CRITICAL MISTAKE ANALYSIS

HOW TO CREATE EFFECTIVE HANDS-ON LEARNING EXPERIENCES BY IDENTIFYING THE RIGHT CHALLENGES

Dr. Gregg Collins, Ph.D.

NIIT®
BUSINESS IMPACT. ACCELERATED.

UNCLE ABNER SAID THAT THE PERSON THAT HAD TOOK A BULL BY THE TAIL ONCE HAD LEARNT SIXTY OR SEVENTY TIMES AS MUCH AS A PERSON THAT HADN'T, AND SAID A PERSON THAT STARTED IN TO CARRY A CAT HOME BY THE TAIL WAS GETTING KNOWLEDGE THAT WAS ALWAYS GOING TO BE USEFUL TO HIM, AND WARN'T EVER GOING TO GROW DIM OR DOUBTFUL.

Mark Twain, Tom Sawyer Abroad

5 STEPS OF CRITICAL MISTAKE ANALYSIS

I HAVE LEARNED THROUGHOUT MY LIFE AS A COMPOSER CHIEFLY THROUGH MY MISTAKES AND PURSUITS OF FALSE ASSUMPTIONS, NOT BY EXPOSURE TO FOUNTS OF WISDOM AND KNOWLEDGE.

Igor Stravinsky

LEARNING FROM MISTAKES

Years ago, some colleagues and I were in Provo, Utah on a consulting engagement, and we decided get dinner in Salt Lake City, with a side-trip along the way to have a look at the Great Salt Lake. The trail to the lakeshore crossed a stream, and while my companions removed their shoes and socks to wade through it, I got the bright idea to jump across. Unfortunately, what looked like solid ground on the far bank was actually foul, reeking swamp muck, into which I promptly did a face-plant. There being no chance of going back to the hotel and still making our dinner reservation, I tossed my ruined clothes in a trash bin, gave myself a shower with bottled water and baby shampoo in the back corner of a nearby Target parking lot—inadvertently exposing several residents of a neighboring subdivision to a traumatizing image that I hope they've been able to forget—and headed to dinner at the best restaurant in Utah sporting the shiny new purple velour pullover, polyester khakis, athletic socks and gray pleather shoes that my friends had purchased for me at the Target store.

I don't know about you, but my brain contains thousands of memories like this one—indelible recordings of embarrassing mistakes and their consequences. Actually, I do sort of know about you, because we all have memories like this. Why do our brains hang onto episodes that our egos would love to forget? Because they help us predict when and how things might go wrong in the future, and thus—hopefully—avoid repeat failures.

In fact, the acquisition of such memories is the foundation of natural learning. We acquire skill by stockpiling lessons learned from many, many such experiences–not all embarrassing, necessarily, but all occasions on which things didn't go as we expected. As a result of this process we reliably improve at whatever we are doing more or less automatically over time. The only slight flaw in this amazing learning system is the cost of mistakes. Natural learning is more or less guaranteed to work, but it's in no way guaranteed to be painless.

Happily, that gives us instructional designers something to do. By creating simulated experiences in place of real ones, we can give learners the benefits of natural learning without the risks. To do that, we need to engineer learning interventions in which learners have the opportunity—so to speak—to make all of the enlightening mistakes they would eventually have made in real life. So a central question for learning designers is how to identify the challenges that learners should confront in training.

Critical Mistake Analysis (CMA) is a methodology designed to answer this question. The central idea of CMA is that the mistakes that merit the most attention in training are the mistakes that have the most impact in real life.

STEP 1
IDENTIFY MISTAKES

IDENTIFY MISTAKES

The first step in CMA is to make a list of the mistakes that practitioners of the target skill make in real life, by consulting existing documentation, interviewing experts and ordinary practitioners, and observing the skill being performed.

To illustrate how this works, I'll use a simple example: Imagine that you and I are planning to create a curriculum training airplane pilots. It just so happens that there is a terrific source of information about pilot errors available to us in the reports of the National Transportation Safety Board, which investigates and analyzes every single aircraft accident that happens in the US. So our CMA process might start by examining those accident reports. There are tens of thousands of such reports in the NTSB database, but if you start to read through them carefully you will quickly see that the great majority of accidents are caused by a relatively small set of oft-repeated mistakes.

To see what we are dealing with, let's consider some examples of very common mistakes:

- A pilot tries to eke a few extra miles out of a tank of fuel and runs dry in mid-air.
- A pilot tries to sneak through a gap in a line of thunderstorms, is trapped when the gap closes, and loses control in the extreme turbulence of the storm cloud.
- A pilot "buzzes" his girlfriend's house and crashes. (Interestingly, I found no instances of a female pilot crashing while buzzing her boyfriend's house.)
- A pilot trying to land on a low-visibility day continues to descend despite not seeing the runway, and either hits an obstacle or misses the runway entirely.
- An inexperienced pilot flying when there is little or no visibility loses control and crashes in a the following way: The airplane gets into a banked turn without the pilot realizing it (something that happens surprisingly easily when the horizon cannot be seen) and the plane starts losing altitude (because a turning plane has less lift than one flying straight). The pilot, seeing that altitude has been lost, pulls back on the yoke. This tightens the turn (it takes a little thought to visualize why—picture a plane banking towards the inside of a turn, and think about the plane being pulled "up" relative to its own orientation). The plane this loses altitude more rapidly, and the pilot pulls the yoke back harder in response, and so on–a vicious circle that ends with the airplane spiraling into the ground at high speed. (I've included this last one mostly to make clear that not all mistakes are simple enough to describe in one line—some are fairly complex patterns of cause and effect).

STEP 2
DETERMINE THE CRITICALITY OF EACH MISTAKE

DETERMINE THE CRITICALITY OF EACH MISTAKE

The next step in CMA is to determine the criticality of each mistake we have identified, so that we can decide which ones are most important to address in training. We define criticality as:

F * C * R

where:

- F is Frequency, or how often the mistake occurs.
- C is Cost, meaning the negative impact of making the mistake. . A cost can be anything from a waste of time to someone getting killed, but we generally assume that all costs can be represented on a single dimension, like the estimated dollar value of whatever went wrong.
- R is Remediability, meaning the percentage of all occurrences of the mistake that would be eliminated if we trained pilots on how to avoid it.

Criticality is an estimate of the value of addressing a given mistake. It represents the positive impact we can expect from training on this mistake, as a result of all the instances of that mistakes that would be eliminated as a result of by that training.

It should be obvious that, all things being equal, the most common mistakes are the most critical to address. But the severity of the mistake matters as well. For example, landing with the landing gear up is relatively common, but people seldom get hurt when this happens. Unexpectedly getting caught in the downdraft of a thunderstorm during a landing approach is relatively rare, but it is generally fatal to all on board. Because of this, it may be more important to address windshear than gear-up landing in the training, which is why we consider "cost" as well as frequency in calculating criticality. board. Because of this, it may be more important to address windshear than gear-up landing in the training, which is why we consider "cost" as well as frequency in calculating criticality.

Finally, some mistakes are easier to fix than others. For example, buzzing your girlfriend's house is a (strangely) common mistake, and a costly one, but the mistake does not happen because the pilot is ignorant about why this is dangerous. Instead, it seems to be the result of what people often call "bad judgment." Pilots who buzz houses do it in spite of–or even because of–their awareness of the inherent danger. We know that training does a much better job at fixing ignorance than fixing bad judgement, so addressing "house buzzing" in training might be not have a very big impact. To account for this, we consider a factor we call "remediability," which represents what percentage of the occurrences of a given mistake we would expect to be eliminated by training. In general, mistakes that are caused by lack of knowledge or skill have very high remediability, while mistakes that are caused by "poor judgment", emotion reactions, self-destructive impulses, lack of trust, or process issues and perverse incentives have low remediability. By looking at data and consulting with experts, we make our best estimates of criticality for all the mistakes we have identified.

STEP 3

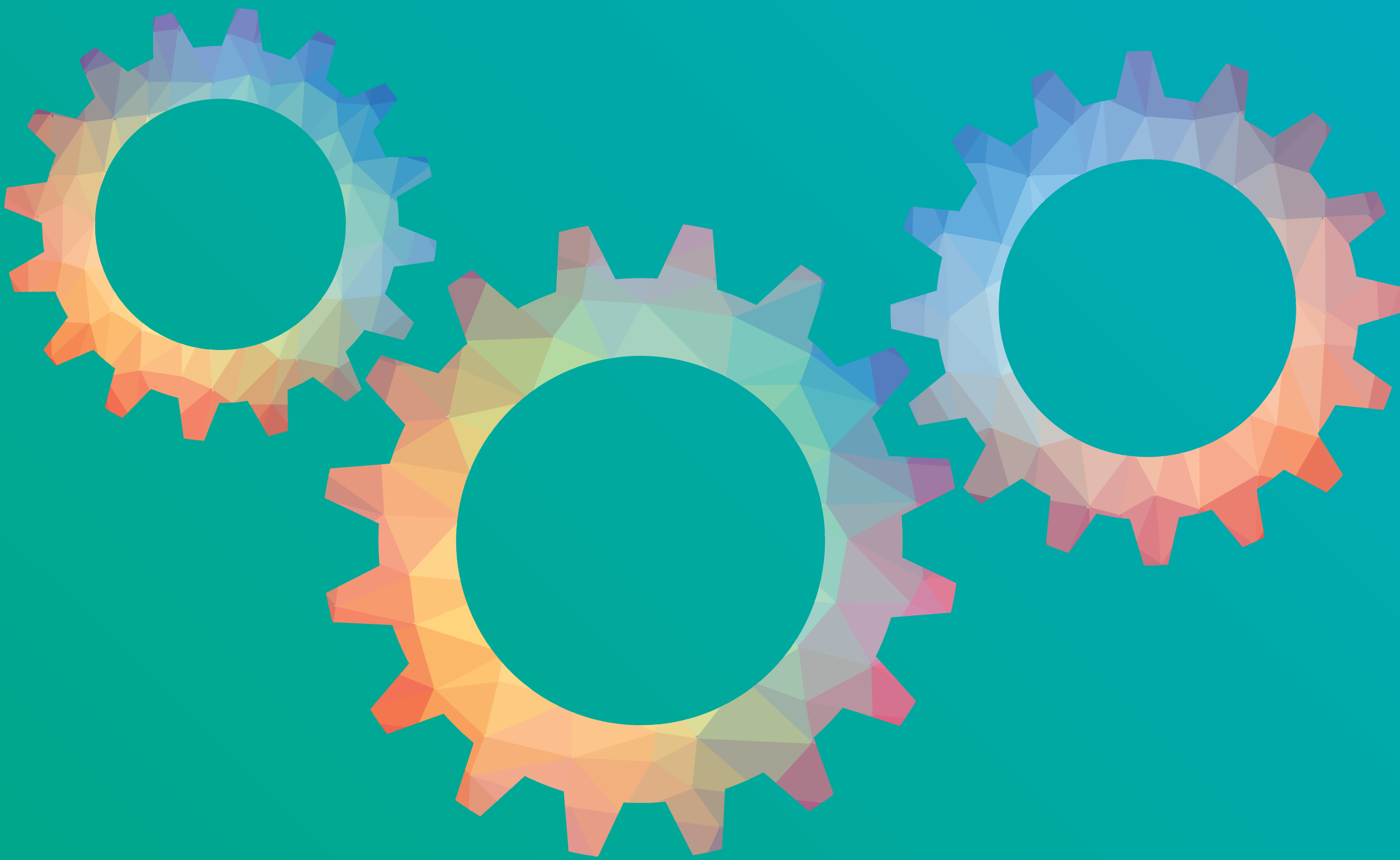
PERFORM A PARETO ANALYSIS

PERFORM A PARETO ANALYSIS

The next step in CMA is to perform what is called a "Pareto analysis," which means listing the mistakes in order of criticality, and looking for a cutoff point at which the value of addressing the next-most-critical mistake no longer justifies the effort and expense of doing so. In general a relative handful of mistakes will account for most of the potential impact of training, while there will be very many mistakes that have a negligible impact, either because they are incredibly rare, or because they do little harm when they occur. In other words, the data on criticality tend to follow a Pareto ("80/20") distribution. It is vital to identify the mistakes that really matter, so we can concentrate training around where it will have a meaningful payoff.

APPRECIATE YOUR MISTAKES FOR WHAT THEY ARE: PRECIOUS LIFE LESSONS THAT CAN ONLY BE LEARNED THE HARD WAY. UNLESS IT'S A FATAL MISTAKE, WHICH, AT LEAST, OTHERS CAN LEARN FROM.

Al Fraken



STEP 4
PERFORM A ROOT CAUSE ANALYSIS

PERFORM A ROOT CAUSE ANALYSIS

The next step is to do a root cause analysis of each mistake on our list. The analysis we do focuses in particular on four things:

- Situation: The situational factors that make the mistake likely
- Decision: The critical decision that leads to the mistake
- Misconception: The misconception that motivates the wrong choice
- Correct Path: The right choice and why it's better

For example, consider the first mistake identified above–trying to traverse a gap in a line of thunderstorms and getting trapped. Analyzing the many accident reports that follow this pattern, we might arrive at something like the following conclusions:

SITUATIONAL

The basic situational factors for this mistake include a line of thunderstorms, a destination that lies on the other side of that line, and an apparent gap. Slightly less obviously, in these kinds of accidents there is often a reason why the pilot was in a hurry to get to the destination—for example, a prearranged meeting with someone at the conclusion of the trip. Not infrequently, a previous airplane has made it through the storms, perhaps giving the pilot false confidence. And in many such accidents, there are other distractions, like fuel that is running low, or an instrument that is not working right, that serve to increase the pilots haste to get to the destination.

DECISION

The basic decision is simple: does the pilot try to fly through the storms, or not?

MISCONCEPTION

The primary misconception seems to be a failure to appreciate how quickly gaps can form and disappear in a line of storms. Secondarily, , pilots may overestimate the extent to which people—their passengers, their family, or their boss, say—might be upset at them if they don't get where they are going on time. They may also believe that, should the gap close, they will have a chance to turn around or, in the worst case, should they get trapped, they will be able to keep control of their small plane in the storm cell—both of which are unlikely.

CORRECT PATH

The right choice in such a case is to retreat and either make a broad circle around the weather or land and wait for it to pass.

STEP 5

DEFINE THE CHALLENGE.

DEFINE THE CHALLENGE

The next step is to define a challenge we can confront learners with in a training scenario that will expose them to the chance of making a given mistake. We have three main goals in designing a challenge:

- To ensure that learners who would make the target mistake in real life will make it in training.
- To make the mistake as memorable as possible (should it happen).
- To make sure learners will be reminded of the episode when and if they are at risk of making the same mistake in real life.

These first constraints suggests that we want a challenge that is fairly difficult, because we want to ensure that learners don't avoid the mistake in training only to make it later in real life; the second suggests that our challenge should entail "high stakes" and big consequences of failure, because that generates an emotional reaction in the learner, which in turn ensures memorability; and the third suggests that it is worth investing in making the challenge we create as close as possible to the way that a learner is likely to experience a similar challenge in real life. We know from extensive research in Cognitive Psychology that people are in general not very good at retrieving and using memories based on abstract, conceptual similarity to their situation. Because of this, it is worth investing in recreating the situations, sights, and sounds of real life.

A challenge in CMA consists of five components:

A "backstory," or description of the situation in which we want to place the user. In this instance, we might want to give the learner the story of a more or less typical airplane flight with the following characteristics

- The flight is "cross-country" (normally people who are flying locally for pleasure or practice don't encounter thunderstorms, and land quickly if they do.)
- The destination is on the other side of the line of storms.
- The destination is the pilot's home (because we know that people are more prone to feel pressured to get home than to get somewhere else in general).
  There is some time pressure—say, because the pilot has promised to attend a function with their kids.

An action sequence. This might look something like this:

- We need the pilot to be flying along at a normal speed and altitude
- We need the pilot to see the thunderstorms
- We want the pilot to be fairly close to them, to create some time pressure to react

CHALLENGE IN CMA

- We might want the fuel to read low, to increase the pressure
- We might want to have the pilot overhear an air traffic control conversation in which a previous plane makes it through the storms
- We need the pilot to see the visual of an apparent gap in the storms. This needs to be artfully engineered so that it is maximally tempting without making it so big that it can obviously be traversed safely.

A decision point. We want to force a choice between turning back and trying to make it through an apparent gap in the storm front. The easiest way to do this would be to have the pilot flying towards the gap, so that they have to take positive action to avoid the error. We also might want to do something to force the decision as quickly as possible—for example, have an air traffic controller inquire about the pilot's intentions.

A playout of consequences. If the learner tries to fly through the gap, we need to show what could happen. We want this to be as dramatic as possible, to make it emotionally impactful and memorable, without making it completely unrealistic. Ideally, we would recreate the zero-visibility and massive turbulence a small airplane would experience in a storm cloud with as much physical reality as possible (this is, by the way, the main reason why real-life pilot trainers invest millions in simulators that are on hydraulic control arms just to be able to shake up the pilot in the right sort of way).

Coaching and feedback. Once the mistake has occurred, and the consequences have played out, the learner is in most receptive state they will ever be in for receiving and assimilating coaching and feedback. Human beings naturally learn by analyzing the reasons for failures. The job of the coach is to enhance the learner's ability to analyze the failure that has occurred by pointing out and explaining aspects of the situation they may have overlooked.

Once we have sketched challenges in this way for all of our targeted mistakes, we have completed our critical mistake analysis.

APPLYING CRITICAL MISTAKE ANALYSIS IN REAL LIFE

While I described CMA in the context of a specific example domain, I hope it is clear that all of the steps in it are completely general—they can be applied to the teaching of any skill, from accounting to well-drilling—all that is required is that it is possible to collect and analyze the mistakes people typically make performing that skill. A curriculum built using a properly done CMA approach is not only effective but also extremely efficient, because it ensures that training time and effort is focused on the highest-impact interventions.
While most people agree that CMA makes sense in general, people are sometimes skeptical about it's applicability to their particular learning need. Usually this is for one of the following reasons, each of which I will address briefly:

"It takes too long." Obviously, aviation is an unrepresentative domain in that mistakes have been pre-compiled and pre-analyzed for you. In most domains, you have to go out and get your own list of mistakes. That can take some time to really do thoroughly, especially if it involves traveling to remote locations to observe. However, we have evolved a process that takes no longer than a typical training needs analysis, which relies primarily on interviewing experts and practitioners. If you feel your experts and practitioners have a pretty good handle on what happens in the field, this is usually good enough. If they don't, it's probably not a bad idea to invest some time in figuring out what is really going on out there before you try to create training.

"We don't know what mistakes people are going to make, because we are doing something new." This is a valid objection when it is literally the case that no one has had any experience performing the target skill (although in that case it is a little hard to see how training is going to be designed except through guesswork anyway). Often, however, there is a way to get data on mistakes—for example, for new application and process roll-outs, there is typically testing, which can be used to gather mistake data.

"We don't want to dictate right and wrong answers." I hear this from time to time, often with regard to leadership training, and I'm always a little confused–not because I can't imagine not having any answers, but because I can't see why I would want to create training if I didn't have any answers. , If you cannot recommend any course of action over any other, it seems to me you literally have nothing to say to learners in which case I would forget training and fall back on learning from real life–which is, always willing to let you know when you've made a mistake.

"Learn to do something the right way and you don't need to learn by trial and error." For very simple things like, say, using the copier, it's quite plausible that you can be told what to do and proceed to do it with no further ado. But there are two problems with this in general. One, it doesn't work well for more complex skills. And two, skill that it based solely on knowledge of the correct procedure is notoriously brittle once you get off the correct path, you have little to fall back on that might help you recover.

Overall, because CMA is fundamentally just a way to exploit natural learning, it almost always makes sense.

> **MISTAKES ARE THE PORTALS OF DISCOVERY.**
>
> James Joyce

LEARN MORE ABOUT CRITICAL MISTAKE ANALYSIS
AND NIIT'S AWARD-WINNING CUSTOM CONTENT
AND CURRICULUM DESIGN SOLUTIONS AT WWW.NIIT.COM.

WRITE TO US AT BUSINESSIMPACT@NIIT.COM
FOR QUESTIONS OR FEEDBACK.

NIIT®
BUSINESS IMPACT. ACCELERATED.