FEEDBACK IN LEARNING SIMULATIONS

PERFORMANCE-BASED FEEDBACK FOR EFFECTIVE LEARNING

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Abstract

Traditional e-learning systems offer learners factual and conceptual feedback, providing a rationale for the right answers and hints for the wrong ones. In contrast, simulation-based learning interventions that offer decision-making in a low-risk, high-fidelity context encourage learners to derive understanding through performance-specific feedback. This paper looks at how a multiplicity of approaches to feedback—experiential, qualitative, quantitative—allow for reflection and understanding. It also highlights how these can address the contextual needs arising from myriad learning styles, profiles, and environments with greater efficacy.

The Learning Simulation Experience

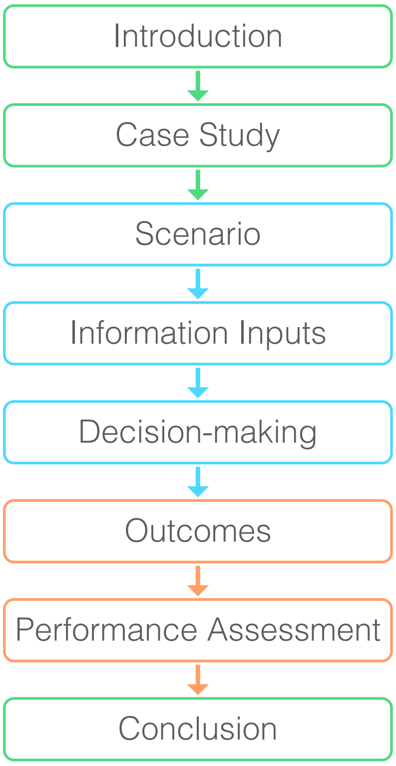
What is a simulation-based learning experience like?

Learners build a conceptual model of a particular subject based on diverse sources of information, such as formal education, books, peers, e-learning interventions, and personal experience and observation.

However, at the time of implementation of this learning to a real-world context, learners struggle with a dip in their performance and confidence, known as the "implementation dip" or "J curve effect". (*Fullan, 2007*). This indicates a gap in the transformation of learning when abstracting principles derived from various knowledge sources into a fresh context. (*Mestre, 2002*)

A learning simulation is a constructivist attempt to create a virtual environment and plunge the learner into an immersive experience, a "safe" place that replicates multiple realistic contexts. It creates the conditions for decision-making that realistically and suitably address the required performance and/or learning outcomes.

It differs somewhat from the traditional simulation in the wider sense of the term, in that it is focused towards learning objectives instead of trying to replicate the concerned system in high fidelity. This does not mean that learning simulations are all low-fidelity; indeed, the learning simulation can span the range of fidelity, but it does not simulate what it does not plan to "teach."



The process starts with an introduction to the simulation, the areas it covers, and the learning objectives. The "case study" follows, setting the stage for the learner in the simulation's virtual world: what is the challenge the learner needs to address? This is generally covered at a topical level.

The scenario element then dives deeper into where the case study left off, focusing on the actual problem at hand. There can be multiple scenarios, arranged serially or "in parallel."

Within the scenario, the learner has access to the informational inputs (qualitative and quantitative) necessary to help the learner make a well-informed decision. Not all inputs are necessarily relevant, or always accurate, particularly for high-complexity simulations; this forces the learner to separate the signal from the noise.

Equipped with information inputs, the learner makes his or her decisions. Decisions come in a wide variety of formats: multiple-choice questions, "checkbox" decisions, numeric fields, spinners, levers etc. Decisions can also be independent of each other, or interlinked, or can branch out based on previous decisions. While making decisions, the learner needs to evaluate potential impacts—or outcomes—of their actions.

The simulation gives the learner agency (*Murray, 1998*); in other words, the freedom and flexibility to explore various possibilities, assess their potential impact, and "contrast their thinking with that of others." (*Mestre, 2002*)

Once the decisions are made, the simulation presents the outcomes within its virtual world; a business simulation shows the impacts on profits, for example. This section performs the vital action of linking decision to result.

The simulation then provides performance-based feedback and encourages the learner to replay it, shooting for better performance. Each trip around the play cycle strengthens the mental model, as learners feed what works and ferret out what does not.

Thus, the learner builds on prior knowledge, exercises critical thinking skills in a risk-free environment, and transfers this knowledge with relatively less friction to the real world.

Feedback in Simulations

How does feedback in simulation-based learning work to reinforce learning?

Traditional e-learning tutorials' theme of immediately reinforcing concepts and understanding lead to quick, bite-sized, diagnostic feedback. Also called "extrinsic" feedback, it shines a light on what the learner did right and wrong. This category of feedback is what Michael Allen and Richard Sites refer to as "judgment." (*Allen & Sites, 2012*)

Simulations take a different approach to amplify the learning derived from experiencing this high-fidelity reality. This approach, which focuses on "consequences," does the following:

1. Displays the outcomes or consequences of learner decisions by showing them instead of telling them (unlike traditional diagnostic feedback that tells the learner what they got incorrect). Akin to real-world feedback, it gives the learner feedback in a relatable form with implications both immediate and remote.

2. Delays the feedback so learners have time to reflect on their decisions and the outcomes of each, resulting in significant cognitive processing[1].

3. Is mapped to specific decision outcomes and thus, to learning outcomes. It promotes a holistic view of the concepts and learners' performances.

[1] "At the present time, the research advocating the use of delayed feedback seems more credible overall than the research advocating for the use of immediate feedback." (Thalheimer, 2008)

Feedback Types

What feedback mechanisms drive simulations?

Feedback to the learner can take multiple forms and weave in different objectives. These can exist independently or in conjunction.

» **In-simulation feedback:**

Feedback is built into the simulation narrative in what Allen and Sites refer to as "consequences." (*Allen & Sites, 2012*). These can be viewed as outcomes within the story and are an important mechanism in sandbox learning, which offers purely outcome-based feedback with no didactic layer.

To further the idea of show and not tell, the simulation itself will present the learner with the consequences of the decisions they have taken so far (or in some cases, contemplating taking), either as quantitative outputs like impact on sales and budgets or qualitative outputs like reactions from virtual stakeholders and feedback from virtual guides or mentors[2].

This may also cascade into consequent decisions. For example, in cases where the learner is not doing well, the learner does not passively view the fallout of their decisions. They must deal with it too, further driving home the enormity of the mistakes made.

In essence, learners are encouraged to create or infer patterns that underpin a particular subject and then verify their rules or understanding by analyzing and interpreting the consequences.

This will further encourage them to attempt the simulation with a different perspective and reinforce and consolidate their learning.

2 Mentors are virtual in-simulation characters that help the learner with hints, explain outcomes, and provide feedback based on decisions made.

» **Terminal feedback:**

This mechanism conveys feedback at the end of a particular series of decisions, a logical pause in the narrative or at the very end of the entire simulation module. We can break up this feedback into subtypes:

Qualitative:
Textual, system-generated feedback is the principal form of feedback employed in the simulations.

Feedback can be:

- Very precise, highlighting and clarifying the right and the wrong in a very precise manner. This is the more didactic type of feedback and is used more in cases when there are very clear right and wrong decisions.

- Used with a degree of suggestion to steer the learner towards more optimal decisions, posing questions to the learner to stimulate critical thinking and illuminate ideas. This is "Socratic" feedback and used either when the decisions have more shades of gray, or when the learner is expected to piece together the answers themselves.

Qualitative feedback is generated using a clear structure, providing the learner with an overall score and an overview of their performance, before deep-diving into a more granular view of performance.

We can subdivide performance-based feedback further based on the data underpinning it:

» **Input-based/Decision-based feedback**
The learner's progress through the simulation leaves behind a trail of decisions taken. The simulation captures each individual decision point and the action taken by the learner. During the development or scripting stage, feedback will be composed for each such decision point. The final feedback will contain all these blocks of feedback, strung together in a logical, coherent manner.

This form of feedback tends to be more precise and didactic, outlining exactly what went right—or wrong—in the course of play.

» **Output / Score-based feedback**
This form of feedback relies on the use of scoring parameters: aspects of performance that the learner is rated on for every choice

made. These parameters may be drawn from real-life Key Performance Indicators (KPIs), behavioral skills expected to be nurtured, or other performance attributes that can be tracked and measured. Each decision in a simulation is assigned a score, for one or more of the learning parameters. As the learner plays, the simulation tracks and accrues a score for each parameter. At the end of the cycle or round, the learner's cumulative scores (overall and parameter-specific) are calculated. The scripting process for this type of feedback, involves the creation of several "strands" of feedback, one for each parameter, based on predefined score ranges. Based on which range the score falls in, the relevant feedback "strands" are concatenated and presented at run-time.

This form of feedback tends to be more high-level and less granular than input-based feedback, although with the use of significant granularity in KPIs and correct mapping of KPIs to decisions, it is possible to approximate the granularity of input-based feedback to an extent.

» **Quantitative:** For data-heavy simulations, particularly with more open-ended ones where the sheer number of permutations of outcomes can be overwhelming, qualitative feedback like the above can be difficult to script. This is generally the case with business and enterprise process simulations. While it is still possible to script a degree of qualitative interpretation at a birds' eye-view level, deep analysis and insights are far more difficult to script, as they involve the scripting of a staggering number of conditions.

  Hence, simulations of this sort generally rely on providing quantitative data as outcomes, along with some form of in-simulation KPIs that roll the outcomes up into targets.

Both these approaches can also be adopted in Instructor-Led Training or workshop-based simulations. However, the instructor debrief serves as the primary feedback mechanism in these sessions. A quantitative approach benefits far more from an instructor debrief than does a qualitative one, as the qualitative approach can stand on its own.

Feedback Choice Considerations

What constraints dictate our choice of feedback?

In order to identify the feedback mechanism that will drive optimal learning, it is important to ascertain certain features of the final deployment and mode of learning.

» In an instructor-led, classroom-based simulation exercise, pared-down feedback with broad performance trends and overall scores offers more discussion points and encourages debate.

» A multi-player simulation, where learners collaborate and compete, can benefit from feedback through mechanisms such as leaderboards and reports. These will add extra dimensions of competition and achievement.

» There may be external constraints to how long and where learners can access the simulation—say, a self-paced simulation in a lab with time slots in which learners must complete a set number of exercises. Specific, precise feedback “that gives the answers away” will accommodate the fact that learners may not have the flexibility to replay the simulation.

» Certain learning environments offer fewer constraints on time and accessibility (perhaps mobile-based simulations) and the only thing standing in the way is learner motivation. In such cases, using rhetorical devices and keeping the feedback open-ended aids replayability.

There are a few other design challenges writers and visualizers must be cognizant of while presenting feedback. Controlling the amount of content on screen and ensuring that hierarchies of information are addressed are critical. A balance must be struck to ensure the screen design is not confusing and overwhelming, while accommodating all relevant content.

Benefits

What are the advantages of these mechanisms?

Feedback mechanisms in simulations hold these benelts for learners:

- **Specilcity:**
  Simulation feedback is highly context-specific; tailored to give learners insight into how they have handled a specific situation. Also, if it hints at the right direction rather than giving the right answers, it capitalizes on the learner's intrinsic motivation to succeed, coaxing them to replay the simulation for better outcomes, thereby increasing the "stickiness" of the learning.

- **Self-Reıection:**
  Since the feedback mechanisms are generally decision-specific and delayed in timing, they give the learner space to pause and contemplate each step they have taken. Allowing the learner to spot trends and identify where they have gone wrong is a tenet of regulated self-learning, allowing them to revise their understanding. (*Bransford, Brown, & Coking 2004*). This connecting of the dots and calibrating the mental model leads to deeper and broader retention.

- **Performance Insights:**
  The detailed, parameter-specific feedback provides scope for a Strength-Weakness-Opportunities-Threat (SWOT) analysis, helping the learner and trainers identify specific areas of improvement. This creates the opportunity for more directed and focused downstream training interventions. The system can share the detailed feedback analysis, often in printable form, with the instructor or mentor, which can lead to more focused interventions, in terms of mentoring for a particular skill. It helps draw up individualized learning plans for learners. It thus lends itself to more instructor-based intervention.

Down the Road

What possibilities does simulation feedback hold?

While current feedback implementation methods are robust and have displayed great effectiveness, leaps in technology and new vistas in the open education field make us believe there are many ways we can leverage our ability to extract specific performance and skill-based data to create more valuable learning and training interventions.

» **Social Simulations and Feedback**
Allowing users the flexibility to conduct peer reviews and provide feedback on a learner's performance (including their own) will lead to more collaboration, sharing, and discussion of ideas. Learners can share real-life experiences, insights, as well as their own takeaways from the learning simulations. For example, a learner takes a set of decisions, gets specific feedback and can add "notes" to a particular bookmark, which will be accessible for other simulation takers in a cloud-based learning environment. They can "upvote," "downvote," or "share" feedback, as appropriate. This "crowd-sourced" mechanism will be most effective with experienced, disciplined learners with a certain level of expertise, such as is commonly seen in cMOOCs (connectivist MOOCs). It is effectively an extension of discussion forums and can be closely integrated across multiple channels such as social media, face-to-face interventions, and mentoring.

» **Adaptive Learning and MOOCs**
We can utilize the scoring and feedback mechanism more effectively to create scaffolding. This can be leveraged to generate adaptive scenarios, thus narrowing the sweep of topics and skills in a program to the most relevant ones. This will allow learning to be more focused and relevant while appealing to each learner's individual needs. (*Kenny & Pahl, 2009*)

Simulations could also track a learner's previous attempts and calibrate their performance on scale. This can be used to tailor the next set of simulation, changing the learning "angle of attack" each time.

This can also be implemented in a Massive Open Online Course (MOOC) environment, by allowing the learner to pursue specializations or follow a "rabbit hole" of skills aligned to a particular topic. For example, let's imagine a student working on their leadership skills, who attempts a simulation, which captures performance on several parameters such as communication, business ethics, mentoring, knowledge, team management, creativity, and innovation. If the simulation reveals a lower score on ethics, the MOOC environment can recommend or “line up” the next simulation or course that deals with ethics at the workplace.

- **Mobile Learning**
  Another vista opens up when you take into consideration the proliferation of learning on mobile devices, or m-learning. Time-based or delayed feedback takes on a whole new dimension, with possible provisions to remind the learner at timely intervals of their performance, pushing them to continue with their learning. Asynchronous social networking can be leveraged to provide instructor-led or peer-driven feedback. This can be extended to on-the-job feedback, complementing the role of a supervisor or mentor.

  Mobile-based learning and advanced technologies like Augmented Reality (AR) also offers many more possibilities, such as feedback that is tailored to the learner’s location or physical space in real-time. Let’s say, a learner is using an AR device to attempt a physical simulation while walking around a factory. The feedback in such a simulation, would be tailored to the learner’s decision in a specific context or location.

We hope that some of these suggestions find widespread application and trigger a discussion on new and innovative ways of offering even more comprehensive and personalized assessment of performance. What must always be kept in sight is that the ultimate goal of learning through simulations and feedback is to provide the learner with the chance to learn by reflection, through experimentation, and with a sense of discovery.

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