

ESSAY

Productive struggle and simulation design: actionable insights for designing engaging simulations

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ABSTRACT

Aristotle's quote 'For the things we have to learn before we do them, we learn by doing them' captures a fundamental value of simulation-based education – learning through experience. Practising tasks before mastering them is an essential experience for many learners and underscores the value of struggle as integral to the learning process. In this regard, there is a strong synergy between simulation-based education and the principles of productive struggle. Both incorporate concepts of guided discovery, preparation for future learning and adaptive expertise. In productive struggle, learners first attempt to solve a problem before being provided with a correct or canonical solution, allowing them to compare and refine their understanding. Simulation-based learning emphasizes active discovery in the learning process, problem solving, skills development and deeper conceptual understanding. In this essay, we introduce the main features of productive struggle as an instructional approach and its value as a theoretical lens for simulation education design.

What this essay adds

- Introduces productive struggle as a theoretical lens to inform simulation design and support adaptive expertise.
- Bridges theory and practice by offering actionable insights for designing emotionally and intellectually engaging simulations.

Introduction

Simulation-based education (SBE) is an interactive methodology for generating new knowledge and developing a range of professional skills. More importantly, effective engagement of simulation has the potential to shape problem solving, decision-making and ultimately practice [1]. Simulation-based educational designs can bring to life dynamic and often complex clinical, interpersonal and professional interactions in part to help learners make sense of ill-defined problems they face in practice. This is particularly important in health care, where uncertainty is not an exception, but a routine part of everyday work, even in the presence of clinical guidelines and best practice standards. Taking Aristotle's quote above one step further, the learning that is transformed into practice in simulation derives from conceptual understanding about the issues (or phenomena) being experienced [2].

Submission Date: 17 July 2025

Accepted Date: 01 October 2025

Published Date: 06 November 2025

Uncertainty, struggle, invention and even failure [3] are crucial for learners' development and foundational for exploring new approaches [4]. Well-designed scenarios presented for learning may have multiple possible responses and problem-solving options. And although there are definitely better and worse outcomes, there may be no one right answer or response. It is in this rich playground that we will explore the various ways that productive struggle can advance conceptual understanding alongside clinical skills.

SBE across modalities shares design considerations that are supported by an array of educational theories. Learning theories fall within different paradigms or ideas about knowledge, how we learn and what learning entails. Briefly, experiential learning theories like Kolb's learning cycle theory [5] fall within a constructivist perspective, valuing the seminal connection between processes of actual experience and education [2,6,7]. Others, the theory of deliberate practice originally developed by psychologist K. Anders Ericsson (1947–2020), follow behaviourist tenets, describing how experts, through repeated practice informed by feedback and stepwise assessments, can produce competence, particularly in psychomotor and intellectual tasks [8,9]. Mastery learning is an application of deliberate practice in SBE [10].

More recent theoretical contributions to literature in the field of SBE recognize that simulation is not simply a method for honing clinical skills through practice or reflection but is also a social activity through which values, beliefs and ideas about what it means to be a professional are being learned [2,9]. Complexity theory is one of many that fall under the umbrella of socio-material theories, offering educators ways to address embodied, relational and situational aspects of practice using ideas such as emergence, attunement, disturbance and experimentation [11].

There are many good sources of information about theories in SBE. The remainder of our essay will focus on those directly relevant to our discussion of productive struggle.

Productive struggle

Productive struggle is somewhat of a new kid on the block with respect to simulation design thinking. It is a central concept underpinning the theory of adaptive expertise. As identified by Mylopoulos and colleagues, 'The need for clinicians to be able to adapt to uncertain, complex, or novel situations while maintaining their effectiveness and efficiency in routine situations has become even more relevant in a climate of increasingly limited resources and escalating patient complexity' [3].

Productive struggle and productive failure are terms put in relation to each other in different ways that we would like to clarify before continuing. The distinction is an important one. While both productive failure and productive struggle approaches involve confronting challenges, productive failure focuses on deliberately designing tasks that are beyond learners' current mastery level to elicit structured struggle and eventual learning. Both strategies underscore the value of productive struggle, but productive failure adds an intentional emphasis on failure to generate the correct

solution during initial instruction. For the purposes of this essay, we will primarily use the terminology productive struggle to capture this broader emphasis on learning through challenge.

In the next section, we will describe the key tenets of productive struggle, its origins and its relationship to another important movement in medical education – adaptive expertise. Following this, we will examine the valuable connections with SBE for educators seeking insight into simulation design rationales.

Productive struggle is an instructional design strategy grounded in constructivist theories of learning, which emphasizes that learners actively construct knowledge through experience and reflection rather than passively absorbing information [12]. By encouraging learners to engage in deliberate cognitive effort, productive struggle aligns with the constructivist principles of learner autonomy, meaningful engagement and the cultivation of conceptual understanding. This strategy highlights the importance of grappling with challenging problems, particularly before formal instruction, as a means to foster deeper comprehension and enhance long-term retention. Rather than viewing errors or confusion as setbacks, productive struggle reframes these experiences as essential components of the learning process.

The conceptual roots of productive struggle are closely tied to guided discovery learning and the generation effect, which suggests that learners benefit from attempting to generate solutions before formal instruction [13]. Daniel Schwartz's research elaborated on this idea with the concept of 'preparation for future learning (PFL)' [14]. Unlike approaches that focus solely on immediate mastery, PFL emphasizes the role of initial learning experiences in equipping learners to learn more effectively from subsequent instruction or resources. Through carefully designed activities, such as invention tasks, learners grapple with problems that stretch their understanding. Even when these attempts lead to incomplete or incorrect solutions, they prime learners to extract deeper insights and integrate new information when formal instruction is later introduced [14,15]. Building on this foundation, Manu Kapur [16] introduced the term *productive failure* to describe a structured learning design in which students engage in problem-solving tasks that are intentionally complex and beyond their current level of mastery. Kapur's empirical studies demonstrated that learners who struggled through such tasks – without immediate guidance – perform better in applying knowledge to novel situations compared to those receiving direct instruction [16]. His work highlights the counterintuitive value of failure, provided that learners are supported with high-quality consolidation and feedback after the struggle phase.

As mentioned above, the theoretical underpinnings of productive struggle are deeply rooted in constructivist learning theory, which asserts that knowledge is actively built through experience, reflection and social interaction [12]. Within this framework, a central concept is Vygotsky's zone of proximal development, defined as the space between what learners can achieve independently and what they

can accomplish with guidance [17]. Productive struggle leverages this zone by placing learners just beyond their current capabilities, fostering cognitive tension that, when paired with targeted support, promotes deep and durable learning [18]. Central to this process is the role of *disfluency* – a state in which information processing feels effortful or uncertain. Although disfluency may seem undesirable, research suggests it can serve as a powerful generative mechanism for learning. When learners confront difficulties, they are more likely to engage in deeper processing, question assumptions and activate prior knowledge, all of which contribute to lasting conceptual change. In this way, productive struggle operationalizes the principles of constructivism by deliberately leveraging struggle as a tool for meaningful learning.

While our focus here is primarily on productive struggle as an individual cognitive process, related traditions such as Cultural-Historical Activity Theory (CHAT) and expansive learning highlight how struggle and transformation can also be understood at the level of activity systems. In this view, systemic contradictions within collaborative, goal-directed activity are a primary engine of learning and change [19]. Acknowledging this broader school of thought situates productive struggle within both individual and collective dimensions of learning, and underscores its relevance in simulation and interprofessional contexts [20]. Alexis Battista follows this thread, suggesting in her article on activity theory in scenario-based simulations that learner participation during engagement in a simulation exercise is part of a dynamic multi-modal system that incorporates other learners as well as equipment, tools, and active participants such as simulated participants [21].

Productive struggle plays a critical role in cultivating adaptive expertise, a form of expertise that includes routine expertise but extends beyond it [22]. While routine expertise reflects efficient performance of familiar tasks within well-defined contexts, adaptive expertise incorporates the ability to apply knowledge flexibly and innovatively in unfamiliar situations. This broader competence demands continuous learning, reasoning forward from incomplete information and thoughtful responses to novel challenges. Core components of adaptive expertise include *epistemic humility* – the recognition of the limits of one's knowledge; a *willingness to question assumptions* rather than rely solely on past experience and *forward reasoning*, where individuals make sense of new situations based on evolving evidence rather than backward application of known rules [22]. Productive struggle supports the development of these capacities by exposing learners to uncertainty and complexity, requiring them to generate hypotheses, consider alternatives and embrace ambiguity [16]. This process aligns with the PPL framework, which highlights how initial struggles enable learners to recognize underlying principles and transfer knowledge to new situations [15]. In SBE, these principles converge well-designed scenarios allow learners to grapple with real-world problems, make errors safely and reflect critically, nurturing the habits of mind essential for adaptive expertise in practice.

Intersection with simulation-based education

Like productive struggle, SBE is both error-driven and guided. Simulation sessions are often designed to challenge learners by including unknown circumstances or new information in order that they will be able to apply past and current information in future situations. Simulation design often includes challenges of varying difficulty so that learners are invited to think critically and problem solve actively. Both simulation and productive struggle are disruptive as instructional approaches in that they include discomfort or 'disfluency' as part of learning. Of the many educational theories that support simulation-based design, there are two that stand out in relation to ideas of productive struggle.

Cognitive Load Theory (CLT) is another often referenced learning theory that supports the main tenets of productive struggle and is likewise supported by ideas within productive struggle [23]. CLT is popular with simulation designers for its coherent framing of considerations to help avoid overloading learners' ability to take in and retain knowledge. Briefly, CLT suggests that working memory has a limited capacity for processing new information and that instructional designers should minimize extraneous cognitive load to optimize learning. Too much information and information not germane to the situation overloads the working memory, thereby impeding a learner's ability to process and retain information effectively. This theory's focus on cognition echoes many of the tenets of productive struggle, particularly the need for alignment between cognitive architecture and learning conditions [24].

Despite its widespread use in SBE, CLT is not without tension – particularly when considered alongside the principles of productive struggle. While CLT emphasizes minimizing extraneous load to prevent overwhelming learners, productive struggle encourages learners to engage with challenging tasks that may temporarily increase cognitive demand [25]. This creates a design dilemma: how to support learners in grappling with complexity without exceeding their cognitive limits. Some argue that productive struggle, when well-scaffolded, can deepen understanding, while others caution that too much struggle – especially for novices – can hinder learning [26]. This tension highlights the need for thoughtful integration of both approaches, ensuring that challenge is productive, not paralyzing. Design considerations in common include balancing task complexity with learning objectives, attending to learners' prior knowledge, and assessing their readiness to engage in actively pursuing an approach to an issue or topic.

Learning in SBE is, as stated, an emotional undertaking and must be considered in any design process. Many instructional tools are in place to support the emotional nature of learning in SBE, with the idea that simulation, as with productive struggle, invites learners to embrace epistemic humility or at least tolerate epistemic ambiguity as they critically question their assumptions and limits. Psychological safety is a concept that was pioneered by Harvard Business School professor Amy Edmondson. Briefly, it refers to a shared belief within a team that it is safe to

take interpersonal risks, such as speaking up with ideas, questions, concerns or mistakes, without fear of negative consequences like punishment or humiliation [27]. Within simulation, it has been described as ‘A feeling (explicit or implicit) where in a simulation-based learning activity, participants can speak up, share thoughts, perceptions, and opinions without risk of retribution or embarrassment’ [28].

Principles of psychological safety are recognized as essential to embed in the preparation of simulation activities, acting as it does as a thread throughout the development, preparation, briefing, running and debriefing of the activity. Perhaps unlike productive struggle, which is often examined within the context of an individual endeavour to solve a problem alone, SBE is often a team-based performance medium in which learners are often engaging with others while being observed demonstrating their skills and knowledge. They are performing their knowledge, skills, decision-making and problem solving in front of their peers, preceptors or supervisors. Often these demonstrations are taking place in the context of a learner’s professional identity that is still in formation and/or in high-stakes assessments. There can be unintended and possibly detrimental effects from poorly designed simulations prepared without regard for the learner, their level of learning, prior knowledge of the topic to be engaged and readiness to take part. Attention to psychological safety is therefore paramount when thinking about the fine details when designing and implementing simulation scenarios.

Another theory central to SBE is Donald Schön’s theory of reflective practice [29]. Simulation-based learning, being non-linear, allows for built-in teaching moments and moments of reflection in action. Reflective practice and the concept of *reflection in action* refer to immediate thinking on your feet. This kind of deliberation, followed by *reflection-on-action* (later analysis of actions in light of outcomes, prior experience and new knowledge) and *reflection about action* (preceding an event), describes the ways in which practitioners may prepare for and react to unexpected experiences in their work. ‘[Schön] argued that practitioners seek to place new and unexpected experiences within a personal framework by identifying similar past experiences and then giving consideration to possible outcomes by selecting new actions’ [9]. Schön’s reflection framework for educating professionals is constructivist and aligned with the precepts of productive struggle described earlier. Specifically, reflection in action [29] has emerged as significant for clinical learners to understand not only the impact of their actions but the cognitive frame that has led to their decisions and behaviour. Of the various kinds of reflection that Schön explores, reflection in action is perhaps the most challenging for learners and designers who need to balance experiencing disfluency with meaningful and transferable learning.

Productive struggle and reflective practice together support simulation designs that include time-out pauses for learners to notice and think about the moment they are in, to have the opportunity to reflect and possibly regroup with another approach. In order for learning from simulation experiences to be enduring and transferable

educational design principles like productive struggle need to be embedded and engaged from the beginning of a design process. The value is in making explicit for a learner to consider what they are seeing, thinking, problem solving and making decisions about while in the midst of action.

Despite minor differences, active struggle, complex or ambiguous problems, and guided learning are foundational educational characteristics inherent in both SBE design and productive struggle.

Discussion

Simulation is uniquely suited to support productive struggle because it offers a potentially psychologically safe environment in which learners can struggle and possibly fail without real-world consequences. As noted above, unlike in clinical settings, SBE allows educators to deliberately design clinical encounters that introduce cognitive tension, ambiguity and novelty – conditions that challenge learners just beyond their current competence. A well-designed preparation and pre-brief phase is therefore essential in order for learners to fully engage in learning through a simulation. Just because we state a learning event is safe may not be sufficient for learners to feel it is so. Scenarios can be designed to withhold key information, present conflicting data or introduce unexpected outcomes, prompting learners to grapple with uncertainty as they navigate the dynamic terrain and generate their own approaches. When followed by structured debriefing and reflection, these experiences transform struggle into a powerful learning opportunities that build resilience, adaptability and the capacity to reason through complex, real-world problems.

Designing simulations to optimize for productive struggle requires intentional departure from linear, clear-cut scenarios. Instead, educators can create non-linear cases that include forks in the road, grey zones and decision points with no single correct answer. These designs invite learners to test their ideas, make meaning from uncertainty and engage in forward reasoning rather than rely on rote protocols. To maximize learning, these challenging encounters must be paired with scaffolded reflection, where learners are guided to unpack their reasoning, confront assumptions and consider alternative approaches. Faculty facilitation is also critical: skilled facilitators can hold space for uncertainty, normalize struggle and help learners connect their experience to broader clinical principles. Through this careful design and facilitation, simulation becomes a powerful vehicle for developing adaptive expertise via productive struggle.

Despite its potential, integrating productive struggle into simulation is not without challenges. As mentioned earlier, health professions education has long been shaped by a culture of performance, where being observed often equates to being evaluated. In simulation, this dynamic can heighten anxiety and discourage learners from taking intellectual risks – precisely the kind of risks that productive struggle depends on. Psychological safety becomes paramount: learners must trust that they can struggle, err and reflect openly without fear of judgement or punitive consequences.

Facilitators play a crucial role in establishing this environment by framing failure as a normal, even necessary, part of professional growth. Without this foundation, the benefits of productive struggle can be undermined, as learners may default to safe, familiar responses rather than engage deeply with the complexity and ambiguity of the scenario.

Creating a culture where struggle and failure are seen as a learning tool begins with deliberate messaging and modelling by faculty [3]. Before simulation begins, instructors can set the tone by explicitly framing struggle as expected and valuable, emphasizing that the goal is not flawless performance but growth through reasoning and reflection. Faculty can also model vulnerability by sharing their own past errors or uncertainties in clinical practice, signalling that expertise includes humility and continuous learning. During debriefs, facilitators should respond to errors with curiosity rather than correction, asking questions like ‘What were you thinking at that moment?’ or ‘What made that decision feel right at the time?’ This approach not only deepens learners’ self-awareness but also normalizes ambiguity as an inherent part of practice. Over time, these strategies help shift the simulation culture from one of assessment to one of exploration – creating space for the kind of generative struggle that fuels adaptive expertise.

Conclusion

Enduring learning that supports transfer of skills and knowledge to clinical situations is supported by simulation and productive struggle.

Integrating productive struggle into simulation design requires an intentional shift from designing for success to designing for uncertainty. Scenarios should be crafted to include incomplete data, shifting priorities, and/or ethical tensions – elements that compel learners to make decisions in the grey zones of clinical practice. Framing is equally important: learners should be explicitly told that struggle and sometimes failure are expected, even desirable, as part of the process. This repositions error as a signal of engagement rather than incompetence. Equally critical is the structure for feedback: debriefings should not only address clinical content but also explore learners’ reasoning, emotional responses and evolving understanding. Here, the role of facilitators is central – they must balance challenge with support, normalize uncertainty and guide learners through reflection without prematurely resolving ambiguity. When all of these elements are aligned, simulation becomes a powerful space for learners to fail forward – deepening their conceptual knowledge and fostering adaptive expertise.

Please see [Table 1](#) followed by a vignette for an example of a scenario designed through a productive struggle lens.

Vignette

To illustrate how productive struggle can be implemented in health professions education, we present an outpatient clinic simulation involving pharmacy and medical learners. This scenario demonstrates key strategies for fostering productive struggle, including framing struggle as expected

Table 1: Practical strategies for embedding productive struggle in simulation

Phase	Practical strategy	Purpose/connection to productive struggle
Preparation/ Pre-brief	Explicitly frame struggle as expected and valuable; emphasize growth over flawless performance; normalize errors and uncertainty	Establishes psychological safety and orients learners towards exploration rather than evaluation; primes learners for productive struggle
Scenario Design	Incorporate ambiguity, non-linear decision points, incomplete/conflicting data and interprofessional role tensions	Creates cognitive tension, encourages forward reasoning and leverages multiple perspectives
Facilitation During Simulation	Resist over-guiding; allow learners to work through difficulty before intervening	Maintains the productive nature of the struggle rather than rescuing too quickly
Debriefing	Ask reflective questions (‘What were you thinking at that moment?’) rather than offering corrections	Helps learners unpack assumptions, normalize ambiguity and transform struggle into insight
Faculty Role Modelling	Share personal experiences of errors or uncertainty	Signals vulnerability as a component of expertise and fosters a culture where struggle is seen as generative

during the pre-brief, designing ambiguity in clinical information, allowing learners to negotiate priorities without immediate intervention, and using reflective debriefing and faculty role modelling. By highlighting these strategies in a realistic interprofessional context, the example shows how cognitive tension and uncertainty can be leveraged to enhance reasoning, collaboration and adaptive problem solving.

Productive struggle in an outpatient clinic simulation

In this interprofessional outpatient clinic simulation, learners assess a patient with poorly controlled diabetes and hypertension and develop an appropriate care plan. The scenario highlights the challenges of clinical reasoning under uncertainty and fosters productive struggle in a psychologically safe environment. The medical student evaluates diagnostic data and considers whether additional labs are needed, while the pharmacy student reviews medications for potential drug-drug interactions and optimization opportunities. Ambiguity is deliberately built into the scenario: some lab results are delayed, the medication history is incomplete, and the patient expresses conflicting concerns about side effects and lifestyle changes.

Prior to the simulation, facilitators frame struggle as expected and valuable, emphasizing learning through reasoning rather than flawless performance. During the encounter, facilitators resist intervening immediately, allowing learners to grapple with uncertainty, negotiate priorities, and challenge assumptions to develop a safe and feasible care plan. For example, the pharmacy student raises concerns about a recent medication adjustment, prompting discussion about balancing therapeutic benefits with patient safety, while the medical student debates whether additional diagnostics are warranted before finalizing the plan.

In the debrief, facilitators ask reflective questions such as: ‘How did the information gaps affect your decision-making?’ and ‘How did your professional perspectives shape the plan?’ Faculty may also share brief examples of their own past uncertainties or errors to model vulnerability and normalize productive struggle. Through this structured approach – combining pre-brief framing, scenario ambiguity, restrained facilitation, reflective debriefing and role modelling – learners experience productive struggle, integrating clinical knowledge with collaborative reasoning, and enhancing both individual judgement and interprofessional problem-solving skills.

Declarations

Authors’ contributions

None declared.

Funding

None declared.

Availability of data and materials

None declared.

Ethics approval and consent to participate

None declared.

Competing interests

None declared.

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