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Insight from hindsight: A practitioner's perspective on a causal approach to performance improvement

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ABSTRACT

The petrochemical industry works relentlessly on many fronts to improve performance and to create desired performance outcomes. Companies' approaches vary widely; yet despite best efforts, the industry continues to experience periods of undesirable performance outcomes in product quality, reliability, process safety, environmental, and personal injury. The industry continues to search for better methods, techniques, and technology that are assumed to be missing, but the causes of incidents illustrate that what is in the way of improving performance may not be what is missing but rather what already exists.

This paper provides an alternative perspective of performance problems viewed from underlying causes and patterns of causes of incidents in these so-called "high hazard industries" (Carroll, 2004) across several years and geographic regions. The perspective includes two distinct insights.

First, although problems can have a wide range of outcomes and impact, the underlying causal patterns are relatively few in number. These few represent essential elements that are repeatedly discovered in various forms under many unrelated problems.

Second, several common obstacles within organizations often inhibit the ability to find the causes, learn from the causes and to effectively address the causes of performance problems.

The conclusion is that when these repeating patterns are combined with a limited ability to effectively find, learn, and eliminate the causes, organizations are left with repeating periods of performance problems despite well-intended efforts to improve.

1. Introduction

Conducting investigations over many years provides one an opportunity to observe the many ways that things can go wrong, and why. In the first decade of my investigative experience I formed many theories about the causes of performance problems and often had them dashed by conflicting evidence and new causal theories I could not have imagined earlier. As hard as plausible theories were to develop, they were even harder to let go of, as explanations provided an easy way to describe what was happening (i.e. the way one believes things work) and provided comfort in knowing. Having to let go of one's "favorite" theories leaves little but uncertainty, some mystery, and the work of "finding out" again. Only after considerable time was it possible to embrace the idea that each investigation is a new and specific discovery of causes that are discoverable only if we do not hold too tightly onto what we have believed and trusted.

But 30 years of investigations also provides insight across performance problems and across time. This view clearly reveals that organizations suffer recurring problems over longer time frames and struggle to resolve the causes of complex performance incidents in real time. These two issues, of course, are related and this paper is intended to describe the underlying patterns that cause the recurring problems and to describe the nature of the difficulty that organizations have in addressing causes. In Section 2 I discuss the insights achieved through hindsight in identifying the underlying patterns that drive recurring problems, observed across many investigations. In the next three sections I discuss what keeps organizations from addressing the underlying causes of problems and thereby missing the opportunities to improve performance. The stories are organized by specific limitations in discovering cause (Section 3), learning (Section 4), and taking action (Section 5). In the final section I offers some ways to address these limitations.

2. Insight from hindsight

Looking back over 30 years of investigative work, several distinct patterns emerge that provide insight into how, despite

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well-intended efforts to improve performance, problems may continue to reoccur and can even get worse. These patterns represent essential elements, or building blocks for creating performance problems. One or more of these patterns has existed in nearly every in-depth investigation of which I am aware.

2.1. We trust the "system" will protect us

Incidents causing significant losses, damage, or injury are usually considered nearly impossible by the organization that suffers these outcomes. It is not uncommon to hear employees at all levels state that they "Could not believe that something like that could happen at a place like this that runs so well". Even individuals in organizations that have struggled with performance problems cannot usually fathom that an incident that yields significant damage and risk to life could happen in their part of the organization and certainly not to them.

We are fundamentally surprised by incidents of significant magnitude (Weick and Sutcliffe, 2001). We seem to hold an inherent and often unjustified trust in the system around us to produce the outcomes we want and to protect us from the outcomes and harm we want to avoid. This trust hides the underlying defects in the system from our view, and as long as the trust remains, the existing underlying defects will remain and more will come, undetected as well.

2.2. We do not see the pre-cursors

After an incident has been causally analyzed, it is common to discover that parts of the incident have happened before; in some cases nearly the same physical event has happened before but at a lower level of impact. And once causes are uncovered, it is also common for individuals near the events to recognize some of these causes. Sometimes individuals were concerned about these issues and sometimes they had seen them so often that they were considered normal.

Prior events and the causes of prior events are often known at some level in parts of the organization before similar more significant incidents occur. The causes of these prior events can exist for long periods of time under the threshold we would deem to be concerning or even noticeable. In hindsight, we can see more clearly how these causes developed over time and the weak warning signals they provided, and we accepted as normal. The inherent assumption that "weak signal" (Weick and Sutcliffe. 2001) equals "insignificant", precludes us from seeing the problems coming and finding them when they are small. We are then left with the problems getting larger and finding us.

2.3. Multiple concurrent causal paths exist all the time

Investigations often show a number of concurrent causal paths that needed to exist in the same time and space to create the event the way it happened. The individual paths, by themselves, often appear insignificant but when aligned with other causal actions and conditions, they can yield some very significant outcomes (fires, explosions, large economic losses, fatalities). In my experience, it is rare to see large impacts occur with less than six concurrent causal paths and incidents may contain more than twice that many (and these are just the paths we know about).

It is actually fortunate that significant incidents usually require a significant number of concurrent causal paths to exist and to align. However, the fact that these significant incidents do occasionally occur suggests that we have many defects (causal paths) in our organizations at any time.

2.4. We introduce new causes with solutions

The causes of current performance originate from many sources including our own solutions. For a number of years I tabulated that about 30% of the causes discovered in significant incidents were the direct result of solutions put in place to either solve the same or other problems. Specific investigations illustrate higher and lower percentages, but the frequency illustrates the risk of unintended consequences from well-intended action.

There is an inherent risk in taking well-intended action, especially if the action is broad and generalized (i.e. not precise). The less we understand the system into which we introduce new solutions, the greater risk we accept that the action will lead to unforeseen outcomes.

2.5. Actions can create an illusion of progress and miss cause

Problems present themselves to us through symptoms we observe. For example, when a pump fails, we know we have a pump problem, and we make repairs. But if the pump failure was not expected, then pump failure is likely just the symptom of underlying causes. The causes of the pump failure could reside in the way we lubricate the equipment, or in the operational conditions surrounding the pump, or in a mismatch between the design and actual operation, etc. In other words, the pump hardware may be just fine; the pump may just be the vehicle through which the problem manifests. The causes that need to be addressed may reside outside of the pump flanges and are not addressed through fixing the hardware.

Addressing the visible symptoms provides us the immediate benefit of restoring functionality but also potentially creates the illusion of longer-term performance improvement. Addressing only the symptoms leaves the underlying causes intact to create future problems.

2.6. We have a part

As humans, we intuitively accept that we have a part in our organization's performance outcomes when the outcomes are really good and exceed expectations. But it is harder for us to accept that we also have a part in performance when it fails to meet expectations or when it leads to significantly bad outcomes. It is more common for us to shift the burden of poor performance to others, especially to those closer in time and space to the event, by concluding that what they did was wrong or that they should have done something different. This "hindsight bias" is seductive. It allows us to view an incident (after it occurs) and to then judge others based upon this new understanding that neither they nor we had before the incident. The result is that others get judged as wrong, while we stay right, and no one learns from what happened or why it happened.

Individuals at many levels of an organization can participate in inadvertently leaving incident causes in place, unknowingly introducing new causal paths, or blocking learning from current performance. In combination, these "normal" human behaviors can create a significant performance challenge for any organization striving to create predictably reliable outcomes. Given that one or more of these underlying patterns exist, the causes of current performance can be very difficult for organizations to discover and address.

The following sections illustrate several key obstacles that prevent well-intended organizations from finding and addressing the causes of poor performance, thereby sustaining recurring problems. The obstacles are presented with summaries of actual investigative efforts to help highlight how problems in the discovery, learning, and action phases of this work can limit an organization's ability to correct performance problems.

3. Discovering cause – *what is in the way?*

One of the early steps in performance improvement is to discover the causes of disappointing performance outcomes that are currently experienced. Learning and taking corrective action is not possible if the causes are not first accurately identified.

Organizations choose whether or not to search for the causes of unwanted performance outcomes and how to conduct these investigations. The following are examples of how organizations limit their ability to find the causes of performance.

3.1. Our performance is good – no need to investigate

It is common to view current good performance outcomes as direct indicators of current performance capability. If the current outcomes are good, or at least acceptable, than we can easily conclude that the underlying performance must be good or acceptable as well. And we may further assume that it will stay that way. At some level, of course this conclusion is true that outcomes are produced by the underlying performance, but it is not true that good outcomes today means that the underlying performance is good today. There is no certainty that good performance outcomes will be sustained.

Many investigations clearly illustrate that the differences between experiencing good outcomes and experiencing undesired outcomes are minor. Often the distinction is merely a slight difference in the sequence of events or conditions.

Example. Several operating units at a chemical manufacturing facility had sustained good reliability statistics over an extended period. The managers and operators explained that the results came from effective operator teamwork, some increased training, and improved technical support. Although the operating facilities continued to experience some small problems, other operating units at the facility had experienced more problems. The managers and operators on these units felt good about their performance.

One morning, one of the operating units experienced several pump failures, which then proceeded to cascade into motors and into other equipment with lubricated bearings. Within a short period of time, several units were down and had incurred significant damage across several pieces of rotating equipment. An investigation revealed that a central lubrication console (which feeds lubrication to equipment across several units) had run out of oil. Although the console was in alarm due to low lube oil level, the alarm continued for several shifts until the console was empty.

The task of maintaining this lubrication distribution system had been accepted by one of the operators who had maintained this equipment diligently for several years, and as a result the reliability of the lubrication to the equipment across these operating had been sustained at a high level. About 2 weeks before these failures, this operator had retired and the understanding of how to maintain this equipment was lost with the individual. We discovered that the other operators did not have sufficient understanding of the lube oil console to conduct the maintenance.

The assumption that the good performance would continue and even that the alarm condition would be corrected (because it always had been corrected) created a "blind spot" for the operators and an overconfidence in their managers of the performance capacity.

If the outcomes are good, then assessing performance from just the outcomes benefits us personally since it makes our coworkers and us feel good and confident about our work and ourselves. As in this case, we can usually explain what we believe causes the good outcomes but it appears, in this case, we confused an efficient division of tasks with effective teamwork.

Confidence lessens our curiosity and need to understand how the current performance is actually caused. Without this curiosity and without negative outcomes to demonstrate that there are performance problems impending, we tend to stay confident and easily conclude that searching for causes is not needed.

3.2. Our problems are small – no need to investigate

We commonly view small problems and incidents as small and isolated issues that are obstacles to be overcome. The causes of these small problems are often assumed to reside where and when the outcomes occur and therefore can be managed locally. This assumption is seductive as it allows us to deal with problems, which may in reality be systemic in nature, in a simplified way, or to decide that the problems are not worth the effort due to their small size.

This mental model conflicts with the reality that problems, small and large, usually have several causes. The interaction and interdependence of these underlying causes is hard to predict but from investigations one can see that causes reside at multiple levels and interact with other causes across these levels. Viewing small problems as minor and isolated does not alter the fact that they can align with other small problems and become significant in impact.

Example. A manufacturing site experienced a significant release of an intermediate chemical used in making plastics. An exothermic reaction of the chemical within a storage tank over 3 days resulted in sufficient temperature rise for the reaction to accelerate and to eventually vaporize the liquid contents of the storage tank, causing the release. An off-specification product problem in unit A diverted the chemical in to this tank, and a 3-day start-up delay at unit B precipitated the 3 days of storage time.

A fractionation column in unit B, designed to be run in a vacuum, was being restarted following maintenance. The preparation for restart included a step to clear the column of air and typically this was accomplished by sweeping the vessel with nitrogen. But for environmental reasons the choice was made on this occasion to use steam instead, which introduced water into the column. The operators of the unit had experience with clearing water from this column and recognized from past experience that it could take several hours to a day to clear this column of water and get the column back into vacuum operation.

As predicted, the operators were unable to get a vacuum on the column in the first day and attributed that to the water in the column. But this condition continued for another one and one-half days. Then a relatively inexperienced operator (not experienced in clearing this column of water) checked the overhead condenser and discovered that the cooling water block valve to the overhead condenser was closed (this was supposed to be open) thereby preventing the condensation of the water in the column. The valve indicator read open when the valve was actually closed (the indicator had been installed backwards). Further investigation revealed that other valves at this site also had indicators installed backwards.

Several years earlier, when these valve indicator installation errors were made, they were considered a nuisance; certainly not a significant problem. The assumption was that the operators would either remember which valves had position indicators that read backwards, or the outcome would be obvious and they would recognize that the valve was in the wrong position and correct the position.

At that time the organization was unable to imagine how a backward reading indicator on one valve could interact with:

1. The need to introduce water into the column in the B unit using steam (they had always used nitrogen before).
2. The operators' experience that water removal from this column would take a long time and hence the backward indication would seem to be correct when the valve was closed, and
3. The need to get this column on line quickly because they were experiencing high tank levels of off-specification material on unit A.

The alignment of these three seemingly separate issues of relatively low significance, created an outcome of sizable significance.

When we discount small problems because they are small we also discount the interrelationships that exist just out of our sight and the effect they can have when they align with other parts of the system in which they reside. The isolated perspective of small problems underestimates the risk inherent within problems and seduces us into believing that we can successfully cope with the problem locally, or ignore the problem completely.

3.3. Our problems are caused by our failure to do the "right thing" – we need to investigate what we should do differently

Performance problems are effects caused by *actions* taken, usually combined with one or more existing *conditions*. Actions not taken or conditions that were not in place may be regretted; however, what was missing or not done does not create the performance effects that exist. For example, investigations often document that "operators *did not follow a procedure*". Of course that is what was not done. What was not done is not causal and does not reveal what was done. To understand the causes we would need to understand what was done and why that was done.

When faced with an outcome judged to be "bad," a natural response is to focus on what should have prevented it (i.e. a missing defense) or what one wishes had happened instead (i.e. a solution), rather than to focus on what actually occurred and why that occurred. But if our intention is to find the causes of our performance problems then we have to stay focused on what was there and what did happen; our reasoning has to stay causal in orientation.

Example. A combined chemical and refinery facility suddenly lost all of the steam supply shutting down all of the units in both facilities in a matter of minutes. The manufacturing site was down for weeks and required repairs to several process units.

Utility system problems were threatening the operation of both the chemical and refinery sites for two weeks prior to the event. For 5 days an exchanger leak in one of the process units was leaking a low pH (acidic) material into the boiler feed system causing an acidic mixture to circulate through the utility steam boilers. Several boilers had suffered leaks and the production units were reducing rates to conserve steam. The utilities department was frantically trying to find the source of the acidic material and stay ahead of the failures that low pH water was creating.

Ten days into the unsteady utility operation the leak was discovered and repaired, but by then several boilers were out of service and the utilities department was running with an abnormal combination of boilers. Then, two of the utility operators reduced steam flow from one of the steam headers and 20 seconds later the entire steam system shutdown triggering an unplanned shutdown of all operating units.

Within minutes, the actions of the two utility operators were deemed to be wrong and conclusions formed that they should have done something different. Faced with the unplanned shutdown that ensued right after their action, the operators also concluded that what they had done must have been wrong. And within hours, there were calls to have these individuals removed from their current roles.

Further investigation revealed that the shutdown was actually caused by an automated steam balance controller at a letdown station, distant from the header that the operators were adjusting. Although this was the first time that this controller was discovered to be set incorrectly, the investigation team found that the utilities department had experienced prior trips when they were in similar steam balance conditions in the last few years. The actions of the operators to restrict the flow on the steam header were correct and necessary to protect the boilers in that section of the plant. It was just their misfortune, and nearly their career peril, that the controller reacted in the same timeframe.

Had we reacted "normally" to the reasoning that the operators had done something wrong, or should have done something different, we would have reprimanded two people (not corrective to the causes) and/or created another set of procedures that would likely not be effective (also not corrective to the causes). And we never would have discovered why the steam system had been tripping (the setting on the controller) and subsequently why a leak could exist for many days before detection.

When we are faced with "bad" or unexplained outcomes, our normal defensive and solution reasoning orientations tend to drive us to look for what was missing, or what should have been done differently. We can easily jump to conclusions based solely on timing (two events close in time), when the conclusion seems to reduce the mystery or reduces the apparent threat of the event to us. Our natural ways of reasoning protect us from uncertainty (Newberg, 2006), and utilize what we have learned from our experience. But these reasoning orientations will not help us suspend what we think we know sufficiently to enable us to discover the causes that we do not yet know. When we rely upon our natural reasoning orientations to find hidden causes, we may only find others being wrong and miss the real causes.

4. Learning from the causes – *what's in the way?*

Following the discovery of the causes of undesired performance is the opportunity for individuals and groups to make meaning from the causes found. This is more than just "reporting-out" and understanding the findings. Rather, this is an overt step to suspend action (or reaction) long enough to enable us personally to gain new insight and draw new conclusions. Since investigations are generally focused on outcomes we did not expect, the causes also tend to be what we do not expect.

In this context, "learning" is the personal shift from what I have believed toward what the causes suggest is real (Newberg, 2006). As such this learning is more likely to be disruptive to what I think I know rather than consistent with what I know. This learning typically requires me to:

1. Let go of what I have believed to be true, and what I have trusted, and then
2. Grasp a different reality, which may be more accurate but less certain.

Personally letting go of what we have believed and trusted is much harder than grasping the new idea. A disruptive learning analogy is the process we experience when someone close to us passes away. We go to the funeral and attend the customary practices to lay one to rest. And as we go through this public process with our friends and family we grieve the loss as we begin to grasp the idea that the person who has always been there with us is no longer there. Letting go of the idea that the person is still there is the hardest part.

Organizations and individuals choose whether to learn from the causes of performance and how to conduct these learning sessions. The following are examples of how individuals and organizations may be limited in what they can learn.

4.1. Learning competes with knowing – no new insight is fair competition with what I already believe

It is common for investigations to surface that what we have believed for some time is either not accurate or is incomplete in some way. Depending upon the context this new insight can be personally threatening since it is just not acceptable against what we already "know."

Example. An individual at a manufacturing site died when he slipped while walking in a pipe rack and fell 30 feet to the ground. He and many other operators had walked in this and other pipe racks for the past 25 years. Before the incident, most operators felt that the practice was safe and consistent with government regulations at that time. Although individuals from other countries, where the practices were different, thought that the activity was dangerous, the individuals from this plant could always argue that for 25 years no one had ever been hurt. Further, the operators could describe how they would traverse the pipes and avoid the places where the gaps between the pipes were too large.

As part of the investigation, the team asked three operators to show them where the other operator had walked so that the investigators could see if this part of the pipe rack was different in some way. Much to the investigator's surprise, when they reached the section of the rack where the other operator had fallen, one of the three operators jumped over the railing and proceeded to show the investigators how he would walk through this same section of the rack.

Even though an operator on the same unit had died a few days earlier doing the same thing in the same pipe rack, this operator still "knew" (believed) that this action was safe. Several months later we were reminded that this operator was not unique. Although the site had forbidden any further walking in the pipe racks with the risk of termination for anyone who violated that rule, we found operators who stated that they would still go into the pipe racks if there were operational problems, which they thought they could resolve by using the valves in the racks. The historical belief that it was safe held despite the evidence.

This example illustrates how tenaciously we can hold onto our beliefs despite evidence to the contrary. Of course, one's own experience is more relevant than the experience of others, but this inherent tenacity to hold one's own beliefs can limit an organization's capacity to learn from the causes of poor performance.

4.2. The unacceptability that the system is designed to produce the outcomes we experience

Dealing with significant events like large economic losses, personal injury, a fatality or near misses that have similar potential is one of the most trying aspects of managing manufacturing complexes. The effects are immediate, significant, and personal. Discovering that the underlying system was perfectly designed to produce those outcomes can be personally uncomfortable.

Example. An individual was seriously injured when a pyrophoric material ignited inside a vessel that was open at the top and bottom. The individual was washing out residual catalyst from the vessel when sufficient oxygen contacted the pyrophoric material and caused the flash fire. This operator and other operators had completed this task many times in these reactors over the last 10 years without injury.

The investigation revealed that very small amounts hydrocarbon and very small amounts of catalyst were necessary to create a flash fire of the size experienced. Further, it was discovered that oxygen could enter the vessel undetected through drain lines in the bottom of the vessel or just through the use of the washing hose depending upon the sequence of steps conducted.

This task was reorganized several years earlier utilizing two operators to improve the teamwork with the production unit and to improve the safety of this work. Two operators working the job together, however, also increased the likelihood of varying the sequence of some of the steps, as they tended to work the tasks in parallel.

As the managers were learning about the details of the incident they continued to be frustrated with why the current system in place did not protect the individual from injury. The conversations centered on what should have or could have been done differently that could have prevented this incident. The managers were trying to find a way to continue to trust that the underlying system they managed was capable of preventing this injury. But they could not create a logical case. Then the insight surfaced that "the system did not protect the individual because the system could not protect the individual." The room went silent for several minutes. The conversation then shifted as the managers realized how the system they were managing, not only did not protect the individual, but had actually caused the incident.

Discovering that the "system" around us is causing unwanted outcomes leaves us with a feeling that we have lost direct control of our performance. Our understanding of the control we thought we had on performance outcomes is disrupted and temporarily replaced with uncertainty. As a result this stage of learning can be accompanied by depression and anxiety. Letting go of the old model precedes grasping a new and more realistic one. This letting go is the first step toward a new understanding of how our performance is created and the part we play in performance outcomes.

4.3. Accepting that human behavior is caused

One criticism we sometimes receive from causal investigations is that we "let people off the hook". In other words, when incidents are understood causally we often find that the causes of the outcomes do not solely reside with an individual close to the event or solely with an individual's actions. This insight can trigger a reaction that the investigations do not hold people accountable for the outcomes experienced. The reaction seems to surface from one or a combination of beliefs that we appear to hold:

- If something bad happened then there must be someone who must "account" for that, or
- We have rules and if in hindsight we find that these rules have not been followed then this must have caused the event and those individuals who did not follow the rules are at fault, or
- If we can not find an individual who is clearly accountable for the event, then we can not create an effective (and simple) solution to prevent repeating the incident.

Causal investigations generally discover that each individual's actions were rational and based upon the situation and how they understood the system around them. Discoveries that preclude the easy assignment of fault to those close to the events can create an emotional reaction that blocks our ability to understand the various causal relationships within the system in which the individuals work. Understanding how the behavior was caused helps us understand the underlying system.

Example. A large compressor train in a chemical facility was wrecked when liquid in the suction line of the compressor was suddenly sucked into the compressor. The equipment was severely damaged and the manufacturing facility was down for over one month.

Soon after the incident, the question was asked, "Did the operators follow the start-up procedures?" A quick review of the written procedural steps and the action taken clearly showed that they were different. Early conclusions assigned the accountability for the outcome to the operators: "The operators had caused a significant incident from not following procedures."

The investigation revealed that the written procedures were intended to guide the compressor start-up with nitrogen in the unit, consistent with restarting after a unit turnaround (complete unit shutdown for extended maintenance). But in this case, the compressor was only temporarily shut down to allow another minor problem in the operating unit to be addressed. As a result the unit remained filled with hydrocarbon and the objective was to bring the compressor back on line with hydrocarbon in the unit. The operators and their supervisors made adjustments to the equipment and the process to bring the compressor back on line and to restart the unit on hydrocarbon.

One of the steps necessary to restart the compressor was to drain the suction lines to the flare header to insure the suction lines were free of liquid. The operators pressured the suction lines and opened the drain lines as prescribed in the procedures but the liquid stayed in the suction lines. So, upon start-up, the liquid was sucked into the compressor. It was later discovered that the prescribed pressure in the suction line was insufficient to transport the liquid into the flare header.

In this incident the operators were required to diagnose the current situation, to make decisions based upon their experience, and to take actions to bring the compressor into full operation on hydrocarbon. Diagnosing situations to decide upon action is not the same work as following tasks documented in procedures. The operators were doing what their supervisors and managers expected them to do; in this case the procedures were largely irrelevant.

The early assignment of accountability to the operators for "not following procedures" is expedient and facilitates simple and direct action, which we can easily confuse with being corrective. If the assignment of fault stands, we have little chance of learning what really caused the outcome.

5. Taking action that is corrective – *what's in the way?*

For many years I assumed that if organizations discovered the causes of their performance problems then they would be able to create the action to subsequently improve their performance. After all, we seem quite capable of turning on action. But not just any action improves performance; the action must address the causes of the performance to shift the outcomes.

When problems recurred and performance continued to get worse we often discovered that:

- Action was not taken, for one of several reasons, or
- Action was taken, but the action did not address the causes.

One of the more frustrating outcomes for investigative teams is to invest in studying problems extensively and then to witness sponsors decide to not take the action recommended or decide to not to take any substantive action at all. At some level we know that the problems will not be resolved without action that is corrective, and yet inaction or ineffective action is common. What keeps us from taking the action necessary to shift performance?

5.1. Not convinced of cause or recommendation – corrective action not taken

In my experience, individuals do not take action unless they are convinced it is necessary. If the investigators have not been able to demonstrate logically how and why the outcomes we most want to change are caused, then the managers may conclude that the findings are just another group's opinions. There are many opinions of what causes the outcomes we want to avoid, but not nearly enough resources under the authority of the sponsors to action them all.

Example. A plugging problem in a fixed bed reactor resulted in off-specification product and eventually an early shut down to replace the catalyst. The reactor was taken out of service and inspected to gather additional data for the investigating team's analysis. The team discovered that nearly all of the catalyst had migrated from the top sections of the reactor (stages one and two) into the lower stages of the reactor causing a nearly solid plug reducing flow dramatically. The investigation revealed a complex sequence of events that led to loading packing that was nearly the same size at the flow openings in the stage screens (the screens are intended to hold the packing within each stage). With some variation on screen opening sizes, some of the packing and catalyst moved from the first stage to the second stage area causing a reduction in catalyst activity. Then operation's attempts to regain the catalyst activity (several violent back-flow attempts through the reactor) dislodged the stage screens in several stages providing more paths to move nearly all the catalyst into the bottom stage, plugging the reactor.

As agreed with the sponsors, the team was scheduled to report their findings to the management team in a short segment of the next manager's meeting. Based upon this timing agreement, the team chose to provide only a summary of their findings, and to present a bullet list of the causes and recommendations.

The meeting did not result in the managers accepting the team's recommendations. Covering only a summary of the findings and discussing the cause descriptions only in bullet form did not provide a sufficient or common understanding of the sequence of what happened in the reactor, the decisions made leading to the specific packing being charged, and why all that happened. Although the contractor involved in loading the catalyst installed what the engineers specified, the managers preferred to believe that the contractor had somehow loaded the catalyst "incorrectly" or had somehow damaged the first stage screens when loading catalyst. Although these theories did not align with the evidence (all screens had similar hole size variation, all the screens were dislodged, the packing loaded was what was specified), the manager's theories were simpler, were probably theories they had held for some time, and could be addressed easily.

The investigation report-out achieved the desired brevity, but the managers were inclined to act on what they had previously believed rather than on what was discovered. Managers have to be able to hear the causes of performance through the overall "noise" that reaches their level. When investigators cannot communicate their findings convincingly, organizations miss the opportunity to improve performance even when the organization is effective at discovering the causes.

5.2. Viewing solutions through historical beliefs – corrective action not apparent

Sometimes corrective actions to problems cannot be developed until we can re-conceptualize how that performance was created. Since we tend to hold on to what we believe, it is common for solutions to take the form of our historical beliefs despite the fact that the causes may illustrate that such action would not address this problem. If, for example, I believed that "not following procedures" was a repeating pattern that caused performance problems, then I may develop action to reinforce adherence to procedures even if procedures were irrelevant to the causes of the current problem. At times it appears that we will enact what we believe unless it can be conclusively proven that the action from my beliefs would be counter productive (which can rarely be proven).

If the investigation of a problem reveals that the causation of the problem is far from what I have believed or experienced, then I may not be able to conceptualize the action that would be corrective.

Example. A well-respected operating company purchased a manufacturing site from another company. The site had a poor safety record and the employees expected that the purchasing company would improve their performance. The new company provided several new managers, transferred in employees from other sites, and implemented several safety programs across the site. But, a year into the transition, the site's safety incidents continued at about the same rate, so the site's management decided to investigate the causes of these incidents.

Incidents: In one of the incidents, a line was being cut by torch when a small amount of the contents in the line ignited (a pop was heard). The worker had heard this before and continued to cut until a much larger ignition occurred. No one was injured. This line was considered to be isolated when in reality it was still connected to the sewer system, and gas in the sewer system ignited. The sewer was considered by many to be just water and hence inert.

In another incident, an individual severely injured their hand by reaching up into a chute (a drain pipe), to free what was believed to be a plugged line. Up in this chute was a piece of rotating equipment (a rotating valve) that was hard to detect because the motor and valve housing had been covered for dust protection and the area was too noisy to hear this equipment running. The operator understood that the unit production would be interrupted if the chute was plugged and the operator had cleared chutes before in similar units. The past, safe, experience in another similar unit was not consistent with the design and hence the safety of the same action in this operating unit. As an interim action, two steel rods were welded across the chute opening to preclude anything from entering the chute from the outside in the future. Within a month, however, this protection had been removed.

The investigation team concluded that several of the causes and the interviews pointed to an underlying belief that the plant was inherently safe (despite the safety statistics). This assumption was widely believed because:

(1) The site manufactured plastics, not fuels or chemicals. And it was widely understood that fuels and chemicals sites handled more volatile products, which are more likely to burn or explode, and
(2) A company with a better safety record (which they discussed regularly with the employees) now owned the site.

A common assumption had developed that the new company would not let its employees work in an unsafe environment. But of course, the statistics were illustrating a different reality.

The site struggled with what action would be corrective to such a widespread belief held by both existing and newly introduced employees at multiple levels. One recommendation to deal with this overconfidence included the idea to help the employees understand that the site was actually unsafe. This approach was disregarded, as it appeared to conflict with the current safety program that was believed to be effective. Other ideas were proposed, but the site leadership team struggled to agree on solutions that they thought would be corrective. As result, the site went back to their original safety program and continued to implement it consistent with their prior experience.

It is hard to tell if this approach dealt with the underlying causes, but the example highlights that when the causes discovered are distant from how we understand performance is created, we may find it difficult to create (to imagine or to accept) action that would be corrective. In these cases corrective action may not be implemented.

6. Addressing limitations

A career of experiences in trying to help organizations improve performance through learning from causes and taking corrective action has helped me recognize several of the more significant human limitations and organizational obstacles to shifting performance. Although these limitations and organizational obstacles can be formidable, they too are caused, can be analyzed for cause, and in some cases corrected. From my own insight I offer the following suggestions to help organizations break through the limitations described earlier in this paper.

6.1. Investigate problems when they are small and easier to resolve

Unexpected outcomes of any magnitude are the feedback informing us about what we do not yet know. They are "gifts." Once the unexpected occurs, the opportunity to discover and to learn emerges for us.

For significantly bad outcomes we do not need to choose to investigate since the outcomes typically set the conditions/need to find cause and to act. But the smaller unexpected outcomes represent where much performance improvement potential resides because: (1) the number of smaller unexpected outcomes is much larger than the number of big incidents, (2) the smaller outcomes still reveal causes, and (3) without the large impacts, the scheduling of resources to investigate is easier. These smaller problems are pre-cursors to the larger incidents and represent the opportunity to preclude the larger incidents by intercepting the causes early.

Suggestion: Help your organization understand the inherent leverage of investigating smaller events by illustrating that large undesired outcomes are comprised of a number of smaller problems. Use prior large-outcome investigations to visually demonstrate how the imbedded smaller problems could have been discovered earlier, and if addressed earlier, would have prevented the larger outcomes. With that benefit in mind, help your organization choose to schedule and conduct a number of investigations per year of unexpected outcomes regardless of impact magnitude (schedule and plan versus react to significantly bad outcomes).

Learn and take action following each investigation to eliminate the causes discovered. Take advantage of these smaller scheduled investigations to build investigator and sponsor skills.

6.2. Get started with what you have

If you have small or large unexpected outcomes and managers who want different outcomes, then you may have enough need and inherent capacity to get started. Building an organization that is both efficient and effective in causal analysis takes years, but the journey usually starts with a small first effort and builds in skill and magnitude from there. Waiting for better conditions (better sponsorship, better investigators) just delays the journey's start.

The best investigators and sponsors of investigative work that I have met did not surface from a newly purchased diagnostic tool or investigative training. Rather they demonstrated their inherent diagnostic reasoning, curiosity, and learning capacity with standard managerial approaches (i.e. asking why questions) and investigative approaches (i.e. cause and effect diagram). Nearly all organizations have individuals with this capacity.

> *Suggestion*: Find those in your organization who are best at diagnosing problems causally and engage them together in diagnosing the most pressing performance problems that are of central interest to managers. Engage the accountable managers in sponsoring these investigations to discover cause, to learn from the causes, and to develop corrective actions.

6.3. Make learning an overt step in performance improvement

Pressing problems tend to create a great need for near-term action and can seduce us into merely reacting to the causes found (i.e. reacting to the causes instead of learning from them). But without learning (i.e. shifting what we believe) the reactions will be based upon the same understanding that existed before the problem and therefore will likely be similar to action we have already taken.

Learning requires an engaged dialogue about what happened and why that happened to help shift understanding with those who have a stake in the outcomes. Manager sponsors have the authority to cause an organization to pause and to create the psychological safety (Edmondson, 1999) necessary for individuals to reveal their insights honestly together. Creating these insights can help shift beliefs about the problem and can then influence the subsequent action.

> *Suggestion*: Create a pause in the process of resolving problems (before taking action) to reflect with the investigative team and the interested managers about what happened and why. For example, request the sponsors schedule a separate meeting to report the findings and to learn from the causes before discussing recommendations. Discuss recommendations and decide on actions at a separate session.

6.4. Help managers build the conditions for finding-out

Confidence, knowing, and a short-term need for action reduce the necessity to find and learn from the causes of current performance and can promote unintended consequences from the action taken. But reducing confidence, lessening the need to know, and lengthening time frames of focus requires letting go of what we have trusted for years. Essentially we have to loosen our grip on what has "worked" for us before we can yet fully trust what might be accomplished by searching for cause. Loosening this grip and building trust is accomplished through personal experience of causal investigations and with those leading them, over time.

> *Suggestion*: Help the managers create their own doubt and demonstrate the benefit of "finding-out" by repeatedly conducting causal investigations and engaging the managers and groups of managers with the findings over time. Through causal investigations on problems that concern the managers most, help managers' experience that actual causes to pressing problems are often different from what they may have assumed. Build trust over time with the managers that the actual causes discovered are not personally threatening and establish through their experiences that addressing these causes creates value.

7. Conclusions

We can be limited in our capacity to improve performance by our personal ability to see the need to discover and to learn from the causes of our current performance. These personal limitations can be supported within our organizations, thus creating a system that is collectively inclined against speaking the truth and learning from what causes our current performance. The result is that actions taken in response to incidents will be based upon historical assumptions, not the causes of the current incidents, leaving the existing incident causes in place and potentially adding more that can worsen the outcomes. Searching outside our organizations for "new" investigative methods and techniques to resolve these inherent limitations is not likely to yield improvement.

Understanding the underlying causes of our current performance and our part in that performance provides us the insight necessary to resolve existing problems and the foresight necessary to prevent developing problems. To achieve the reliability that most organizations desire, we need both the insight and the foresight. Discovering and learning from the causes of performance outcomes (the gifts) that we have today provides us the opportunity for building the understanding we need to improve the performance for tomorrow.

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