

Failure is an Option: Implementing Safe Failure as Learning Strategy

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ABSTRACT

Military, civilian, and contractor personnel who handle, store, and transport munitions, explosives, and hazardous materials are subject to a myriad of regulations from the U.S. government, the Department of Defense, and the Army. To keep their jobs, these workers must complete initial and refresher training to maintain certification as prescribed by Federal law. On-demand distance learning exists to meet the wide demand for this certification training. Following 21 certification courses in 2022, over 145,000 learners completed distance learning courses and were certified to handle, transport, package, secure, and store the world's most dangerous items. The designers and developers of these distance learning certification courses must meet the challenge to apply effective learning strategies that ensure learners can retain and apply the necessary information to keep warfighters and other personnel safe.

In this paper, we explore failure as an effective way to learn using branching scenarios that allow learners to fail safely and repeatedly in a variety of ways. Learners can make a mistake and then correct it. They can fail miserably, resulting in horrific and potentially real outcomes, such as imprisonment, death, or severe harm to others. They can make smart choices where nothing happens—no explosion, no medal or promotion, just going home at the end of their shift. The learners make decisions and “experience” the outcomes. They can always start over and replay the scenario, making different choices.

This paper discusses how safe-failure scenarios enhance learning and motivate student receptiveness to learning, presents key design elements of safe failing in branching scenarios, and analyzes several years of pass rate data and qualitative data from student surveys following certification courses with high student throughput.

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INTRODUCTION

As instructional designers creating distance-learning courses to certify and recertify military and civilian personnel who work with explosives and other hazardous materials, we are challenged with presenting a large number of government regulations in a meaningful, retainable way. We are tasked to create straightforward, narrative-style distance learning courses that teach specific safety rules and processes. These courses are distributed through the Army learning management system and are completed by over 145,000 learners each year. Some are taking a course to become certified for the first time; others are taking a course as a recertification refresher required by law.

Federal and Army regulations are in place to prevent rare but dangerous mishaps and their existence is easy to justify. Learners do not struggle with having a regulation, but they struggle with the details that must simply be memorized. For example, when transporting flammable liquids, you must not smoke within 25 feet of the vehicle. This regulation is in place to prevent an explosion or fire. If you violate this regulation, you can be fined, jailed, or otherwise penalized by whichever judge has jurisdiction. This same regulation must also be memorized. It makes sense that you must not smoke near a flammable liquid. However, it is not obvious that the non-smoking threshold is 25 feet. Why not 30 or 50 feet? The challenges are to reinforce appreciation of the regulation and present the details in a way learners can internalize them for use beyond the exam. One solution is to build branching scenarios that focus on failure.

Motivation of Failure

Fear of failure and actual failure are known motivators. Adults fear failure and will do almost anything to prevent it. Robert Evans Wilson Jr. said it nicely in his *Psychology Today* article entitled “The Most Powerful Motivator” when he wrote, “Fear is a primal instinct that served us as cave dwellers and still serves us today. It keeps us alive, because if we survive a bad experience, we never forget how to avoid it in the future” (Wilson, 2009). According to Guy Winch PhD, a licensed psychologist, speaker, and author, unless we respond to failures in psychologically adaptive ways, they will paralyze us, demotivate us, and limit our likelihood of success going forward. Failure can make our goals seem less attainable, distort our perception of our own abilities, cause us to choke, and increase our fear of failure (Winch, 2015). One psychologically adaptive way adults respond to failure is to learn at least enough to prevent similar failures in the future. If the failure is a small mistake such as forgetting someone’s name or misspelling a word, an adult might pay more attention in the future. If the failure is performance-based such as losing a game or failing a course, an adult might be motivated to spend considerable time researching, practicing, reflecting, or discussing strategy. This type of failure, referred to as “failing forward,” is common. Our culture encourages us to embrace such failures and learn from them. Seminars, books, and wall art all challenge us to “hang in there” because “failure is merely a stepping-stone to success.” We keep trying until we succeed. Then we can boast about the number of failures that got us there. We rally under the banner of famous failures like Thomas Edison, who once said, “I have not failed 10,000 times—I’ve successfully found 10,000 ways that will not work” (Hendry, 2013).

However, there are some failures that are so catastrophic they cannot be embraced. Deadly explosions, widespread toxic contaminations, and pandemics are examples. No one wants their name on a quotation that says, “I did not cause 10,000 deaths—I’ve successfully found 10,000 ways to not keep people alive.” When in fear of disastrous failure, adults are motivated individually and as a society to learn how to avoid it. Researchers Hyo Jung Kim and Hyeheyun Hong studied the degree to which two strong emotions (fear and anger) motivated information-finding and problem-solving behavior during the early stage of the COVID-19 pandemic. They found that South Korean adults were motivated by both fear and anger but were significantly more motivated by fear (Kim and Hong, 2022).

Fear of failure can also motivate others. When the ultimate failure occurs and many people are affected, the community is motivated to learn from it and may even enact laws to prevent similar failure in the future. This type of situation happened in 1928 when the Department of Defense Explosives Safety Board was established in response to the 1926 disaster at the Naval Ammunition Depot, Lake Denmark, New Jersey. Without an effective lightning protection system like the ones required today, buildings storing black powder were unprotected. When lightning from a storm struck the buildings, the resulting fire destroyed the depot and caused heavy damage to adjacent Picatinny Arsenal and the surrounding communities, killing 21 people (National Academy of Sciences, Engineering, and Medicine, 2017).

Because the explosive safety courses present regulations that, if not followed, could allow catastrophic failure, it makes sense to develop the fear of failure in those learners. Knowing that their actions, whether intentional or out of ignorance, could coincide with an unexpected event and cause significant harm should motivate learners to learn and follow the details of safety regulations.

Effectiveness of Branching Scenarios

Scenarios work well for simulations of failure. A branching scenario can put learners into a situation where they must know the details of applicable regulations and decide whether to follow them. Scenarios can then expose those decisions to an unexpected event that is created by or made significantly worse by bad decisions. For example, the course might present regulations about how to load toxins on a rail car. This list provides content learners may or may not value or remember. But when a scenario asks a learner to load virtual rail cars and then runs that train off the track in the middle of Ohio, the learner experiences success or failure. If loaded correctly, the containers are minimally damaged and the contaminant fairly well contained. If loaded incorrectly, the containers break open and toxins flow into the sewer and groundwater. The learner then continues the branching scenario, in which their work is investigated by the DOT and EPA, makes the national news, and may be responsible for contaminating the water supply of an entire town. The learner experiences the relief of following regulations or the pain of being at fault and learns the possible punishment for whoever loaded that rail car incorrectly. The scenario causes that list of regulations to become more significant and worth learning.

In their book with Peter C. Brown, *Make it Stick: The Science of Successful Learning*, cognitive scientists Mark A. McDaniel and Henry L. Roediger III compile and interpret decades of empirical research into how people learn. Their goal was to determine the most effective, proven ways for “acquiring knowledge and skills and having them readily available from memory so you can make sense of future problems and opportunities.” They identify two levels of learning: short term and durable. They describe short term learning as retaining new information only long enough for retrieval in the next task (such as passing an exam). They describe durable learning as mastering and assimilating new knowledge for retrieval in the next task and in other, even dissimilar, tasks in the future. One of their recommendations for achieving durable learning is to create scenarios—to ask yourself practical, scenario-based questions that cause you to apply new information to existing knowledge and experiences. They cite multiple studies that found learners who apply new information in realistic scenarios have significantly more long-term retention (durable learning) than learners who relied on traditional rereading or cramming methods of study (Brown, McDaniel, and Roediger, 2014). While prepared scenarios in a distance-learning course are not created by each learner, they can be designed to present common tasks to which most learners can relate, and thereby nudge learners to envision how the regulations apply to their own jobs.

Another conclusion of Brown, McDaniel, and Roediger was to encourage learners to be prepared for failure—to see it as a normal part of the learning process. The studies they reviewed found that when learners expect to fail, they spend more energy exploring the problem and less energy being anxious about their progress. Learners who have “a high fear of making errors when taking tests may actually do worse on the test because of their anxiety.” (Brown, McDaniel, and Roediger, 2014). When learners embrace failure as a normal part of the learning process, scenarios can encourage durable learning. A scenario could be placed at the beginning of a course before new information is provided and allow learners to become aware of what they do not know (productive failure). Scenarios could also require information from earlier topics along with the most recent. Scenarios could even require critical thinking to make a judgement call or prioritize requirements.

Finally, using branching scenarios supports the educational process of the Army TRADOC Command, under which these courses fall. TRADOC Pamphlet 350-70-7, *Army Educational Process*, says the educational process is to:

...provide the knowledge, skills, and tools necessary for Soldiers and Department of Army (DA) Civilians to succeed in positions of increasing responsibility throughout their careers. While education provides knowledge necessary for success, it also prepares the individual how to think to solve newly encountered problems and challenges. When educators combine training and education with experience, they assist to develop Soldiers, DA Civilians, and cohesive teams that are capable of winning in a complex world. (U.S. Department of the Army Training and Doctrine Command, 2018).

CHARACTERISTICS OF A SCENARIO

Well-crafted scenarios are effective ways to let learners apply and practice what they have learned and, therefore, reinforce new information and hone critical thinking skills. Scenarios are not limited to a specific media format or technology and can be used to reinforce learning of any type of regulatory content. Much has been published describing the characteristics of a well-built scenario. For this paper, we started with the design criteria found in *Evidence-Based Guidelines for Online Workforce Learning* by Ruth C Clark (Clark, 2013).

Learner Role

Effective scenarios make the learner the primary actor. The learner must apply the course content to decide what to do and how to do it. The learner directs the story and is, therefore, solely responsible for the outcome. This point of view pins both success and failure on the learner. The scenarios we developed varied based on the audience for each course and included roles of truck driver, explosive safety officer, quality control specialist, and site manager.

Realistic Tasks

Effective scenarios are not games that take place in alternate realities. They are situations or tasks similar to those the learners already experience or expect to experience on the job. To identify which tasks to use, we asked the SME to identify the ones learners struggle with most. Those tasks became decision points in the scenario. For example, we were told new drivers do not always check the shipping paperwork before leaving the supply point and often select the wrong placard for the transport vehicle. So we designed a scenario in which the learner is the driver and must decide whether to check the shipping papers, identify inconsistencies between the paperwork and the load, select a placard, and place the placard on the vehicle correctly.

Unexpected Event/Conflict

As in any good story, scenarios put learners into a conflict or have them face at least one unexpected event that must be addressed by applying the course content correctly. The learners must respond to practical experiences and challenges. To identify realistic events, we researched actual mishaps reported by the DOD and the press. We found interesting, believable story lines such as:

- A truck full of munitions waste is stolen while the drivers are inside a convenience store.
- A boulder strikes a transport vehicle, which explodes and leaves a crater in the highway.
- Incorrectly stored explosives suddenly explode and send a shockwave through a city.
- Explosive dust is found while tearing down an operations building.
- Potentially explosive munitions are dug up by developers building homes in a new neighborhood.

FAILURE-FOCUSED DESIGN ELEMENTS

We believe the effect of a branching scenario that focuses on failure is significant—that it couples the motivation provided by failure or the fear of failure with the retention advantage of applying new knowledge to a learner's experience. In a failure-focused scenario, the learner performs a task similar to what they will experience every day. However, on this scenario day, things go terribly wrong and bad decisions make things worse. To create such scenarios, we implemented the following design elements.

Believable Characters

Scenarios should use believable characters. When presenting scenarios to others, we observed that scenarios with more realistic characters caused more emotional reactions. For example, if the scenario called for a head-on car crash, killing the “other driver” was shrugged off, but killing “a single dad” while “his two small children were found safe in their car seats” evoked sadness (not full-on tears, but comments about how horrible it was). When supporting characters are needed, they should be realistic. Supervisors, lab technicians, patients, and even innocent bystanders have names, lives, problems, and weaknesses.

Multiple Decision Points

To let a learner experience failure in several different ways, a failure-focused branching scenario should break the task into steps and ask the learner to make a decision at each step. Figure 1 shows an example flowchart, in which decisions can change the course of the story. For example, to transport toxins, drivers must load the truck according to standards, check the paperwork, inspect the vehicle, attach placards, and follow all driving and parking rules. The related branching scenario should replicate some or all of the steps and make the learner decide between good choices and bad choices throughout. A driver may load the truck correctly but then miss an important part of the vehicle inspection. Having multiple decision points allows the scenario to reinforce several regulations and tell several different stories.

A Path to Redemption

As in real life, scenario mistakes should be able to be recognized, addressed, and corrected—until they cannot. As shown in Figure 1, each decision point should give the learner a chance to redeem themselves, make a good decision, and track towards the good ending. Likewise, a learner on a good path should be able to make one bad decision, and plummet towards the bad ending. Drivers can pull over and check tires, turn back, or slow down. They can also replace tires and then fail to secure the load. Regardless, every scenario eventually reaches a point of no return. The ending becomes inevitable, and the learner can only experience the consequences.

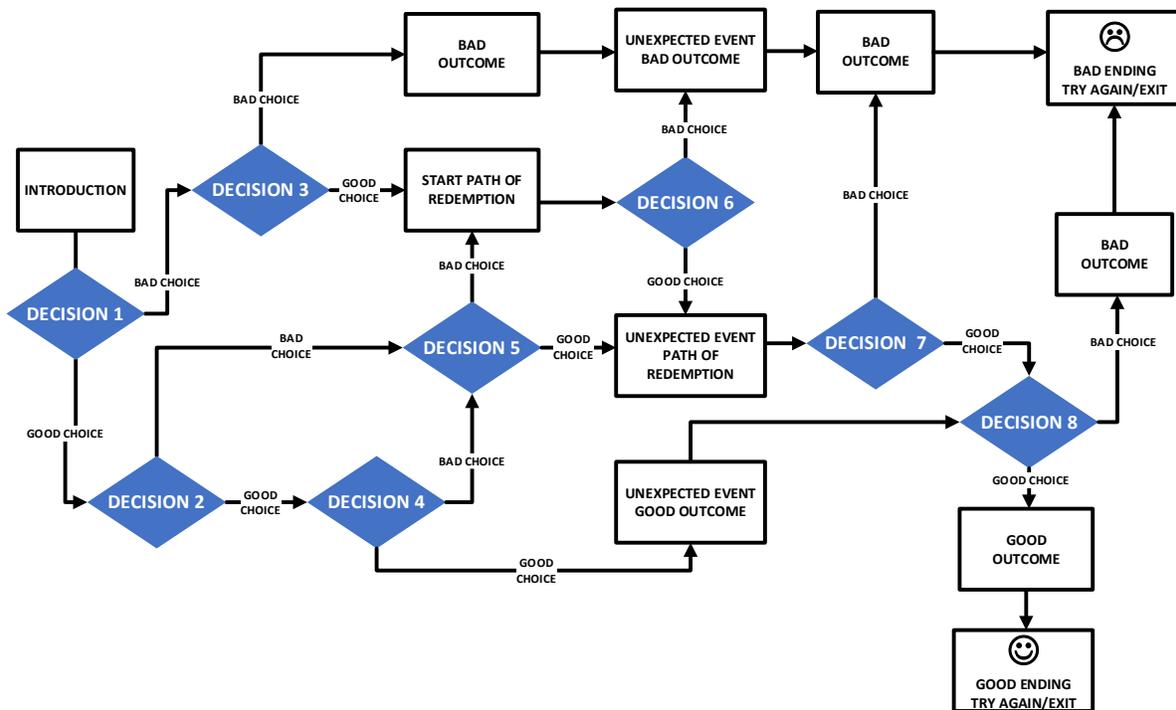


Figure 1. Branching Scenario with Multiple Decision Points and a Path to Redemption

Common Excuses

Every decision should have a rationale. When faced with an everyday decision for an everyday task, the smart choice should be clear, and the bad choice should come with a common excuse. Scenarios should not offer the learner a criminal solution. For example, the learner should not be asked whether to miscount inventory in order to steal product. Instead, the learner, faced with the unexpected event or conflict, should be distracted, tired, or in a hurry and is, therefore, tempted to bypass or gloss over a step. Ideal excuses include those shown in Figure 2, excuses the learner recognizes and may have already thought or used.

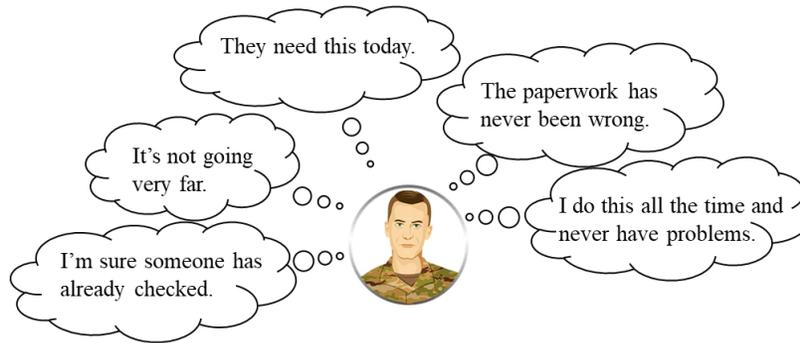


Figure 2. Common Excuses

Worst Case Events

When a learner makes a bad decision in a scenario, it should be one that either causes disaster or causes an impending disaster to be worse. For example, the learner might decide there is no need to check the tires because the motor pool guy said they were good. When that scenario introduces a reckless driver or an ice storm, an unchecked bad tire should cause the truck to crash head-on or roll over into a ravine while a truck with good tires should just fishtail.

Evaluative Feedback

During the story, the scenario, should intervene after each decision with a comment and a reference to the course content. If the learner makes a good choice, the intervention should be encouraging. If the learner makes a bad choice, the intervention should respond as a sympathetic friend and remind the learner that there is still a path to redemption. See Table 1 for examples of early feedback.

Table 1. Examples of Early Feedback

Good Choice Feedback	Bad Choice Feedback
“Nicely done!”	“Well, that wasn’t your best moment.”
“Good choice!”	“You may regret that.”
“Looks like you are back on the right track.”	”Not so fast.”
“So far so good.”	“Hmm, remember…”

Near the end of a scenario, the learner’s fate is sealed. They are out of decisions and must face the consequences. If the learner is irrevocably headed toward the bad ending, feedback should become blunt and place blame on the learner with accusatory comments. If the learner is headed toward the good ending, the scenario voice should complement the learner for making the right decisions and may reward them with credit for saving lives, a promotion, or becoming the “go to” expert. More often, the good ending feedback is neutral. The scenario does not celebrate that no one died. It just lets the learner go home at the end of the day. See Table 2 for examples of feedback given at the end of a branching scenario.

Table 2. Examples of Ending Feedback

Bad Ending Feedback	Good Ending Feedback (With Reward)	Good Ending Feedback (Neutral)
“Because of your poor decisions, a family will never be the same. After investigation, you were dismissed from your job, fined \$\$, and sentenced to 18 months in prison.”	“Because you followed the regulations, the crash caused minimal damage. You even received an accommodation for rescuing the other driver.”	“You did your job. Ensuring the vehicle is serviceable took time, but it paid off when you were able to avoid collision. Everyone made it home safely.”
“The highway was cratered, and several properties damaged. An investigation proved it was your fault. The judge fined you \$\$ and a civil lawsuit is pending.”	“Your supervisor was impressed with your quick thinking and knowledge of regulations. You prevented a disaster. Good job.”	“You did the right thing. The blizzard worsened and people were stuck everywhere. Getting the munitions back to the ASP kept them safe and secure.”
“It is your fault. You should have followed the regulations. Now your family is attending your funeral instead of your birthday party. Your children will grow up without you.”	“Great job! You delivered the load safely and the exercise can proceed on schedule. Your accident-free record stands.”	“Good job. After returning the truck, you clock out and make it home in time to watch the game.”

SAFE DESIGN CHARACTERISTICS

We consider scenarios to be safe ways to fail. The explosions are online and the harm fictional. However, we want to encourage the learner to loop through the scenario several times and explore the different failure points and their consequences. During development, we observed that, although adults fear failure in the real world, they like to experience it in a scenario. As we showed prototypes and actual builds to our peers and customers, we noticed that those who did not know the content very well chose the good decisions first. However, when we showed the scenarios to knowledgeable people and asked them to make a scenario decision, every single knowledgeable person wanted to make the bad decisions first. They wanted to see what would happen. Because the scenario is repeatable, a learner may start with either success or failure. We applied specific functional design characteristics to allow this freedom.

Not Tracked or Graded

Because each scenario has multiple paths, and we want learners to experience them freely, scenarios should not be tracked or graded. The learner should not be told the number of times they loop through a scenario. The learner does not even need to know how many unique loops are possible. Scenarios should be presented as exercises, not questions. They should not affect the learner’s score or cause them to pass or fail the course. There should also be no incentive for getting it right the first time. The introduction should make this clear and should explicitly invite learners to rerun the scenario as often as they want in order to explore the consequences of good and bad choices.

Easy to Navigate

Decisions should be final. Learners should not be able to go back and change their minds. If they want to see what happens when they make a different decision, they should run the scenario again. It should also be easy to start over. Our design has two buttons, TRY AGAIN and EXIT, at the end of each scenario. Learners do not have to close a window or tab or scroll anywhere. They are one mouse click away from looping back through the scenario or moving on to the next topic.

Employs Trust

The scenarios should be linked into the course in a way that forces a learner to go through each scenario one time. After that, the learner should be able to choose whether to loop back through and explore the consequences of other choices. We trust that each learner is an adult who is responsible for learning the regulations and passing the exam.

Many times their job or future job depends on it. A learner may be seeing the course content for the first time or may be recertifying and, therefore, retaking the course after several years of applying the regulations in their workplace. The novice is free to loop, and the expert is free to exit. If someone wants to skim the course and page through the scenario without thought, they are free to do so. As Otto Friedrich Bollnow observed, learners are always free to fail. He describes it as “the active rebellion of the other’s will against that of the educator.” (Bollnow, 1959) Some adult learners embrace learning; some tolerate it; and some refuse it.

MEASURABLE VALUE

The data provided for fielded courses is limited and includes high level data for the number of times a course was passed, learner survey responses, and learner comments. When we looked at the data, we wanted to see whether adding scenarios resulted in more exam passes, whether learners thought courses with scenarios were more effective, and what learners said about the courses. We needed to determine whether scenarios were worth creating.

Pass Count

An analysis of the pass count was inconclusive. To determine whether adding branching scenarios increased the number of learners who passed the courses, we looked at the first three courses to which we added scenarios. Shown in Figure 3, the pass count for the three courses (Courses A, B, and C) trend upwards after scenarios were added. However, when we looked at similar courses without scenarios (Courses D, E, and F), we saw a similar upward trend (Figure 4). Because exams were taken just after the course content, the data was actually measuring a mixture of retrieval from short-term memory and durable learning. Also, the learners are known to be a mixture of people who are new to the subject and people who are taking the course as a required refresher.

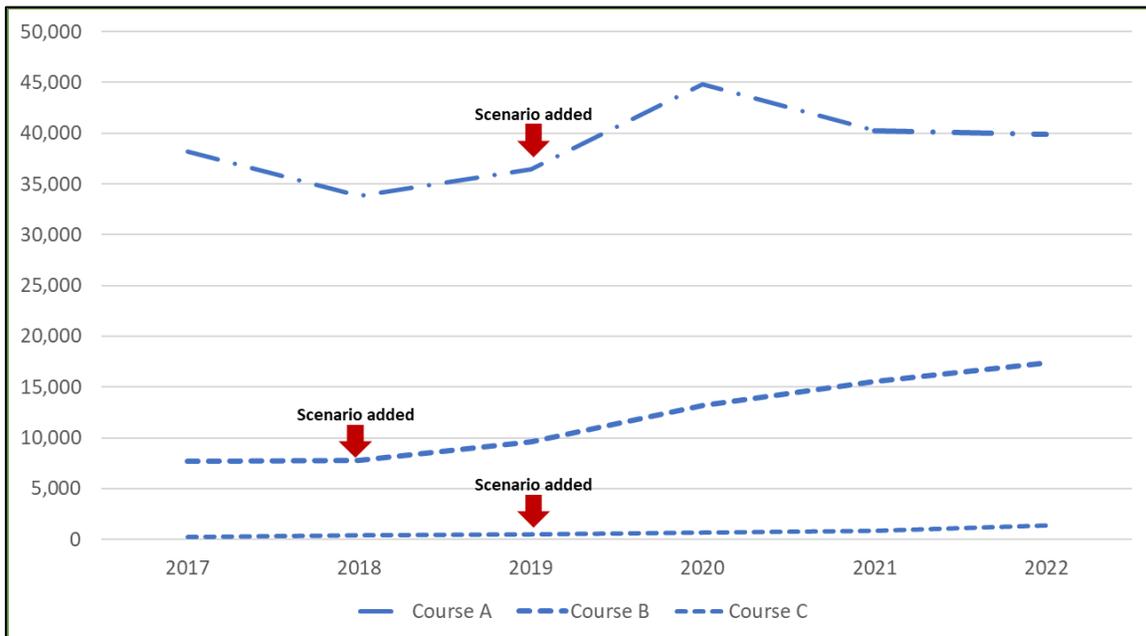


Figure 3. Pass Count Trend Before and After Adding Scenarios

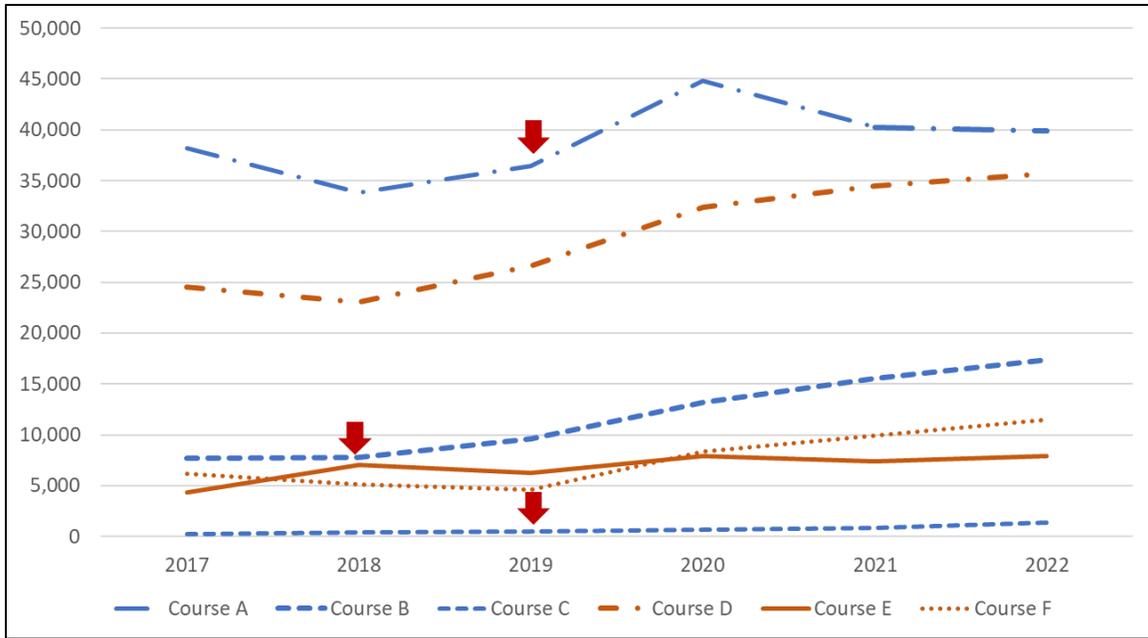


Figure 4. Pass Count Trend for Courses With and Without Scenarios

Survey Responses

After learners take a course, we ask them to complete a short survey. This survey measures their opinions of the course by asking them whether they agree or disagree with ten specific statements. They are then invited to submit any comments. As shown in Figure 5, the survey responses were encouraging. The percentage of learners who agreed the course is effective increased by at least 3% for each of the three courses after adding branching scenarios.

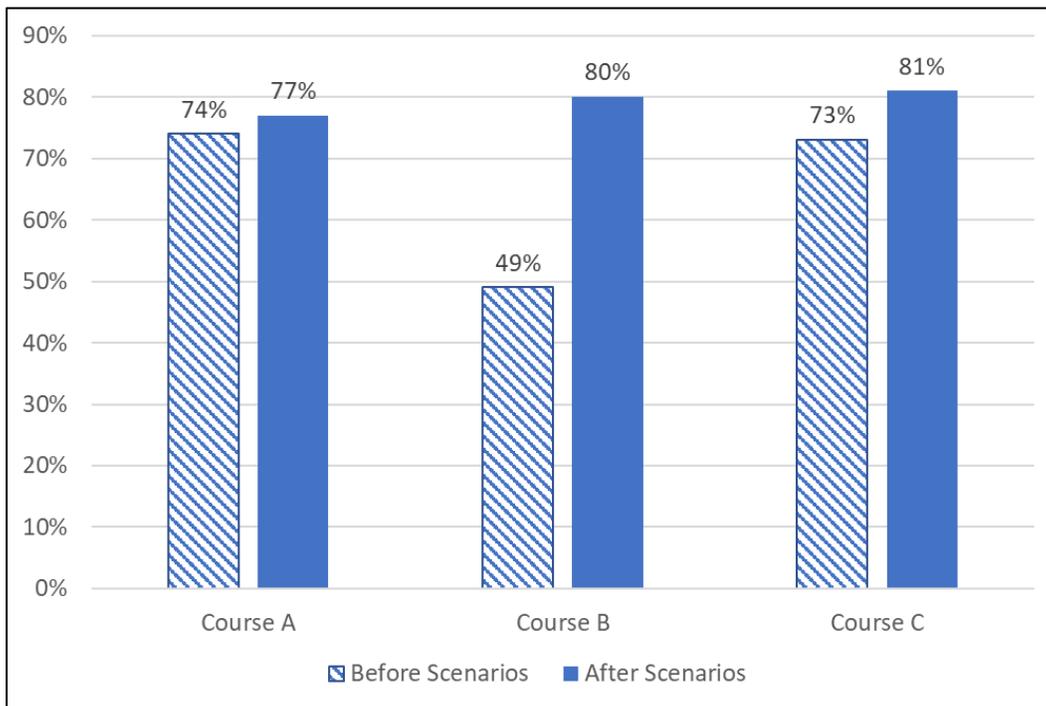


Figure 5. Percentage of Learners Who Agree the Course is Effective

Learner Comments

The number of learner comments in praise of the new scenarios was also encouraging. The free-form comment space following the survey questions allows learners to give us any type of feedback on a course. These comments give us an idea of how well learners liked the course. Normally, these comments are about technology issues or requests to be allowed more attempts at the exam. Praise is usually generic and rarely mentions a specific design element such as a branching scenario. Yet there were many positive comments that mentioned branching scenarios. The comments praising scenarios included claims that they helped the learner understand and remember the course content and even that they were fun. Figure 6 shows some of the comments we received.

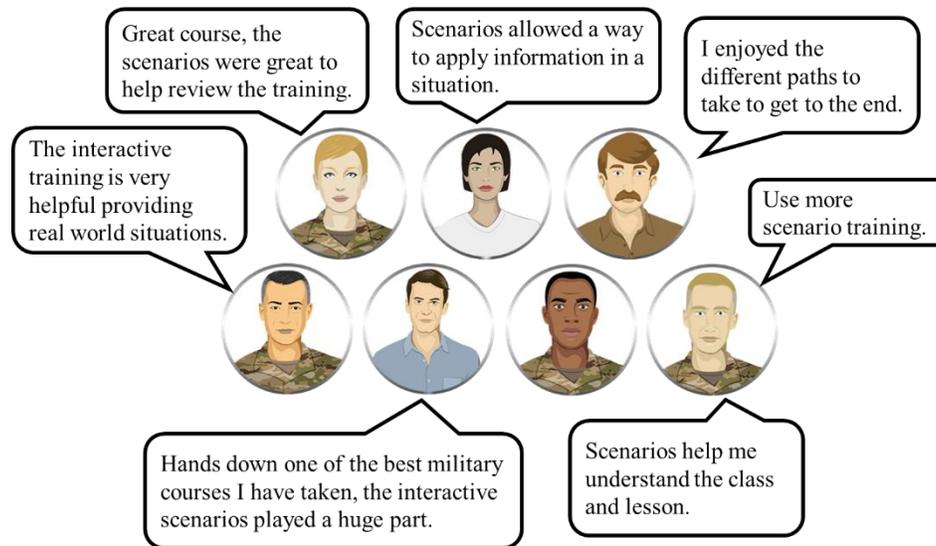


Figure 6. Learner Feedback

SUMMARY

As designers of courses that teach safety regulations, we can create safe branching scenarios that remove the fear of not passing an exercise and still allow learners to experience the possible catastrophic failures and the personal penalties of being at fault. Cognitive science has shown scenarios to be an effective strategy for long-term, durable learning, and our post-implementation survey responses and comments indicate they are received well by learners and worth developing for other safety courses.

Our experience is limited to scenarios for safety courses. Formal studies of failure-focused, safe scenarios and their effectiveness might include determining other types of content that would benefit from scenarios, the most effective size or number of paths, effects of different types of feedback, or whether the safe failure scenarios increase long-term retention as well as those scenarios that are tracked and graded.

By providing experience through safe, failure-focused branching scenarios, those of us who design distance learning safety courses have a strategy that supports TRADOC's educational process and improves durable learning. Learners who pay attention to the scenarios and experience the different paths can learn the details of the regulations and see how easily one seemingly harmless bad choice can snowball into the disaster we hope will never happen. For the over 145,000 learners who take these distance learning safety courses each year, these are valuable lessons that help keep warfighters and other personnel safe.

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