Expertise in Business: Evolving with a Changing World

Lia A. DiBello

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Edited by Paul Ward, Jan Maarten Schraagen, Julie Gore, and Emilie M. Roth

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Abstract and Keywords

The chapter on expertise in business attempts to show how changes in society have influenced a greater need for expertise in business. The chapter touches on a number of themes. Clients teach businesses the nature of expertise while businesses help clients adapt to an increasingly complex and interconnected world of business. The new “expert” in business may not be an individual at all, but rather a high-performing and highly efficient team, with team-level self-awareness of who has what piece of the skill puzzle in addressing complex challenges. Further, all business employees probably need to be closer to an expert than in the past, if only to add value to a team. Lastly, pushing the envelope on accelerated learning can only help more people feel secure that they will be able to find a meaningful and rewarding role in the future workforce.

Keywords: expertise, business, Piaget, performance, Vygotsky, assessment, accelerated expertise

Setting the Scene of Expertise in Business

In order to write a chapter on expertise in business, my team and I have had to become attuned to the ways that business has changed and therefore, how business expertise plays a role in today’s society. By looking at business expertise, we have also learned a great deal about expertise in general and its role in human adaptation to challenging environments. Perhaps for this reason business *expertise* has become important to those outside the expertise research community.

When it comes to business specifically, what we have learned from our work with over 7000 people from 40 different companies is that highly effective teams that understand the challenges before them and efficiently deploy their resources might be more critical *experts* than individuals. In fact, we suspect that our ways of accelerating expertise are so effective at helping companies because they actually create highly expert teams. The

individual members do gain in measurable expertise—and there is no question that there is value in that—but with teams there are marked changes in the reshuffling of resources, and this is what has the impact when the teams return to work.

In this chapter I will discuss our view of expertise and why we think business is an important domain for expertise research, and review what we have learned from helping our clients by providing some illustrative cases. It has been challenging to summarize a 25-year career in a few pages and choose business cases that non-experts in business can follow; my intention is to share some insights from these experiences.

Why is Business Expertise Important Now?

There is no question that higher levels of expertise are required among business professionals than in times past. In recent years, we estimate that senior leaders must reinvent the value of their firms or change strategy as often as every 18 months, making senior management assessment an important feature of responsible corporate governance (e.g., Stamoulis 2009; Kaplan & Minton, 2012). In contrast, in decades past, a single approach could work for an entire career. More recently, we are seeing that mid- and low-level professionals are expected to have a deeper understanding of business fundamentals, and especially forces involved in value creation.

The emergence of *expertise* in business is driven in part by the relatively recent increased pace and complexity of business itself, which in turn, is driven by the influx of advanced information technology. This trend began transforming the nature of business in the early 1980s and gaining full momentum in the late 1990s. This new economy, typified by global information and communication technologies, has enabled exponential growth and innovation from unexpected sources, increased competition for markets, and a vast interconnectedness. And yet, our work indicates that while the expertise of business leaders is complex, and largely intuitive, it may not be a black box we once thought it was.

Our View of Expertise

Workplace Technology Research Inc. (WTRI) studies and assesses business expertise of all kinds and helps companies re-align the expertise of their senior teams to keep pace with changes in the marketplace through services and products it has developed over the past twenty-five years.

The research on the nature of *intuitive expertise* that most influences our notions of business expertise probably began in earnest in the 1980s with work by Robert Glaser, Micki Chi, Robert Hoffman, and others (Chi, Feltovich, & Glaser, 1981; Chi, Glaser, & Farr, 1988), and continuing (e.g., Chi, 2006; Ericsson, 2003, 2016).

In the 1980s Gary Klein conducted pioneering research on expertise in dynamic areas, or areas of knowledge that change quickly and where effective actions require understanding the dynamic underlying principals defining the domain itself (Klein, 1989).

This framework was well suited for looking at business experts in action and helped us with developing assessments and with mapping the problem spaces of business experts (e.g., Klein 1993, 1998, 2000).

In general, dynamic domains require that the same cognitive mechanisms come into play as that in other kinds of expertise, but manifest in different decision-making capabilities. Very broadly speaking, these capabilities were:

1. Developing an intuitive understanding of the domain that constitutes a gestalt shift, resulting in seeing things that non-experts cannot see;
2. Being able to assess and address situations not cognitively available to non-experts;
3. A way of thinking based on *first principles*, rather than the result of memorizing a set of facts or concepts; and
4. The ability to *forward simulate* eventualities in a domain that is rapidly changing and take appropriate actions proactively.

The question is how do these capabilities manifest in business experts?

Our view of expertise is that it comes about as a result of stage-like development in the sense of Piaget (e.g., Piaget 1977) but in a domain-specific way. In this sense, we are like others who have looked at expertise using Piagetian or constructivist models (e.g., Bickhard & Campbell, 1996; Campbell & DiBello, 1996; Spiro, Feltovich, Jacobson, & Coulson, 1992). However, we differ from other genetic epistemologists in that our work incorporates Vygotsky's theory of *scientific concept* (Vygotsky, 1978). Vygotsky was a contemporary of Piaget but did not share Piaget's view that higher levels of cognitive capability were the result of epistemological development. Rather, he believed that knowledge was acquired through an elaborate process of shared understanding through shared activity. His notion of *scientific concepts* in today's terms is systems of knowledge created collectively within a field through social agreement and formalized through language and symbolic representation, such as formulas or written language. *Understanding* develops dialectically, as a result of activity, usually with others.

In other words, expertise develops through a series of stages. However, *what* develops and what constitutes an expert is guided by the nature of the domain itself. As such, experts *enter* into a way of understanding the world already in place for other experts; i.e., the elements of the domain itself apply an adaptive pressure to select specific cognitive processes or capabilities that come into play as mastery develops (see DiBello, 2002 DiBello & Missildine, 2011, 2010, 2012; DiBello, Missildine, & Struttmann, 2010).

Our Methods and What We Learned

Although our aim was to understand the nature of expertise and the cognition of experts, our opportunities for getting that data tended to be via distressed organizations. Over the years this led to a set of services and assessment products that allowed us to assess levels

of expertise among executives and build solutions that accelerated skill performance outcomes.

Assessing Expertise

We had developed a number of ways of assessing the working mental models of business professionals using knowledge elicitation instruments very similar to those designed by others who research expertise (e.g., Crandall, Klein, & Hoffman, 2006; Hoffman & Lintern, 2006; Hoffman et al., 2014; Hoffman, Shadbolt, Burton, & Klein, 1995; Schraagen, 2009; see also Chapter 19, "Incident-Based Methods for Studying Expertise," by Militello & Anders, and Chapter 17, "A Historical Perspective on Introspection," by Ward et al., both this volume).

After several years using different methods, we noticed that highly talented business performers are very similar to each other. That is, they have *decoded* the domain of business much like chess masters had decoded chess (see Chapter 2, "The Classic Expertise Approach and Its Evolution," by Gobet, this volume). This led us to realize that —as a domain—business itself is an orderly closed system of relations between principles, and that so-called intuitive experts in business have an implicit grasp of this. If this is the case, it would follow that all highly skilled business experts should recognize each other and share a common mental model of these principles, although they may manifest differently in different industries. Since business has been evolving in recent years, this model would have to be very robust, running deeper than recent societal changes.

In a study funded by the National Science Foundation conducted over four years (NSF Award ENG 9548631) we found that those who show considerable and consistent talent in business have such a mental model, shown in predictable ways of making use of information. Leveraging our relationships with companies and clients, we had unusual personal access to study a large number of highly placed leaders. Doing in-depth studies of talented business leaders who were repeat successes—even in very challenging markets—and who had risen to very high positions (such as chairmen of large corporations) and maintained that level of position even as business itself has grown much more complex, we discovered a shared mental model among all of them. Like experts in other domains, business experts rely not on greater analysis or greater information, but *better ways of structuring or organizing their knowledge* (in the sense of Ericsson et al., 2006; Ross et al., 2004). Further, a business expert differs in the *manner in which he or she looks at the business landscape, particularly with regard to what is linked with what and what is important to manipulate*. For those interested in the details of the model, the results of that research are published in-depth elsewhere (DiBello, Lehmann, & Missildine, 2011).

This research led to a standardized instrument for measuring business expertise along a stage-like continuum. At this point, it is in an online form that automates much of the scoring and analysis. The participant is assigned a case relevant to his or her industry. Expertise is measured by how accurately he or she predicts the future outcomes of

decisions by examining several years of a company's case material, one year at a time, predicting the subsequent year's events, then getting the opportunity to read that material to see how accurate their predictions were, doing the same thing again, and so on. Since the scenarios are based on actual companies where the outcomes are known and the material is actual raw material such as financial reports or letters from the company CEO, the task is to see whether people can see what *experts* have seen in the same material and make the same predictions. Over the years, these instruments have proven to be extremely reliable predictors of expertise for both executives and—more important to our clients—executive teams, and are routinely used by companies for succession planning, executive coaching, and executive committee coaching. They are also useful for observing what is *broken* in the thinking of an executive or a team of executives. What follow is an example of how the instrument was used to help a *broken* team.

An Example of a Broken Executive Team and One Expert

Having a useful model of an ideal business expert that has stood the test of time for ten years has been useful in helping companies find out what is lacking in their executives. Comprehensive business expertise rarely occurs in one person; more likely, it occurs among an executive committee or team, and for the most part, it is more useful to ensure that—as a team—an executive committee is working as an expert.

One of our most dramatic cases was a financial services company in Europe which was badly hurt in the sub-prime mortgage crisis in 2007–2008. This company is not a *bank* in the normal sense, but the kind of services company that has other banks or countries as its customers. Being on the brink of implosion was a crisis not only for the company, but for its country. The executive committee had a misunderstanding of mortgage risk and reinsured enormous holdings of extremely risky subprime mortgages. In order to survive they had to borrow $3 billion overnight with an interest rate of 12 percent, with pre-payment penalties of 44 percent. We used one of our online assessments to elicit the working mental model of the executive committee and their staffs. About 70 people were evaluated. Our assessment revealed that the entire issue was caused by a failure to anticipate a market crisis that was obvious to many experts outside the company. Unfortunately, it is common for an entire executive committee to share a blind spot that can cascade down through major decisions.

The assessment used here was a version of our online business simulation in which each participant must solve a business mystery by predicting what will happen over the course of a business's life in one-year intervals after being given a year's worth of data at a time and *judge* the actions of the executives in the case. We chose an actual *case* that was similar to this company's but which encountered its challenges in a different time of history. In contrast to their company, the company in the *case* had not made the same mistakes. After removing all identifying information—including dates—we presented each person with five years of material, one year at a time, and asked them to examine the company's data, decisions, plans, and declarations and predict the outcomes of the

following year and judge the actions of the executives. We use a scoring scheme designed to evaluate the present or absence of our model of an *ideal* business expert. We also ask the participants to choose the *clues* in the material that drove their thinking. Each *clue* is like DNA or fingerprints at a crime scene. An expert will not only see that it is significant, but *what* it signifies. Therefore, if the participants predict that the executives in the case do not see that a market downturn is coming and choose the clues that in fact are an early warning sign of that fall, we can see that they are attending to the right clues in the *market* portion of the model. Each question and each *clue* is coded using an association matrix that links back to the model. From this we can generate charts of a person's mental model compared to an ideal *expert*, and a *heat map* showing by color where good clues were identified and where there are blind spots (black) where clues were overlooked.

Figure 1 shows some material that a participant would examine. The question and clue selection screens are all online and involve easy clicks. The participant can stop mid-stream, save their work, and come back to it later. The idea is to replicate the actual decision process of busy business executives.

Figure 1 Material from CAAT.

In real life, the banking executives were having a particularly difficult crisis as a team. They were having serious disagreements with their CEO about how to recover. Some were working behind the scenes to have him removed by the board of directors. A unique feature of our instrument is that it can show how a *team* is thinking. When we mapped the executive team's results—as a team—on the dimensions of expertise critical to their recovery, we found that they were at risk for making the same mistake again due to a shared blind spot in the area of finance and risk management. The only person on the team who could mentally simulate the eventualities accurately was the CEO with whom they were violently disagreeing and whom they were trying to depose.

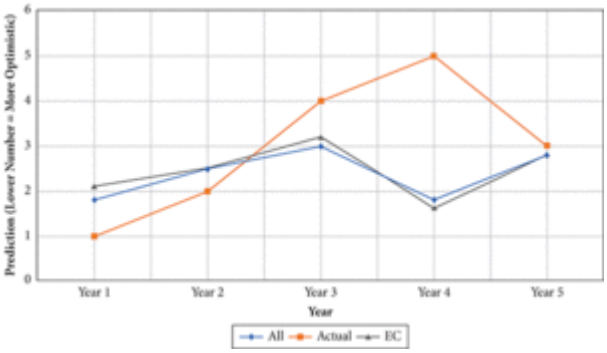

Figure 2 Financial risk prediction. This shows that all the executive committee members underestimated the financial risk coming in years 3 and 4.

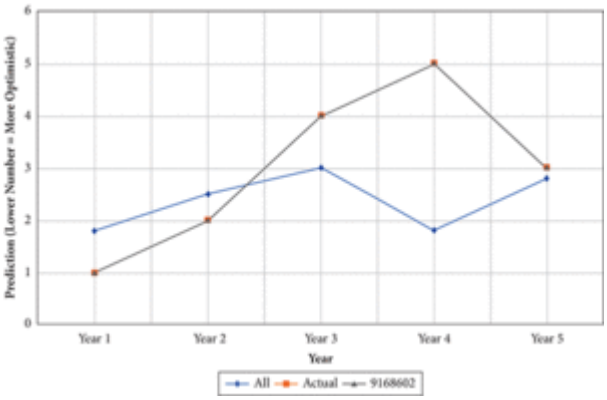

Figure 3 Financial risk prediction. This shows the CEO (9168602) predicted the risk exactly.

Figure 2 shows the teams' results on this important dimension. This chart shows what they predict will happen in the case versus what actually happened in the real case. They did not see the impending disaster (the executives in the case did) and did not agree with what the executives in the case did to prepare.

Figures 3 and 4 show the CEO's predictions on the same instrument. As can be seen, he predicted exactly what happened in the case. On other dimensions of business expertise, they were very impressive and quite homogeneous. Figure 4 shows a heat map example illustrating how the blind spots can be identified.

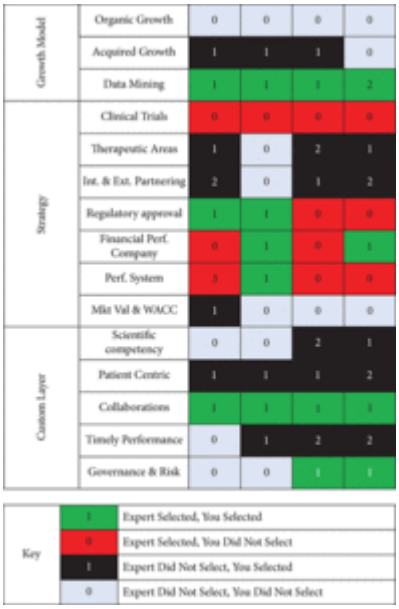

Figure 4 A "heat map" showing the blind spots in the participant's reasoning.

This study is interesting on two fronts. It shows how easily a team can develop a common *theory of the crime* over time, even when it is not working, perhaps explaining how whole companies can sometimes implode. But it also shows how complex business has become and how the insights of one person can be difficult to communicate. Fortunately, using these data, the executives' advisors were able to convince the executive committee that—as a team—they needed to re-distribute responsibility and put those with the deepest insight into the capital risk environment on the front line during the recovery. As a committee, they could function as an *expert* but only if they knew where the different elements of their expertise resided.

This company did recover, enjoying a doubled stock price in less than a year, but it was by developing a shared understanding of how they were going to divide up running the business and yet keep all the parts linked in the way they ran the committee meetings. In the end, they followed the insights of the one lone wolf in one area, abandoning their preferred notions of what would work while they came up to speed on what he was seeing.

Achieving Expertise with Rehearsal

WTRI *fixes* a company that is underperforming or failing in the market with custom-designed emulations of our clients' companies which allow companies to *rehearse* the probable future facing their companies, somewhat like a *war game* used in the military. The context of these emulations is a simulation of the world economy with the emulated company and its competitors in it. The idea originally was to help companies adapt to changes in the business world, usually having to do with implementing enterprise information technology, but we realized early on that we are actually helping individuals and teams develop new capabilities for addressing competitive issues in a dynamic economy. Expertise comes from experience, and specifically from experience with difficult and complex problems in which one can link the decision made with the outcome that occurred. It is generally believed that it can take many years of mistakes and reflection to develop enough exemplars to see the pattern between decisions and the outcomes that occurred. Most corporate professional development plans of promotability assume five to

ten years before managers can navigate complexity. In today's business world, this learning curve is too long.

With *rehearsals*, *expertise* can develop quickly under the right conditions. In fact, the European financial company discussed in the previous section was turned around with a rehearsal in a very short time, although the rehearsal was extremely complex. Rather than chronological time, cycles of trial and error against a highly visible goal with granular feedback can accelerate the development of expertise. We believe that we are actually accelerating cognitive reorganization of existing procedural knowledge or propelling new levels of expertise with compressed cycles of experience, or both. We are exploring both hypotheses in our lab.

In our rehearsals, we found that compressing time and providing instant feedback could result in five to ten years' worth of expertise in a few short days. If the emulated company resembled the *real* company in a reality-analogous way (from the point of the view of the participants and their experience), the transfer back to the real workplace was immediate and profound (DiBello et al., 2010).

In most cases (see Figure 5), we built actual physical models of the company, emulated the actual enterprise technologies and the worldwide distribution and economy.

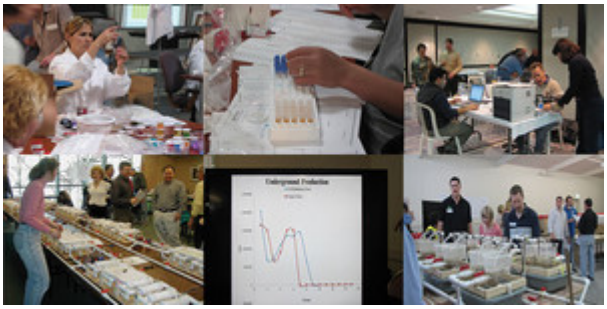

Figure 5 Photos from face-to-face rehearsal events.

There are four critical components to the rehearsals that turned out to be important to accelerating expertise.

1. Time compression;
2. A rich unfolding future that has a pattern;
3. A non-negotiable goal with multiple ways available to achieve it; and
4. A rich history that is similar to the past the participants have experienced but not identical.

Participants run through the rehearsal twice, experiencing several cycles of failure and detailed feedback before they hit on a solution that will work. The first day of the rehearsal does not go well; when a major organizational breakdown is present in real life, participants invariably fall back on default behaviors and *fail* in a way that replicates their current problems in the real workplace. At the start of the second round of the rehearsal, participants are given feedback based on various performance metrics from the activities of the previous day. Detailed data are provided that show the ideal versus the actual performance. The participants discuss among themselves three issues: (1) what went wrong, (2) what we will do differently this time, and (3) how will we know it is working. On Day 2 they are given an opportunity to rework and develop novel solutions. As such,

the solutions they devise on Day 2 often reflect workable strategies to bring back into the real workplace. Because various teams can coordinate across multiple functional areas with dynamic, real time feedback in a consequence-free environment, the rehearsal allows old systems to be discarded and new models emerge.

Over the years, rehearsals have become very powerful tools; almost without exception the financial performance achieved in the rehearsal after two rounds is achieved by the actual company within a few months after the team implemented the rehearsed approach (e.g., see Bower, 2004 DiBello & Missildine, 2011, 2012; Hoffman et al., 2014).

We became well known for these events because of their impact on companies. Working with our interdisciplinary team of economists, artists, developers, and cognitive scientists working out of our lab in San Diego, we were able to turn around the performance of scores of companies radically in a very short time frame with predictable and measurable financial results. With support from investors and basic research support from the National Science Foundation, we developed a number of enabling technologies to make it easier to design powerful rehearsals more quickly.

We estimate the delivered value to companies when the rehearsed outcomes are replicated in companies to be in the billions. However, the biggest benefit of these events is what we learned about the nature of business expertise and how it might be changing. The following section describes an example of a success that was financially modest (this was a relatively small client for us) but cognitively very striking, and compared to many of our cases, a relatively easy business to understand for illustration purposes.

The Midwest Foundry

The Midwest Foundry Company (MFC) is an old foundry that makes all sorts of iron castings, including small machine parts and large-scale castings such as cast iron engine blocks for freight train locomotives. However, over the past several decades, the foundry business has changed drastically. Many items once cast in iron are now fabricated using other means, and small castings are outsourced offshore at greatly reduced cost. However, there is still modest demand for domestically made very large (multi-ton) castings, which are normally not made in large quantities. MFC had facilities capable of making castings weighing as much as 30,000 pounds, with their average casting being 5,000 pounds.

When sales in 2000 were down 11 percent—the general perception was that the company was losing money because it was losing sales. As a result, the owner and the management entered into increasingly risky agreements in order to attempt to retain customer business. These were viewed as marketing programs designed to secure additional business. However, many times prices charged to desirable customers were below cost of production for MFC. As such, the more castings they made, the more money they lost.

MFC’s real opportunity resided in their close proximity to their customers and their ability to make very large castings, but they needed to look at the opportunity differently than they had been. They needed to offer greater value rather than lower prices. Customers would pay a premium for something they need quickly and which is hard to get. Large castings are often used in other products that are not bought in large quantities but which, when needed quickly, are highly profitable for the seller. Therefore, price cuts were not necessary for items customers are desperate to have.

Problems on the Shop Floor

Just as the process of casting has not changed much over the centuries, foundry workers and managers tend to be second- or third-generation foundry men. Most of the workers had lived in the Mid-west for generations and still farmed the land they were born on as a way to subsidize their living. The workers and many of the managers were also not financially knowledgeable enough to know how their foundry was doing or what they could do to contribute to its survival. Notions like *breaking even* and *covering overhead* were not part of their daily language on the shop floor. They were efficient and skilled mold makers, pourers, and finishers, not businessmen. They tended to make as many molds as they could—whether there were orders for them or not. This created a widening disconnect between the day-to-day operations and the larger goals of the company.

There was also a disconnect between the different functional areas. The life of a casting begins with the pattern. A pattern is made and handed off to the mold makers. Large-scale casting molds are made in three pieces. The true craft of large casting involves getting as much of the intricacy of the final piece to be a part of the casting by controlling the flow of the molten metal in such a way that you get uniform filling and cooling. As such, mold makers cannot simply follow a set of directions; rather, the real expertise for the mold makers is in understanding how the molten metal will flow into the mold. This requires a complex placement of holes and *chills* that control the proper moving and cooling of the molten metal. With large items, the placement of the holes and chills and the skill in making each individual mold is as important as the design of the pattern.

A near non-existent tracking process led to a six-week lead time from the time a customer placed an order to the time of delivery, even though much of that time, the casting may have been sitting in a pile of uncleaned inventory. Six weeks was about the amount of time needed to get through the twenty-foot pile that resulted from excess inventory. Once an item was selected for cleaning, the focus of the workers’ attention was on doing a stellar job of preparing the casting for the customer. Again, the workers proved superior at this task as others did at making the molds. A great deal of artisan skill and knowledge accumulated over generations was involved in preparing the final casting. However, many of these were not due for shipment while others that were already late could not be found.

This process led to a less than 30 percent on time delivery. In addition, because the molds were not cleaned with any priority, any flaws in the castings were only revealed when the part got through the finisher. Flaws in the castings could be a problem with either the

pouring process or the original pattern. Understanding the nature of the flaw requires visual inspection by mold makers. Yet, often a casting was not scrapped until quite a bit of labor had gone into *knocking off* the sand mold to reveal the flaw. Since this happened in another building entirely, the molding and pouring personnel may not know that rework had to be done until weeks after the casting left their control.

Simply, MFC could not afford to continue with the same work patterns that had made them successful in the past. Business used to move more slowly; on-time delivery was not as important as price and inventory practices. Workers had decades of expertise as mold makers, pourers, or finishers. They had developed their priorities and impressive decision-making skills in response to environmental pressures at a time when quality was difficult to obtain and timing was not as important.

The Rehearsal

For MFC, we developed a rehearsal to develop expertise in on-time delivery and value pricing. MFC's rehearsal was a two-day, simulation-based intervention, in which participants engage with a *reality analogous* version of the foundry's mold making, pouring, and ERP system, as well as its profile of customers (see Figure 6 to get a sense of what the *rehearsal* looks like as well as pictures of the actual foundry floor).

Figure 6 Molds in inventory on the foundry floor vs those in the rehearsal.

Organizing Forces and Leading Activities

Before designing the mock work environment, we needed to understand what kinds of thinking supported their current practices. We asked the workers to develop an *as is* map of their process, outlining how they see the workflow from pattern to delivery, and subsequently develop a *to be* map. During the rehearsal it emerged that their *as is* map did not include on-time delivery, and their *to be* map seemed to be an extension of the current way of thinking—they simply created new ways to push more product through the pipeline, without realizing the new bottlenecks that this would create. In addition, for the mold makers, cleaning and shipping were not part of their process maps. Activities not involved in actually making the casting were not the object of their thinking and decision making. Therefore, entire parts of the process, such as handing off the job, trucking the unfinished casting to the cleaning facility, and storing were not represented on their maps and were not objects of their attention. We needed to get them to think about these missing things.

If their old ways of thinking had emerged in response to adapting to one environment, we needed to create an environment with new goals that were highly visible. As such, the rehearsal design began with a set of outcomes to which they would be held accountable:

1. Customer orders must be shipped on time; anything late had to still be delivered, but there would be no payment for it;
2. A lower cost per item budget;
3. Reduce scrap rate goals; and
4. A specific revenue goal with specific profit margin that had to be met by the game's end, with reasonable interim milestones along the way showing progress.

We constructed a miniature foundry in which they had to make molds from miniature *patterns*, prepare them for pouring, and generally route the product through the process laid out on a series of large table tops. We did not replicate the entire foundry in miniature; rather, we created an environment that exaggerated what was important to work on and downplayed what was not. In that sense, it is a physical caricature of the decision space.

The rehearsal design ideally represents those aspects of the work environment where critical decisions are made and places them in the context of the new outcomes. For MFC, we replicated pattern retrieval, mold making, and casting cleanup, because these are the points in the process where decisions are made and things can go awry. We used a polymer sand that, when mixed with water, makes a temporary mold used for making plaster of Paris castings. This also replicated the fragility of the real molds; within 30–45 minutes, these polymer molds start to fall apart (real-life sand molds start degrading within days). They are supposed to be used immediately.

The process of making molds engaged their default, routine work activities, but in the rehearsal, these activities were placed in the context of the primary decision points that were tied specifically to high-level outcomes for which they were held accountable. On the shop floor, mold making alone is the final measure of their performance. In the rehearsal, mold making and routing are part of a larger process of on-time delivery, cost reduction, reduced scrap rate, and meeting profit margins.

While making molds was easy for them, in the context of new requirements the task became more complicated. For example, there are about eight steps to making most castings. If you are late with step 2, you are already *too late*, even if the casting is not yet due to the customer. Thinking about the lateness of a casting by step 2 was not part of their thinking. Time had not been thought about in that way before in the context of their work. To develop this kind of thinking, we gave them tools offering visibility into the effect of accumulating lateness. One tool was a MRP (material requirements planning systems)-generated list of internal deadlines (by customer order) for internal *customers* (i.e., the eight steps in the process) such as *making the cores*, the *pouring room*, or *finishing facility*, which allowed to them see that delay in one process had a domino effect on other parts of the process, even if it is weeks ahead of the planned ship date. We required that the MRP router (a printed form with all the steps and interim due dates)

travel with the job (pattern, mold, and casting) and each person had to check off their step and when they did it. The due date (or game period in this case) was shown for each step, not simply the due date at step 8. Thus, at every hand-off, they could see the accumulating lateness. In addition, the customers (played by staff facilitators) did not always accept orders that were late and certainly did not pay for them. MFC had had a MRP system for nearly four years, but they had never used it except to track customer information, such as shipping addresses, customer item numbers, and sales contacts.

Results in the Rehearsal

The first day of the rehearsal, the MFC workers replicated many of the dysfunctions that had occurred in real life. Less than 30 percent of the orders were on time, and the financial picture by the end of Day 1 was nearly identical to their real finances. All the molds and castings were beautifully done, but always late. As the day progressed, we tracked their performance and projected charts using an LCD projector. The projected charts were updated every few minutes. Even though they could see where they were headed, they could not come up with a solution. In order to get the *customers* to take the castings, they cut prices below cost and tried to make up the losses with volume. Even though this group had developed a careful *to-be* plan and process map, this was entirely abandoned during the rehearsal. The phones keep ringing and the suppliers kept sending bills. We stayed in role as unhappy customers throughout the day, allowing the numbers to speak for themselves.

On the second day, we reset all of the numbers and gave them an opportunity to meet privately and devise a new approach. The second rehearsal was thus an opportunity to rehearse a new strategy. All of the same parameters were in place. They had new molds to make, and were held accountable to the same top-line revenue goals, but the customers and orders were different. Nearly everyone showed up early and each team was rearranging their tabletop work floor before we got there. When they saw us, they asked for their data again, and asked for it in different forms. They were given a prep period of a couple hours to figure out what went wrong the day before. When the rehearsal started again, they had to come up with a plan to fix the problems that had occurred the day before.

Very early into Day 2, they began asking the customers (facilitators in role) how important was it that the castings be on time. They wanted to know if we would pay a premium if we got guaranteed on-time delivery. We said we would pay full price for on-time delivery and a slightly higher price for a shorter lead time. They took this information back to their huddle. They also rearranged their tables and examined their data from the day before, and began strategizing how they would move the casting quickly from stage to stage with as little sitting around as possible. They also discussed developing ways to know where a given order was and if it was late. A sample of dialogue illustrates:

D: Okay, but when you're done with making that, you can't just say "okay I did my part" and make a little pile at your elbow. I am waiting for you to be done with that so I can do my piece. You have to let me know it's ready or give it to me, because if you get it to me later than I need it, it's late, period.

T: Right, and the whole team doesn't get paid.

L: Yes, we don't get paid. Everybody got that! You don't move your stuff, we don't get paid!!!!! So maybe we should move you guys to be closer together and come up with a way to signal that you're done.

B: Listen up you guys. I just got the customer to agree to a higher price with a shorter lead time. Can we do that? Let's look at the routing and see if we need all the time on there.

T: Has anybody figured out the break-even by piece? Are we charging enough? We need to look at the prices; the more stuff we made yesterday, the more money we lost.

It should strike the reader that long-term experience of the workers has not changed, but their thinking is changing, both individually and collectively. In fact, it is their experience that makes the new level of expertise possible, even though before, it was the very thing holding them back. By rearranging the context in which their expertise is deployed, new goals will select ways of thinking and develop capabilities that make meeting those goals possible. The design of the rehearsal only focused the participants on accountability for outcomes, not on the best way to get there. This stimulated participants to begin to find new ways of thinking about the same things.

On the second day of the rehearsal, *on-time* was incorporated as part of *excellent casting* and *more throughput* was transformed into the idea of *more of what we need; less of what nobody is buying*. By the end of Day 2, they had designed a pull system as opposed to the push system they had previously had in place. This made the MRP routings and reports as central objects in the decision landscape. Important to note, all the *unachievable* goals of Day 1 were achieved easily on Day 2.

Results in the real world. After 9 months, they were on time nearly 82 percent of the time and returned to profitability. As a result, they reduced their scrap rate from 13 to 9 percent. They began to turn a profit, focusing on premium pricing and on-time delivery and gradually retired commodity products.

A few months later the company confronted a crisis. The owner was involved in a lawsuit with the bank; he was accused of using bank loans secured for capital improvements to make acquisitions of other businesses. The bank took possession of the company and the owner suddenly passed away. This was very discouraging news since the workforce had made considerable progress in understanding the key to profitability in today's market. Although the plant never actually shut down, the workforce struggled to meet commitments. They found it hard to pay suppliers with assets being seized by the bank.

After trying to negotiate with the bank, some of the managers who had participated in the rehearsal sought out and found a financial backer. This backer bought the company on an "assets only" basis (he did not assume the debt), which allowed the workforce to continue with their program of improvement while the investor acted largely as a silent partner. The idea was that they would repay him with interest from the profits.

Two-Year Follow-up

On our return visit after two years, most of the same people we had worked with were still there. Orders were being *pulled* through the system in an orderly fashion, on time, at a low cost, with little scrap. They had achieved 100 percent on time to the customer and had shortened their lead-time from six weeks to two weeks and negotiated premium prices from customers for shorter lead times. They had reduced their scrap rate down to 2.9 percent, well below the 6 percent industry average. The entire customer service department was eliminated, profits were consistent, and for a foundry, the margins were higher than is typical.

We found that they were still using a version of tools developed in the rehearsal, but had gone beyond them, innovating new technologies. This was remarkable for a workforce that had been computer illiterate two years before. As the industry changed again, the workforce modified the information tools to support better decisions. Each team of workers gets information each morning with all orders and all offsets, and a detailed version of accountabilities for the whole company. The larger goals and complexities of the entire process were made transparent to workers in all parts of the process. In other words, every worker has visibility of his or her work in the context of the whole business and all workers have access to the tracking technologies.

As stated earlier, two years prior there was typically a 16-foot high by 40 foot in diameter *pile* of sand-encased castings to be cleaned in the cleaning area. Cranes were used to move the multi-ton castings in order to find out what was there and find those that were due to be cleaned in time for shipping. During our follow-up visit, there were only two relatively sand-free castings that had just arrived for cleaning. Within 20 minutes, cleaners who were expecting them had them moved them to cleaning booths.

In summary, the workers had gone well beyond what they learned from the rehearsal. What they developed in their rehearsal was a first principles understanding of the dynamic nature of their business and an ability to continually adapt and change their strategy as the business changed.

Scaling Rehearsals for Education

Businesses are more alike than different, and scalable educational applications in the form of *generic* rehearsals may have the same expertise accelerating benefit as our labor-intensive and expensive face-to-face rehearsals.

We are in the early stages of exploring ways to bring expertise in business to a much broader audience. Recognizing that society does need scalable solutions to meet the need for increased expertise in business, for the past two years we have focused on scalable versions of our approach for the explicit purpose of developing expertise in both individuals and teams. We are developing virtual world *rehearsals* on a proprietary platform. Unlike other virtual world platforms, this is built specifically for complex business scenarios. Our partners in the early work are the National Science Foundation, IBM Research, and the Project Management Institute among others. We are currently focused on two areas that capture much of business expertise but are not as complex as running a whole company. These are mergers and acquisitions scenarios and complex project management for business. Below is a summary of a project management study which was our first attempt to test a scaled acceleration of expertise for small teams and individuals in a business domain,

After extensive research on what made an *expert* project manager, we made the virtual world versions of our rehearsals as complex as our physical face-to-face emulations (see Figure 7). In one sense it was easier; the enabling technologies that make the experience rich and complex can be attached to the virtual worlds permanently and enrich an immersive experience. Further, the worlds are quite large. Some of our agricultural and mining worlds are fifty square miles or two miles deep and can be experienced with a virtual reality headset. In single-player mode, however, the other *players* are robots, and the programming can be challenging.

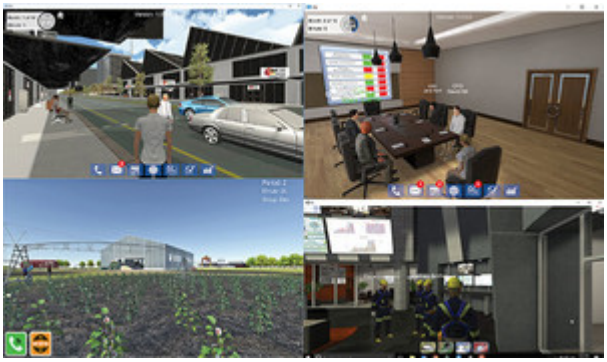

Figure 7 Screenshots of the project management "worlds."

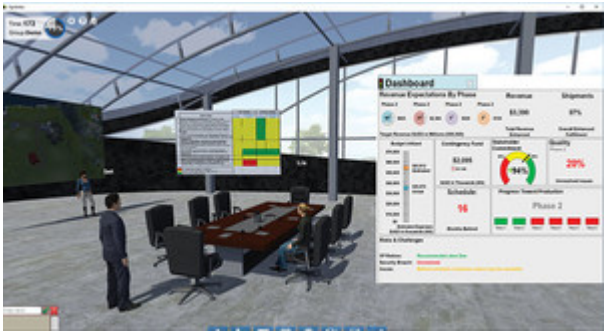

Figure 8 Example of a dashboard for tracking progress inworld.

We added detailed feedback using dynamic dashboards (see Figure 8) which update instantly and automatically and which can be accessed via a button in the user's heads-up display.

In general, the multiplayer virtual world rehearsals performed exactly as the face-to-face versions, differing only in that they did not involve travel by the participants, could be stored in the cloud, and could be conducted over a number of weeks instead of two days. The learning impact was the same even with the increased time between inworld sessions as long as the iterative grammar was preserved. Teams still got to complete the entire rehearsal twice and invariably made all their mistakes the first time through. We were less hopeful about the single-player versions of the product, where the participant is essentially on their own playing against and with robotic avatars. However, here too, the impact held up.

In a world-wide test in 2016, 203 participants tested a single-player version of a product we built for a one of the largest project management certification organizations in the world. All were volunteers. By our data collection deadline date, 46 had completed two sessions by completing the 60 or more tasks involved to finish (eventually 78 finished).

A complicated scoring scheme developed over two years with funding from the National Science Foundation used to measure learning. The details are beyond the scope of this chapter. In sum, it involved five levels of expertise evidenced by levels of difficulty in the project in addition to challenging events that acted as both embedded cognitive probes and obstacles that had to be overcome.

As can be seen in Tables 1, 2, and 3, the participants scored at a level higher on all types of scorable tasks between time one and time two. To put this in context, this kind of change is normally seen in "real life" after three to five years of experience. We were both surprised and encouraged by these results.

Table 1 Level of Performance on All Activities between Time One and Time Two

Group	N	Av ratio time one	Av ratio time two	df	Sig.
<60 events	46	0.433	0.591	45	$p < 0.0001$
>60 events	73	0.377	0.523	72	$p < 0.0001$

Student’s T analysis of the differences between time one and time two change in level-up scores on all scoreable activities, and includes all activities, challenges, and core events.

Table 2 All Challenges; Comparison between Time One and Time Two

Group	N	Av score time one	Av score time two	df	Sig.
Challenges	46	0.761	1.054	45	$p < 0.001$

Student’s T analysis of the differences between time one and time two change in level-up scores on all challenges.

Table 3 Performance on Challenges Unique to Time Two

Group	N	Av score time one	Av score time two	df	Sig.
Challenges	46	0.35	0.44	45	$p < 0.04$

Student’s T analysis of the differences between time one and time two change in level-up scores on unique challenges that functioned as cognitive transfer indicators.

This study showed that the basic principles proven to accelerate expertise—namely, cognitive reorganization through iterative trial and error with embedded feedback—held up in a single-player application with volunteers working alone, relatively unguided, and remotely. In general, the product resulted in learning benefits much better than anticipated—especially for a product still in development—and much better for something that was completely voluntary. We were also able to show that fundamental cognitive mechanisms must be involved; because this method had been heavily tested with groups prior to this study, it could be argued that *individuals* had not necessarily undergone a change in their ways of thinking. In this study, all participants were working on their own and showed measurable changes in expertise in universal and consistent ways.

Beyond proving the robustness of the method, there are other implications. The strong results show promise not only for this product, but for the potential to deliver accelerated expertise educational methods more widely than thought possible for professional development purposes.

Conclusion and Further Work

Much of the work we have done—using the understanding of business expertise we possess to devise ways to assess and help our clients—has showed us what we don’t know and what future research must address. We have touched on a number of themes throughout the chapter.

From the evidence we have collected it appears that the new *expert* in business may not be an individual at all, but rather a high-performing, highly efficient team, with team-level self-awareness of who has what piece of the skill puzzle in addressing complex challenges.

Further, all business employees probably need to be closer to an expert than in the past, if only to add value as a member of a high-performing team. Pushing the envelope on accelerated learning can only help more people feel secure that they will be able to find a meaningful and rewarding role in the future workforce. The response to products we are experimenting with now show us that scalable, remotely accessible, and affordable accelerated skill development solutions need to be widely available.

It is becoming more obvious that lifelong learning—even within the domain of business—will be necessary for all people. Perhaps the rehearsal has shown us that there is a fundamental mechanism involved in the development of expertise that comes into play, and that what we now call intuitive expertise is actually an innately human adaptive response to challenging environments.

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Lia A. DiBello

Lia A. DiBello, PhD, Workplace Technology Research Inc., USA