now have additional criteria. I have the size of the oven and a yes/no (10 or 0) parameter called automatic timer. Let's say I am only going to use this oven to make cookies when I am writing. In that case I have yet another criterion: cheap. I want the cheapest oven that will hold a temperature of 375 degrees Fahrenheit for 11 minutes and turn off after that.

No matter how low or high tech the application, the process is the same. We look at the 5 W's:

1. Who puts their hands on the technology?
2. What are they doing with it?
3. Where are they doing it?
4. Why are they doing it?
5. When are they doing it (including how often)?

The 5 W's tease out metrics we can use to compare solutions. For baking my cookies the metrics are things like temperature, time, automatic shut-off, and cost. Once I have the metrics, I can hop on the Web, call my best friend, drop by the appliance store, or collect data in any other way I choose.

In technology transfer market research, our practice is to start with the Web. A quick search reveals all I need is a toaster oven, so I can narrow my search. I find some units, like Cuisinart TOB-175, that have more bells and whistles than I need, but clearly will make great cookies. Unfortunately it costs around \$180 (or did at the time I am writing this).

Over performance usually carries cost penalties. Ever hear about the Boeing B-52 \$640 toilet seat? Boeing took a lot of flack for that one. But then it was milspec'ed for B-52s intended to be in use more than 40 additional years. So over-performance can only be defined with reference to a requirement or baseline.

Other units, like the Panasonic FlashXpress NB-G100P, cost less but do not have automatic shut-off. Then I find the Sanyo Space Saving Toasty Oven. Bingo! That's my ticket to cookie happiness. It is only \$50 and has a 15 minute timer with an automatic shut-off.²¹ My choice is clear. All I need to do is to check reviews to confirm the Sanyo unit is a suitable tool given my cookie cooking criteria.²²

One caution: Be aware that within practices, there are divisions of labor. These are important. Although end-user needs determine adoption opportunities, and resistance from end users can kill a transfer, the people who actually use a technology are not normally the folks who make the decisions about acquiring new technology. That decision is usually determined by managers farther up the organizational hierarchy. The oft-cited golden rule is: (S)He who has the gold, rules. A key challenge is determining the various players in the decision process and their roles and responsibilities.

To conclude: Insofar as people engage in practices, the goals of those practices set constraints on the techniques and goods that can be used in each practice. Why? Because the techniques and goods have to allow the people engaged in the practice to attain their goals or it is pointless to use them. These constraints can be operationalized into some range of acceptability for metrics determining competitive advantage.

Needs → Functionality → Performance

where $a \rightarrow b$ means a constrains b

We can say more. Since each task or task sequence is conducted by someone, there is a participant. As noted, that player enters into the practice with some skills and knowledge. Sometimes the skill sets and knowledge

²¹ Data from Consumersearch.com, "Toaster Ovens," 2002, http://www.consumersearch.com/www/kitchen/toaster_ovens/comparisonchart.html (accessed September 18, 2004).

²² See Amazon.com, "Reviews Written by J. Manly 'healthychoices,'" n.d., <http://www.amazon.com/gp/cdp/member-reviews/A1B4917VQ36TVX/104-5562854-0551143?display=public&page=3> (accessed September 18, 2004).

vary widely among players. Other times they are uniform, particularly where certification or licensing is required to engage in the practice. Regardless, once we know the skill set and knowledge of the participant we can say whether we are likely to find on hand the know-how and other capabilities to use a technique or to use a tool or material. If the know-how and capabilities are there, the technique or tool or material is likely to be easier to use.

Knowledge + Know-How + Skills → Ease of Use

PLAYERS

To do a deal, there must be parties. To conduct a practice, there must be participants. Even technologies cannot exist without inventors. So the last construct we need to model technology transfer is players (see Exhibit 1.6).

Needs are an attribute of players. As we have seen, needs are imperatives rooted in the fact that outside some range of conditions we cease to exist. Don't eat. Die. Freeze. Die. Pretty simple.

Abraham Maslow argued that humans need more than basic survival imperatives. He proposed a hierarchy of needs. He argued first we meet

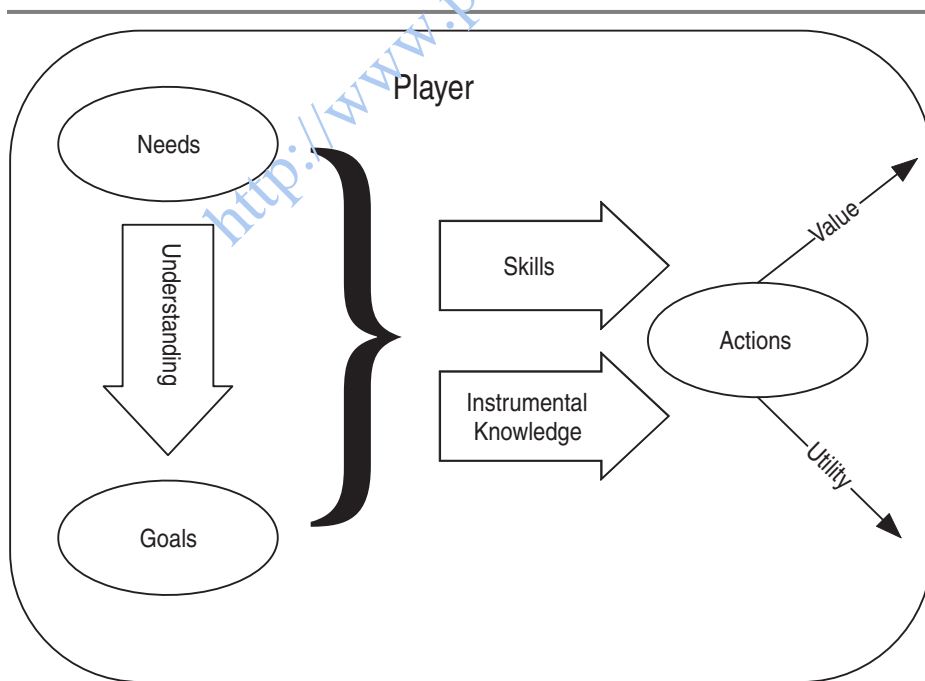


EXHIBIT 1.6 Attributes of a Player

physiological needs, then safety needs, then love and esteem needs, and finally self-actualization needs.²³ Physiological needs address what we need to survive. We die if we do not take in food, air, water. Safety needs address avoiding bodily and psychological harm. They include things like home, family, and as September 11th pointed out, prevention of attack. Love needs address community and belonging. If the prior two sets keep us alive and functioning, love needs acknowledge we are social creatures and that sociability creates needs for companionship and ways to facilitate making and keeping friends. Esteem needs are both self- and other-directed. These needs address the human tendency to seek admiration and power. Finally, self-actualizing needs reflect the inner beauty of people—that something that leads to art, philosophy, charity, and the like. These needs are the ones that emerge when one's life allows leisure time.

For our purposes, it is irrelevant whether Maslow is right or not. It is irrelevant if his categorization makes sense. It does not even matter if the needs he describes are not rooted in humanity as animals but rather are some social creation that varies by time in history and geographic region. All that matters is needs exist and they must, by definition, be satisfied.

Ask yourself, what is the price of a suit in your favorite store? Odds are if you are not looking to buy a suit you will not know. No need, no sale. Have you ever known the prices for suits? If you were ever in the market for one, you probably did at that time. The lesson: Needs are temporal. You have to move when your customers have them or they go away.

As always, an example. We assessed an advanced tunable IR-laser based spectrometer in order to find a market niche where it could be sold. We found significant interest in the laser within the semiconductor industry. Companies like Intel were interested due to problems with contamination during chip fabrication. Two years later, the spectrometer company returned to us for help in making the deal. The firm had never contacted the targets we had identified during our prior work. When we re-contacted those targets we were told they had subsequently found a solution last year from a different vendor and were no longer interested in our customer's spectrometer.

²³ Gwynne, "Maslow's Hierarchy of Needs," 1997, <http://web.utk.edu/~gwynne/maslow.htm> (accessed September 18, 2004).

The way players meet needs is by applying skills, knowledge, and know-how in order to manipulate tools, techniques, and materials.

Skills are capabilities for accomplishing tasks, which is to say skills are ways of shaping ourselves as tools for meeting our own needs. I can bake cookies. I can toss the ball through the hoop from the free throw line. Skills encompass both the manual dexterity and mental aptitude to do a task or ability repeatedly over time.

Sometimes a skill is innate rather than developed. You can be at the carnival and see this kid walk up and start knocking down the dolls with a baseball even though he never threw one before. The kid is just a “*natural*.”

Knowledge is an organized set of information (data and analysis) that can be used to make conclusions about facts not in the original data set. I can add and subtract numbers I have never seen before. I am confident that I will be able to comprehend and analyze poems that will be written tomorrow.

Knowledge can be categorized into two types: instrumental knowledge and understanding.

The first type of knowledge relates to perceptual experience, to “*what is*.” It is this kind of knowledge, to use an example from Umberto Eco’s *Kant and the Platypus*, that allows us to say “this is my wife and not a hat” when confronted by an object of perception.²⁴

Perceptual knowledge contains an inter-subjective organizing scheme for the raw data of perception. It can be formalized and codified, in which case we talk about a field of knowledge or body of knowledge, or it can remain tacit and implicit. One way to formalize and codify knowledge is to filter perception through explicit sequences of behavior designed to ensure the conclusions about what is being perceived are recreated reliably across observers. Science, from this perspective, is a way of creating formalized perceptual knowledge.

As we have seen, knowing “what is” allows us to create “how to’s.” We call this kind of formal knowledge instrumental knowledge, in recognition of its utility for inventing “how to’s.”²⁵

Instrumental knowledge underlies technology. If I can calculate trajectories and I know the weight of a ball, I can adjust the force I apply when

²⁴ Umberto Eco, *Kant and the Platypus: Essays on Language and Cognition* (New York: Harcourt, 1999). The issue addressed in the book is how we construct, and what is, “intersubjectivity.” Eco explores how one goes from the awareness of sensation to what is unique and individual to each of us, the subjective, to labeling something part of that hard, rap your fist against it, knock knock on the door, stuff of the world called objectivity.

²⁵ Instrumental knowledge is, in the German philosophical tradition, *verstand*. See Wikipedia, “Verstand,” September 12, 2004, <http://de.wikipedia.org/wiki/Verstand> (in German, accessed September 18, 2004).

throwing it to improve my odds of knocking down enough dolls to win that Kewpie doll at the carnival. I can use that same knowledge to design a machine that will throw the ball for me. Since there is not a big market for machines to knock down carnival Kewpie dolls, I can reposition it as a baseball pitching machine so I can get out of playing catch with those dumb boys on the little league team my parents made me join. But those dumb boys grow up and go to war and so I turn my machine into an artillery gun in the hopes of keeping my friends out of harm's way. (As William Tecumseh Sherman said: "A battery of field artillery is worth a thousand muskets."²⁶) From there it is not far to launching rockets that put men on the moon or making toys that toss little basketballs into hoops when you put a quarter in the slot at the carnival arcade.

Stepping back for a moment, consider that the same instrumental knowledge can be applied to help satisfy a wide range of needs. Of course, as the example above suggests, as the knowledge is applied in different contexts, it needs to be adapted. Tossing artillery shells requires considering the effects of chemical combustion whereas tossing a baseball with a pitching machine does not. But there is little doubt that the underlying knowledge for making pitching machines can provide a jumping off point for making howitzers.

Should we make howitzers? We pause here for a moment because, like all human activity, technology transfer does have a moral dimension. If you want to make deals, you should always be asking is this specific deal the right thing to do?

There are actually two ethical dilemmas here: one about ends and one about means. The first dilemma is whether we want to make weapons at all. It cannot be answered with instrumental knowledge because it is about goals, about the ends of the human activity called deal making. The second dilemma is different; it can be answered with instrumental knowledge. It presumes the answer to the first question is yes and asks two further questions. The first question is which weapon works best, given the goals of the practice. Are we safer making howitzers than exploring some other alternative, such as making directed energy weapons or increasing foreign aid for humanitarian purposes? The second question addresses the moral integrity

²⁶ CWArtillery.org, "The Civil War Artillery Page," October 31, 2000, <http://www.cwartillery.org/artillery.html> (accessed September 18, 2004).

of the party to whom we are transferring the technology. Should we do this deal if it licenses military technology to the Iranian government? Should we do it if the license goes to a terrorist cell?

We cannot avoid the moral responsibility we all bear for the fate of humanity, our planet, and with the move into space, the cosmos. We must always ask should the technology be transitioned to anyone and if so, can the party we are dealing with be trusted with it? Last year we assessed a technology for looking through walls in order to watch the activity of the people inside. One potential market is police and intelligence agencies. Anti-terrorism? Of course. Meth labs? Yes. Sex between consenting adults? Whoops. Political dissidents? No way. If you license it for police use globally can you control which police forces or internal security agencies get their hands on the technology?

Understanding is the second type of knowledge. It addresses meaning. Understanding results from contemplation rather than perception, from reflection on imagination.

The German word for this kind of knowledge is *verstehen*. *Stehen* is to stand, to become, to face. *Ver* gives us motion, action, a “to do.” If perceptual knowledge is objective, understanding is subjective. What you see depends on where you stand and where you are going. For our purposes, it is relevant because the “*might be*” can spring from it. That “*might be*” constrains the goals for a practice.²⁷ It provides the meaning and motivation for undertaking the practice. Knowing meaning and intention allows us to understand “*why*.”

Understanding “*why*” is critical for determining whether the outcome of action is successful or not *for the player who conducts it*. That suggests any technology is actually meeting two sets of criteria: One which reflects the demands of the practice, the other which reflects the demands of the participants. The extent to which these demands can be expressed as measurable criteria we can improve our ability to determine competitive advantage. But we must define *which* player’s goals when making the determination.

Know-how is unorganized procedural data and analysis. It is fragments of technique that can be articulated or documented, but which have not yet been systematized into knowledge. As I type this, I set my notebook computer on a portable Instand™, but have my mouse on the pull out shelf of my roll top desk. I find this a very comfortable configuration. I know the

²⁷ Wikipedia, “Verstehen,” July 29, 2004, <http://de.wikipedia.org/wiki/Verstehen> (accessed September 18, 2004).

stand is adjusted to be an inch or two above my thigh and the mouse is about a half inch to an inch above the computer. Now by telling you this, you can figure out how to replicate it. I could come over to your house, sit you down at a table, and figure out how to set up a workspace you might find comfortable. But to say that is very different than saying the Center for Disease Control's ergonomic position for computers has the keyboard at a 90 degree angle at the elbow, the mouse at the same level, etc.²⁸ Similarly, I had a discussion the other day with a chemist and manager at a pigment company. He told me that the industry was slowing moving overseas to places like China, but one factor slowing the move was that there was still a bit of art in running the formulations. Art in this context is know-how that is transmitted through apprenticeship.

CONCLUSION

Technology transfer occurs where people do deals in order to obtain better tools, techniques, materials, etc. for conducting practices. It is a transaction in which each side gives something to the other, usually money in exchange for technology.

End users evaluate potential technology on the basis of its net utility for them. This utility is constrained by the tasks and task sequences being conducted in the practice and by the skills, knowledge, and capabilities or the people who do the practice. Where the net utility is large enough, the end user may become a buyer.

The utility of a technology can be described in terms of three sets of criteria: performance, ease-of-use, and aesthetics. At least the first two of these can usually be discovered by examining the dominant design for the core technology used in a practice. The dominant design also provides a reference point for what will constitute sticker shock.

When utility is expressed as money, net utility is roughly equal to value. Value is more than purchase price. Value has to take into account all the costs of acquiring, implementing, and using the technology, as well as some marginal utility that the buyer seeks in order that it is worthwhile for her or him to engage in a transaction with the seller of the technology.

Where each party believes the deal is fair and that they will be better off by doing the deal than waiting or abandoning the deal, a transfer occurs.

²⁸ "Computer Workstation Ergonomics," August 11, 2000, <http://www.cdc.gov/od/ohs/Ergonomics/compergo.htm>, accessed December 18, 2005.