Online Supplemental Material for On Episodic Memory in Experiential Learning via Flightcrew Training Simulations

Nathan A. Sonnenfeld, Blake Nguyen, Caroline Gomez, Florian G. Jentsch, Stephen M. Fiore

Institute for Simulation & Training, University of Central Florida

Orlando, Florida

nsonnenf@ucf.edu, blake.nguyen@ucf.edu, ca077242@ucf.edu, florian.jentsch@ucf.edu, sfiore@ucf.edu

APPENDIX A: 4E COGNITION

This appendix includes a resource **(Table 1)**, adapted from McGowin et al. (2023), which defines the features of embedded, embodied, enactive, and extended (4E) cognition according to Schiavio and Van der Schyff (2018).

Table 1: 4E Cognition Definitions—Adapted from McGowin et al. (2023)

Name	Definition
Embedded Cognition	"Cognition is not an isolated event separated from the agent's ecological niche. Instead, it displays layers of co-determination with physical, social, and cultural aspects of the world." (Schiavio & Van der Schyff, 2018, p. 2)
Embodied Cognition	"Cognition cannot be fully described in terms of abstract mental processes (i.e., in terms of representations). Rather, it must involve the entire body of the living system (brain and body)." (Schiavio & Van der Schyff, 2018, p. 2)
Enactive Cognition	"Cognition is conceived of as the set of meaningful relationships determined by an adaptive two-way exchange between the biological and phenomenological complexity of living creatures and the environments they inhabit and actively shape." (Schiavio & Van der Schyff, 2018, p. 2)
Extended Cognition	"Cognition is often offloaded into biological beings and non-biological devices to serve a variety of functions that would be impossible (or too difficult) to be achieved by only relying on the agent's own mental processes." (Schiavio & Van der Schyff, 2018, p. 2)

APPENDIX B: DESIGN PRINCIPLES, FEATURES, & RATIONALE

This appendix includes additional information the design principles and instructional features for XR simulations based in the concept of episodic memory (**Table 2**).

Table 2: Rationale for EM design principles and instructional features for XR simulations

Design Principle #1: Optimize Presence in XR Simulations.

- In flightcrew training contexts, particularly using XR, an important consideration is the salience of stimuli and of the episodic elements perceived upon which higher constructs (e.g., spatiotemporal models, narratives, etc.) depend. That salience being relative to the *fidelity* (e.g., physical, cognitive) of the training and the *immersion* (i.e., the degree to which the system provides inclusive, extensive, surrounding, and vivid stimuli; Slater & Wilbur, 1997) afforded by the given configuration (e.g., hardware, software) (Fiore et al., 2007; Jones, 2021; McGowin et al., 2021; Smith & Mulligan, 2021). This instructional choice impacts the salience of the episodic elements and the relations between them for encoding within EM (Conway, 2009), immersion assists with embedding the learners within the environmental and situational context and provides the sensory stimulation requisite of embodiment in the experience (McGowin et al., 2021; Winn, 2002). The salience of episodic elements within the EM system is not just a matter of the clarity of the stimuli, however, but also the meaning attributed them—meaning which is derived from enaction and interactions in the experience (Markant et al., 2016; Sauzéon et al., 2012; Tuena et al., 2019). Thus, the *presence* of the learner embodied within the simulation (Costa et al., 2013; Schubert et al., 1999; see also Mystakidis & Lympouridis, 2023), the requisite degree of immersion, and the *interactivity* afforded by the training configuration (Nilsson et al., 2016) become critical factors for supporting EM in experiential learning during these simulations—consistent with contemporary frameworks on learning using XR configurations (e.g., Makransky & Petersen, 2021; McGowin et al., 2021; Stanney et al., 2021a). While the importance of presence and associated constructs in XR simulations is not new to the literature, the alignment of this design consideration to the support of EM in experiential learning is hoped to provide a position for grounding its application in findings and theory from the cognitive sciences.
- To support this design principle, an applicable instructional technique may be to increase immersion through inclusive, extensive, surrounding, and vivid sensory information of the authentic environment (McGowin et al., 2023; Slater & Wilbur, 1997). This should be applied with caution, however, as there may be tradeoff between presence and cognitive load (Mayer et al., 2022), for different types of tasks (Dorsey et al., 2009), and at different times during instruction (Waterworth & Waterworth, 2001). Examples of ideal fluctuations in focus (presence vs. absence) and sensus (high vs. low attention) for conceptual and perceptual learning tasks across the learning cycle reflect the transitions of transformation and grasping from the EL cycle (Kolb, 2015). To optimize presence for the

support of EM, training developers may need to reconceptualize it as being dynamic within and across training events, proficiency- and task-dependent, and the result of design decisions beyond the immersiveness of the delivery medium.
Design Principle #2: Optimize the salience of meaningful information and stimuli in XR simulations. • Because it is important to leverage trainees' activation/inhibition of sensory details in EM during the Abstraction and Reflection phases of EL, the salience of information and stimuli in XR simulations should be optimized based on the meaningfulness of that information for the given training objective. Task-relevant information and stimuli could be made clear during training (e.g., signaling), while task-irrelevant information and stimuli (e.g., seductive details) could be minimized during the high-load contexts associated with XR simulations (Howard & Lee, 2020; Mayer & Fiorella, 2021; see also Patterson et al., 2014). While these techniques are not new within the relevant training literature, the alignment of this design consideration to the support of EM within EL may provide further grounding for its application. • One strategy that has been effective in the literature has been to increase the salience of relevant information through signaling, particularly for novice learners (Carroll & Sanchez, 2021; Mayer & Fiorella, 2021; Vogel-Walcutt et al., 2013). Specific instructional tactics that have been used to implement this strategy relevant to XR simulations include visual (highlighting, pointing) and auditory cues (e.g., volume, leitmotif) and the addition of task-relevant contextual information (e.g., annotation enrichment) (Limbu et al., 2019; Tan et al., 2010). Whether these cues may take advantage of learners' disposition for embedded or extended cognition depends on whether they are augmenting or adjuncting to the task context (McGowin et al., 2021; Singer et al., 2006); regardless, the implementation of these tactics during the Experience and Experimentation phases of EL lends support to bottom-up (e.g., assimilation) and top-town (e.g., goal-relevance) EM processes through the Abstraction and Reflection phases, strengthening elaboration and recall (Macchiarella et al., 2009). Thoughtful application of this design principle in XR simulations should be considered, in context with other principles of multimedia design (Mayer & Fiorella, 2021), to leverage the activation/inhibition mechanisms of the EM system.
Design Principle #3: Provide graphical representations of conceptual information in XR simulations. • Given the centrality of visual representation in the EM system, conceptual information should be presented graphically rather than textually to trainees to aid in encoding and schema development. While the benefits of graphical representations in instruction have been well enumerated in the literature, the rationale for their use has traditionally focused on supporting WM functions and the assimilation of conceptual knowledge within the SM system. While the benefits of graphical representation appear to extend to XR simulation contexts (Albus & Seufert, 2023; Kao et al., 2021), their application as primary and supplementary instructional material in EL may provide additional benefit for the EM system, with a plausible rationale in the modification of element interactivity (with different visualizations reducing/increasing the instructional elements of a given learning task, relative to content and expertise; Mayer & Fiorella, 2021; Scaife & Rogers, 1996). • Graphical representations (e.g., diagrams, data visualizations) may also function as scaffolds for schema construction (Patterson et al., 2014; Stanney et al., 2023a), leveraging learners' extended cognition, through computational offloading, re-representation, and graphical constraining (Scaife & Rogers, 1996). XR simulation environments may be designed to provide cues and other instructional techniques (Limbu et al., 2019) consistent with the principles of cognitive load and multimedia theories (Mayer & Fiorella, 2021) as necessary for scaffolding representation through the visuo-spatial sketchpad of working memory (Fiore & Nicholson, 2007; see also Baddeley et al., 2021). Specific instructional features for supporting graphical representation include the use of advance organizers (Vogel-Walcutt et al., 2010; 2013) and providing graphical representations at the embedded point-of-need within the XR simulation (Limbu et al., 2019; Stanney et al., 2023a). Trainees could also be provided with a means to manipulate or create their own graphical representations to support extended cognition (Kirsh, 2017) and self-regulation (Greene & Azevedo, 2009; see also Efkides, 2001) in support of EM.
Design Principle #4: Support multiple perspectives of events in XR simulations. • As EM tends to have perspective, multiple perspectives of events in XR simulations should be supported to facilitate encoding and retention. In consideration of the concept of enactive cognition (e.g., McGowin et al., 2021; 2023), we suggest that designers prioritize the experience of learners from the 1st-person point-of-view (POV). Use of alternative perspectives should be considered as supplementary activities supporting the objective(s) of training. XR simulations may leverage cross-training tactics such as positional rotation (Fiore et al., 2005) that have been emphasized as part of line operational flight training (LOFT; Federal Aviation Administration, 2015) to apply this principle of multiple perspectives to facilitate team coordination outcomes, facilitating tacit knowledge in a manner by which semantic and procedural memory systems alone cannot account (see Tulving, 1998). • Perspective may also be used in other ways. Observational points of view (3rd-person POV or otherwise) may be effectually used to onboard novice learners (Stanney et al., 2023a) or to support evaluation-level objectives by having the trainee take on the role of an instructor/evaluator in assessing their prior performance or that of another trainee or agent. Abtiahi et al. (2022) described how the use of beyond-real interactions including space transformations (e.g., scaling), body transformations (e.g., alternate morphologies), and time transformations (e.g., speed changes) may be used to support learner action facilitating the acquisition of conceptual knowledge, while McGowin et al. (2023) provided specific examples of how beyond-real interactions could be applied to science education from a 4E cognition perspective. In flightcrew training, manipulation of perspective through beyond-real interactions could allow for learners to manipulate visualizations of fight data to understand how approach factors impact landing performance, to adopt alternate morphologies allowing them to explore the interior of avionics systems, or to visualize the effects of duty time and rest requirements on fatigue over time. Creative application of this design principle for XR simulations should continue to be explored, drawing inspiration from extant interaction metaphors and mechanics (Jerald et al., 2017; see also Adams & Dormans, 2012).
Design Principle #5: Provide supports to facilitate learners' SRL in XR simulations. • Because the temporal bounding of EM is framed by the learners' goal system, supports should be provided to facilitate learners' regulatory processes and behaviors during experiential learning in XR simulations, particularly for learning experiences that are not otherwise directly facilitated by an instructor (Brydges et al., 2015). Self-regulated learning (SRL) may be understood in brief as a process of metacognitive monitoring and control concerned with goal setting and attainment (Greene & Azevedo, 2007; Pintrich, 2000; see also Goldberg & Spain, 2014), in which goals are both a product and the standard by which metacognitive evaluations occur (Winne, 2001). XR simulations tend to afford learners greater control and agency over the learning experience than other types of

instructional media (McGowin et al., 2021); support of learners' self-regulatory processes may help facilitate bottom-up and top-down interactions between the EM and goal systems (Conway, 2009; Conway & Loveday, 2015) in support of training objectives, as has been explored in other relevant instructional systems (Goldberg & Spain, 2014; Goldberg et al., 2015).

- System-initiated strategies have been found to encourage effective SRL (Azevedo et al., 2008)—particularly for novice learners—through tactics such as prompting and back-chaining (Fiore & Vogel-Walcutt, 2010; Goldberg & Spain, 2014; Stanney et al., 2023a). Strategies to facilitate learner-initiated SRL may involve using an SRL palette (Wiedbusch et al., 2021) and/or embedded environment/interface elements (e.g., instructional agent, notetaking system) (Dever et al., 2023), termed SRL widgets (Nussbaumer et al., 2014) that allow learners' to enact a broader range of SRL processes (see Greene & Azevedo, 2009), as they acquire metacognitive knowledge associated with their use (Wiedbusch et al., 2021). Regardless of the instructional features used to implement this design principle, the design goal is to provide, within XR simulations, supports necessary for facilitating and assessing learners' strategic planning (e.g., goal setting; time/effort planning), monitoring (e.g., self-assessment), enactment (e.g., searching, notetaking, summarizing), and adapting (e.g., help-seeking, context control) of learning processes (Greene & Azevedo, 2009; Roscoe & Craig, 2022; see also Brydges et al., 2015) to influence the framing and temporal bounding of episodes (Conway, 2009; Conway & Loveday, 2015; Efklides, 2001), leveraging learners' extended cognition by scaffolding or otherwise offloading facets of cognition within the learning environment (McGowin et al., 2023; see also Goldberg et al., 2015).

Design Principle #6: Retain spatiotemporal realism through interaction fidelity in XR simulations.

- Given the temporal order and linearity of the EM system, XR simulations should be designed to retain spatiotemporal realism in activities directly related to the training objective—leveraging embodiment and enaction (McGowin et al., 2023) to support learners' understanding of spatiotemporal relations among episodic elements in the simulated environment (Andonovski, 2022; Conway, 2009). This design principle grounds the concept of transfer appropriate processing during experiential learning (Fiore et al., 2007; Jones, 2021; Rugg et al., 2008) within the observed function and characteristics of the EM system (Conway, 2009; Conway & Loveday, 2015).
- Instructional festures for implementing this design principle may include providing a self-avatar and supporting learners with control over their movements within the XR simulation (Gonzalez-Franco et al., 2020; McGowin et al., 2023). A specific tactic for implementing this strategy could include ensuring interaction fidelity (e.g., biomechanical symmetry) between psychomotor movements in the XR simulation with those of the real environment (McMahan, 2011; McMahan et al., 2016)—by requiring, for example, trainees to use different realistic movements to flip switches, turn dials, and press buttons (Paul, 2023), as a re-specification of Caro's (1988) concept of *mediators* in context of the affordances provided XR simulations (see also Cordell, 1991; Moroney & Lilienthal, 2009; Williams & Blanchard, 1995). That is, tactile feedback may not be required for procedural task objectives—but retaining spatiotemporal realism through the interactive fidelity of psychomotor movements (McMahan, 2011; McMahan et al., 2016) may support the effectiveness of XR configurations for training physical tasks (Kaplan et al., 2021) as grounded within the functions and characteristics of the EM system (e.g., temporal linearity; experiential summaries; Conway, 2009).

Design Principle #7: Provide trainees with access to comprehensive case libraries of XR simulations.

- Due to the need to facilitate trainees' retention of meaningful information throughout the EL cycle to address the rapid forgetting of experiential details during the process of semantic assimilation and proceduralization (Anderson, 1981; Conway, 2009; Fiore & Nicholson, 2007), we suggest that developers should provide trainees with access to comprehensive case libraries of XR simulations for related to the target objectives and tasks. Other directly actionable guidance to mitigate forgetting in the acquisition of knowledge and skill and across the training footprint have been prevalent throughout the literature (Vogel-Walcutt et al., 2010; 2013; see also Hoffman et al, 2013; Stanney et al., 2023a). While thoughtful integration of these various features is crucial for supporting episodic recall, a pressing issue for the flightcrew training community in the current zeitgeist is the avoidance of using XR simulations as isolated "one-off" training experiences and the advancement of integration and collaboration in the use of XR simulations to support the pilot training pipeline. To effectually implement the strategies discussed in the literature across the flightcrew training footprint (e.g., Stanney et al., 2023a), air carriers and other flightcrew training stakeholders should encourage the development of comprehensive case libraries that allow trainees to attain proficiency in a set of training objectives. Trainees should have access to training experiences to help them advance from initial training (e.g., remembering concepts, system components, and procedures) through competency (e.g., resolving simple//common task scenarios) to expert proficiency (e.g., resolving rare, novel, and complex task scenarios) with the opportunity for interleaved whole-task practice to promote retention (Hoffman et al., 2013; Stanney et al., 2023a; Vogel-Walcutt et al., 2013).
- The current state of XR simulations implementation in commercial flightcrew training has similarities to the state of LOS training in the 90s. XR simulation developers manually create singular scripted scenarios for XR training—each separately conceived, developed, and tested by the training organization. With a limited scope of XR training simulations for use in the air carrier industry, the cost, time, and risk of training and training development, such that air carriers may again discard existing XR simulations as they become familiar to trainees, replacing them with new versions. The flightcrew training community may wish to avoid repeating this situation. A solution was previously addressed through the development of tools to generate rapidly reconfigurable LOE scenarios (Bowers & Jentsch, 2004), the underlying concepts of which remain extant in current aviation training practices (e.g., The Boeing Company, 2023; FAA, 2015). As emerging technologies (e.g., digital twins, artificial intelligence) now vastly accelerate production of XR simulation training assets and environments (Katano et al., 2023; Long, 2022; Stanney et al., 2023b) applicable to flightcrew training contexts across a variety of use-cases (Nguyen et al., in press) a similar paradigm should be adopted to (1) leverage the increased availability of experiential learning across the training footprint as supported by XR systems, (2) enable trainees to access XR simulation training of an appropriate quality and breadth in their progression from novice to expert proficiency and in recurrent training, and (3) mitigate the financial costs and risks of developing standalone XR training solutions.

Design Principle #8: Use narrative techniques to frame events and support schema development n XR simulations

- As the EM system may be understood to ground (bottom-up) and framed by (top-down) higher-order cognitive functions such as the goal system and the conceptual-self (Conway, 2009; Conway & Loveday, 2015), designers should leverage top-down and bottom-up EM processes in the Reflection and Abstraction phases of EL by using narrative instructional techniques in XR simulations to frame events and support schema development. While the air carrier training community is well familiarized with approaches such as EBT/SBT which systematically decompose operational narratives into training events and content (e.g., Fowlkes, 1998; Longridge, 1997; Oser, 1999), the connection that these implementations have not previously been grounded.

- Specifically, the use of SBT as a narrative technique may be understood to provide a structure for ensuring the use of a combination of perspective, experiential processing, visual representation, and goal-relevant temporal bounding in simulation-based experiential learning (Fiore & Nicholson, 2007; Fiore et al., 2005), leveraging learners' embedded cognition (McGowin et al., 2023; Stanney et al., 2023a). Furthermore, systematic use of briefing/debriefing (Bowers et al., 2013; Fiore & Nicholson, 2007; Fiore et al., 2005) in LOS methodologies may be viewed in an EM context support bottom-up (episodic-to-self/autobiographical) and top-down (self/autobiographical-to-episodic) influences on the EM system (respectively, chinking of episodic elements into personal narrative summaries, and filtering of goal-relevant and personally-relevant information) (Conway, 2009; Conway & Loveday, 2015). Guidance for LOS briefing/debriefing encourage actions in support of narrative co-creation (Conway, 2009; Ochs & Capps, 1996), in which narrative elements such as dialogue are used to provide the context for learners to reflect upon (chunking) and abstract (assimilate) through the EL cycle. Dialogue, perspective, story, and other narrative elements have long been employed to facilitate pilots' acquisition and dissemination of experiential, tacit knowledge—not only through scenario events and briefing/debriefing, but through facets of instruction including mentoring (Liulevicius et al., 2011; Mauro & Barshi, 2003), hangar talk/war stories (Chappell & Mitchell, 1997; Kearns & Sutton, 2013), reflection (Carroll & Sanchez, 2021; O'Hare et al., 2009), and incident reporting (Huddlestone & Harris, 2006; Linde, 2001), among other examples (Carim et al., 2016), arguably leveraging learners' capacity for extended cognition in social contexts (McGowin et al., 2023; see also Brown, 2020; Lyre, 2018; Sutton et al., 2010; cf. Wiltshire et al., 2015).. Given that the scholarly work of Conway (2009) and others (e.g., Ochs & Capps, 1996) have provided a lens for understanding the relationship between narrative and the EM system, and that flightcrew training practices have demonstrated the value of narrative techniques and elements in support of the acquisition of tacit knowledge and simulation training effectiveness, developers and researchers should explore different ways of implementing narrative techniques and elements within XR simulations.

Design Principle #9: Encourage retrospection and prospection in support of XR simulations.

- In support of the recollective experience of EM, designers should encourage retrospection (e.g., reflection) and prospection (e.g., mental simulation) during the Reflection phase of EL in support of training using XR simulations. Reflection and retrospection are a cornerstone of the EL cycle, and its application has been discussed throughout flightcrew-relevant training literature (Carroll & Sanchez, 2021; O'Hare et al., 2009; Vogel-Walcutt et al., 2013)..Stanney et al. (2023a) described specific tactics for both reflection-in-action (e.g., situational dissonance; focusing on situational differences and discrepancies) and reflection-on-action (e.g., reflective observation; taking on multiple perspectives to analyze an experience) and others associated with metacognitive prompting (e.g., self-assessment, self-reflection) throughout the training cycle (Fiore & Vogel-Walcutt, 2010; see also Greene & Azevedo, 2009). Video (e.g., audiovisual recording, animation/replay) has been found to be a beneficial tool to support reflection during simulation debriefing sessions (FAA, 2015), particularly for trainees and instructors in offloading bottom-up EM functions (e.g., remembering the temporal order of events as they occurred) to focus on top-down functions (e.g., reflecting on performance relative to goals) (Kikkawa & Mavin, 2018). Other features for encouraging reflection could include journaling or learning logs to support this phase of the EL cycle (Schatz et al., 2012).
- Prospection—such as visualization, mental simulation, and mental practice/rehearsal—typically discussed in the training literature without grounding in the functions and characteristics of the EM system. has also been an encouraged facet of flightcrew-relevant training (Jentsch et al., 1997; Kearns, 2010; Schatz et al., 2012). One of flightcrew members' most important abilities is mentally simulate and predict the likelihood and risk of the outcomes of their actions under different circumstances (Jentsch, 1997). Example instructional features include guided mental practice through video observation (Kearns, 2010), and pre-mortem simulation, in which trainees imagine that a trained response to a situation has failed (Rivera et al., 2016). The mechanisms of prospective simulation are grounded not just in the theoretical characteristics and functions of the EM system, but also in findings supportive of embodied and enactive accounts of cognition and motor imagery (i.e., neural traces encoded during related experiences are activated during prospection; Jeannerod & Frak, 1999; Michaelian & Sant'Anna, 2021; Wiltshire et al., 2015). Based on this grounding of EL in the functions of the EM system, designers developers of XR simulations should implement instructional features supportive of retrospection and prospection throughout the training cycle (see also Fiore & Vogel-Walcutt, 2010).

REFERENCES (SUPPLEMENT)

Adams, R. & Dormans, J. (2012). *Game Mechanics: Advanced Game Design*. New Riders Games.

Albus, P., & Seufert, T. (2023). The modality effect reverses in a virtual reality learning environment and influences cognitive load. *Instructional Science*. https://doi.org/10.1007/s11251-022-09611-7

Azevedo, R., Moos, D. C., Greene, J. A., Winter, F. I., & Cromley, J. G. (2008). Why is externally-facilitated regulated learning more effective than self-regulated learning with hypermedia? *Education Technology Research and Development*, *56*, 45–72. https://doi.org/10.1007/s11423-007-9067-0

The Boeing Company. (2023). *Boeing Maintenance Synthetic Trainer* [Webpage]. https://services.boeing.com/training-solutions/maintenance-training/maintenance-synthetic-trainer

Bowers, C., & Jentsch, F. (2004). Engineered experiences for scaled worlds: An example from aviation. In L. R. Elliot, S. G. Schiflett, & M. D. Coovert (Eds.), *Scaled Worlds: Development, Validation, and Applications* (pp. 67-74). https://doi.org/10.4324/9781315243771

Bowers, C. A., Serge, S., Blair, L., Cannon-Bowers, J., Joyce, R., & Boshnack, J. (2013). The effectiveness of narrative pre-experiences for creating context in military training. *Simulation & Gaming*, *44*(4), 514–522. https://doi.org/10.1177/1046878113475341

Brydges, R., Manzone, J., Shanks, D., Hatala, R., Hamstra, S. J., Zendejas, B., & Cook, D. A. (2015). Self-regulated learning in simulation-based training: a systematic review and meta-analysis. *Medical Education*, *49*(4), 368-378. https://doi.org/10.1111/medu.12649

Carim Jr, G. C., Saurin, T. A., Havinga, J., Rae, A., Dekker, S. W., & Henriqson, É. (2016). Using a procedure doesn't mean following it: A cognitive systems approach to how a cockpit manages emergencies. *Safety Science*, *89*, 147-157. https://doi.org/10.1016/j.ssci.2016.06.008

Carroll, M. B., & Sanchez, P. L. (2021). Decision making with conflicting information: Influencing factors and best practice guidelines. *Theoretical Issues in Ergonomics Science*, *22*(3), 296-316. https://doi.org/10.1080/1463922X.2020.1764660

Chappell, A. R., & Mitchell, C. M. (1997). Intelligent tutoring systems for 'trained novices': Building expertise in mode management. *Proceedings of the 9th International Symposium on Aviation Psychology*. https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=c014444f1707ed220a8e2f869f000888a30c10f6

Dever, D. A., Sonnenfeld, N. A., Wiedbusch, M. D, Schmorrow, S. G., Amon, M. J., & Azevedo, R. (2023). A complex systems approach to analyzing pedagogical agents' scaffolding of self-regulated learning within an intelligent tutoring system. *Metacognition Learning*. https://doi.org/10.1007/s11409-023-09346-x

Dorsey, D., Campbell, G., & Russell, S. (2009). Adopting the instructional science paradigm to encompass training in virtual environments. *Theoretical Issues in Ergonomics Science*, *10*(3), 197-215. https://doi.org/10.1080/14639220802151427

Federal Aviation Administration. (2015). *Flightcrew Member Line-Operational Simulations: Line-Oriented Flight Training, Special Purpose Operational Training, Line Operational Evaluation* (Advisory Circular 120-35D). U.S. Department of Transportation. https://www.faa.gov/documentLibrary/media/Advisory_Circular/AC_120-35D.pdf

Fiore, S. M., & Vogel-Walcutt, J. J. (2010). Making metacognition explicit: Developing a theoretical foundation for metacognitive prompting during scenario-based training. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, *54*, 2233-2237. https://doi.org/10.1177%2F154193121005402703

Greene, J. A., & Azevedo, R. (2007). A theoretical review of Winne and Hadwin's model of self-regulated learning: New perspectives and directions. *Review of Educational Research*, *77*(3), 334-372. https://doi.org/10.3102/003465430303953

Greene, J. A., & Azevedo, R. (2009). A macro-level analysis of SRL processes and their relations to the acquisition of a sophisticated mental model of a complex system. *Contemporary Educational Psychology*, *34*(1), 18-29. https://doi.org/10.1016/j.cedpsych.2008.05.006

Goldberg, B., & Spain, R. (2014). Creating the intelligent novice: Supporting self-regulated learning and metacognition in educational technology. In R. Sottilare, A. Graesser, X. Hu, & B. Goldberg (Eds.), *Design Recommendations for Intelligent Tutoring Systems*, *2*, 109-134. https://apps.dtic.mil/sti/pdfs/AD1158927.pdf#page=144

Goldberg, B., Sinatra, A., Sottilare, R., Moss, J., & Graesser, A. (2015, November*). Instructional Management for Adaptive Training and Education in Support of the US Army Learning Model—Research Outline* (ARL-SR-0345). US Army Research Laboratory. https://apps.dtic.mil/sti/pdfs/ADA623560.pdf

Howard, M. C., & Lee, J. (2020). Pre-training interventions to counteract seductive details in virtual reality training programs. *Human Resource Development Quarterly*, *31*(1), 13-29. https://doi.org/10.1002/hrdq.21378

Huddlestone, J., & Harris, D. (2006). Using grounded theory techniques to develop models of aviation student performance. *Human Factors and Aerospace Safety*, *6*(4), 371. https://core.ac.uk/download/pdf/228153989.pdf

Jeannerod, M., & Frak, V. (1999). Mental imaging of motor activity in humans. *Current Opinion in Neurobiology*, *9*(6), 735-739. https://doi.org/10.1016/S0959-4388(99)00038-0

Jentsch, F., Bowers, C., & Salas, E. (1997). Could mental practice and imagery be techniques for enhancing aviation performance? *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, *41*(2), 1172-1175. https://doi.org/10.1177/107118139704100210

Jerald, J., LaViola, J. J., & Marks, R (2017). VR Interactions. *ACM SIGGRAPH 2017 Courses*, *19*, 1-105. https://doi.org/10.1145/3084873.3084900

Jones, M. (2021). Effects of simulation fidelity on learning transfer. *Journal of Educational Informatics*, *2*(1). https://doi.org/10.51357/jei.v2i1.116

Kao, D., Magana, A. J., & Mousas, C. (2021). Evaluating tutorial-based instructions for controllers in virtual reality games. *Proceedings of the ACM on Human-Computer Interaction*, *5*, 234. https://doi.org/10.1145/3474661

Kaplan, A. D., Cruit, J., Endsley, M., Beers, S. M., Sawyer, B. D., & Hancock, P. A. (2021). The effects of virtual reality, augmented reality, and mixed reality as training enhancement methods: A meta-analysis. *Human Factors*, *63*(4), 706-726. https://doi.org/10.1177/0018720820904229

Katano, G., Sandrin, L., Gress, J., Klose, N., & Ramsey, R. (2023, March 31). *New technology and best practices for virtual production* [Panel presentation]. Presented at the Central Florida Immersive Technology Summit. Full Sail University. Orlando, FL.

Kearns, S. K. (2010). Guided mental practice: an instructional strategy for asynchronous e-learning of pilot safety skills. *The Collegiate Aviation Review International*, *28*(1), 92-100. https://doi.org/10.22488/okstate.18.100403

Kearns, S. K., & Sutton, J. E. (2013). Hangar talk survey: using stories as a naturalistic method of informing threat and error management training. *Human Factors*, *55*(2), 267-277. https://doi.org/10.1177/0018720812452127

Kikkawa, Y., & Mavin, T. J. (2018). Integrated digitised video recordings in postflight-simulator training: A matter of reflection. In C. Harteis (Ed.), *The Impact of Digitalization in the Workplace: An Educational View,* Professional and Practice -based Learning (Vol. 21, pp. 103-121). https://doi.org/10.1007/978-3-319-63257-5_8

Kirsh, D. (2017). Thinking with external representations. In S. Cowley & F. Vallée-Tourangeau (Eds) *Cognition Beyond the Brain*. Springer, Cham. https://doi.org/10.1007/978-3-319-49115-8_4

Liulevicius, V.G., Tinker, C. L., Mariner, R. B., McConnel, M. P., Rall, J. W., & Mully, F. (2011, Fall). *UT At War*. War Stories: Dispatches from the Center for the Study of War and Society at the University of Tennessee, Knoxville. http://volweb.utk.edu/~wpcsws/wp-content/uploads/2012/09/CSWS-2011-fall.pdf

Long, G. (2022). Building a world with deepfake content – Who needs read data? *Proceedings of the Interservice/Industry Training, Simulation, and Education Conference*, 22190. https://s3.amazonaws.com/amz.xcdsystem.com/44ECEE4F-033C-295C-BAE73278B7F9CA1D_abstract_File16562/PaperUpload_22190_0708111824.pdf

Macchiarella, N. D., Liu, D., & Vincenzi, D. A. (2009). Augmenting reality as a means of job task training in aviation. In D. A. Vincenzi, J. A. Wise, M. Mouloua, & P. A. Hancock (Eds.), *Human Factors in Simulation & Training* (pp. 333-348). CRC Press.

Makransky, G., & Petersen, G. B. (2021). The cognitive affective model of immersive learning (CAMIL): A theoretical research-based model of learning in immersive virtual reality. *Educational Psychology Review*, *33*(3), 937-958. https://doi.org/10.1007/s10648-020-09586-2

Mauro, R., & Barshi, I. (2003). Cognitive science and aviation training: Foundations for effective learning and operational application (No. 2001-01-3061). *SAE Transactions*, *112*(1), 683-692. https://www.jstor.org/stable/44699250

Mayer, R. E. & Fiorella, L. (2021). *The Cambridge Handbook of Multimedia Learning* (3rd ed.). Cambridge University Press. https://doi.org/10.1017/9781108894333

Mayer, R. E., Makransky, G., & Parong, J. (2022). The promise and pitfalls of learning in immersive virtual reality. *International Journal of Human–Computer Interaction*, 1-10. https://doi.org/10.1080/10447318.2022.2108563

McMahan, R. P. (2011). Exploring the Effects of Higher-Fidelity Display and Interaction for Virtual Reality Games (Doctoral dissertation, Virginia Polytechnic Institute and State University). http://hdl.handle.net/10919/30123

McMahan, R. P., Lai, C., & Pal, S. K. (2016). Interaction fidelity: The uncanny valley of virtual reality interactions. In S. Lackey & R. Shumaker (Eds.), *Virtual, Augmented and Mixed Reality* (Lecture Notes in Computer Science, Vol. 9740; pp. 59-70). Springer, Cham. https://doi.org/10.1007/978-3-319-39907-2_6

Moroney, W. F., & Lilienthal, M. G. (2009). Human factors in simulation and training: An overview. In D. A. Vincenzi, J. A. Wise, M. Mouloua, & P. A. Hancock (Eds.), *Human Factors in Simulation & Training* (pp. 3-38). CRC Press.

Nilsson, N., Nordahl, R., & Serafin, S. (2016). Immersion revisited: A review of existing definitions of immersion and their relation to different theories of presence. *Human Technology*, *12*(2), 108. http://humantechnology.jyu.fi/archive/vol-12/issue-2/immersion-revisited/@@display-file/fullPaper/Nilsson_Nordahl_Serafin.pdf

Nguyen, B., Sonnenfeld, N. A., Finkelstein, L., Alonso, A., Duruaku, F., Gomez, C., & Jentsch, F. (in press). Using AI tools to develop training materials for aviation: Ethical, technical, and practical concerns. *Proceedings of the Human Factors & Ergonomics Society Annual Meeting*.

Nussbaumer, A., Kravcik, M., Renzel, D., Klamma, R., Berthold, M., & Albert, D. (2014). A framework for facilitating self-regulation in responsive open learning environments. *arXiv*, 1407.5891. https://arxiv.org/ftp/arxiv/papers/1407/1407.5891.pdf

O'Hare, D., Mullen, N., & Arnold, A. (2009). Enhancing aeronautical decision making through case-based reflection. *The International Journal of Aviation Psychology*, *20*(1), 48-58. https://doi.org/10.1080/10508410903415963

Oser, R. L. (1999, September). A structured approach for scenario-based training. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, *43*(21), 1138-1142. https://doi.org/10.1177/154193129904302105

Patterson, R. E., Blaha, L. M., Grinstein, G. G., Liggett, K. K., Kaveney, D. E., Sheldon, K. C., Having, P. R., & Moore, J. A. (2014). A human cognition framework for information visualization. *Computers & Graphics*, *42*, 42-58. https://doi.org/10.1016/j.cag.2014.03.002

Paul, N. (2023). *An Experimental Comparison of the Effectiveness of Various Levels of Simulator Fidelity on Ab Initio Pilot Training* (Master's thesis, University of Waterloo). http://hdl.handle.net/10012/19456

Roscoe, R. D., & Craig, S. D. (2022). A heuristic assessment framework for the design of self-regulated learning technologies. *Journal of Formative Design in Learning*, *6*, 77-94. https://doi.org/10.1007/s41686-022-00070-4

Rugg, M. D., Johnson, J. D., Park, H., & Uncapher, M. R. (2008). Encoding-retrieval overlap in human episodic memory: a functional neuroimaging perspective. *Progress in Brain Research*, *169*, 339-352. https://doi.org/10.1016/S0079-6123(07)00021-0

Schatz, S., Barlett, K., Burley, N., Dixon, D., Knarr, K., & Gannon, K. (2012). Making Good Instructors Great: USMC cognitive readiness and instructor professionalization initiatives. *Proceedings of the Interservice/Industry Training, Simulation, and Education Conference*, 12185. https://apps.dtic.mil/sti/pdfs/ADA576348.pdf

Slater, M., & Wilbur, S. (1997). A framework for immersive virtual environments (FIVE): Speculations on the role of presence in virtual environments. *Presence: Teleoperators & Virtual Environments*, *6*(6), 603-616. https://doi.org/10.1162/pres.1997.6.6.603

Smith, S. A., & Mulligan, N. W. (2021). Immersion, presence, and episodic memory in virtual reality environments. *Memory*, *29*(8), 983-1005. https://doi.org/10.1080/09658211.2021.1953535

Stanney, K. M., Archer, M., Brawand, N., Del Guidice, K., Haddad Jr., S. G., & Riley, J. M. (2023b). *U.S. Patent No. 11,551,407 B1*. Washington, DC: U.S. Patent and Trademark Office.

Sutton, J., Harris, C. B., Keil, P. G., & Barnier, A. J. (2010). The psychology of memory, extended cognition, and socially distributed remembering. *Phenomenology and the Cognitive Sciences*, *9*, 521-560. https://doi.org/10.1007/s11097-010-9182-y

Tan, S. L., Baxa, J., & Spackman, M. P. (2010). Effects of built-in audio versus unrelated background music on performance in an adventure role-playing game. *International Journal of Gaming and Computer-Mediated Simulations, 2*(3), 1-23. https://www.igi-global.com/article/effects-built-audio-versus-unrelated/47083

Vogel-Walcutt, J. J., Fiorella, L., & Malone, N. (2013, September). Instructional strategies for training military-relevant perceptual-cognitive skills. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, *57*(1), 1239-1243. https://doi.org/10.1177/1541931213571275

Waterworth, E. L., & Waterworth, J. A. (2001). Focus, locus, and sensus: The three dimensions of virtual experience. *CyberPsychology & Behavior*, *4*(2), 203-213. https://doi.org/10.1089/109493101300117893

Wiedbusch, M., Dever, D., Wortha, F., Cloude, E. B., & Azevedo, R. (2021). Revealing data feature differences between system- and learner-initiated self-regulated learning processes within hypermedia. In R. A. Sottilare, & J. Schwarz (Eds.), *Adaptive Instructional Systems. Design and Evaluation* (Lecture Notes in Computer Science, Vol. 12792). Springer, Cham. https://doi.org/10.1007/978-3-030-77857-6_34

Williams, K. W., & Blanchard, R. E. (1995, February). *Development of Qualification Guidelines for Personal Computer-Based Aviation Training Devices* (DOT/FAA/AM-95/6). U.S. Department of Transportation, Federal Aviation Administration. https://apps.dtic.mil/sti/pdfs/ADA292961.pdf

Winn, W. (2003). Learning in artificial environments: Embodiment, embeddedness and dynamic adaptation. *Technology, Instruction, Cognition and Learning*, *1*(1), 87-114. https://www.learntechlib.org/p/96269/

APPENDIX C: FURTHER READING

Episodic Memory

Akimoto, T. (2021). Cogmic space for narrative-based world representation. *Cognitive Systems Research*, *65*, 167-183. https://doi.org/10.1016/j.cogsys.2020.10.005

Altmann, E. M., & John, B. E. (1999). Episodic indexing: A model of memory for attention events. *Cognitive Science*, *23*(2), 117-156. https://doi.org/10.1207/s15516709cog2302_1

Bréchet, L, Mange, R, Herbelin, B, Theillaud, Q, Gauthier, B, Serino, A, Blanke, O. (2019) First-person view of one's body in immersive virtual reality: Influence on episodic memory. *PLoS ONE*, *14*(3), e0197763. https://doi.org/10.1371/journal.pone.0197763

Corriveau Lecavalier, N., Ouellet, É., Boller, B., & Belleville, S. (2020). Use of immersive virtual reality to assess episodic memory: A validation study in older adults. *Neuropsychological Rehabilitation*, *30*(3), 462-480. https://doi.org/10.1080/09602011.2018.1477684

Easton, A., & Eacott, M. J. (2008). A new working definition of episodic memory: replacing "when" with "which". In E. Dere, A. Easston, L. Nadel, & J. P. Huston (Eds.), *Handbook of Episodic Memory* (Handbook of Behavioral Neuroscience, Vol. 18, pp. 185-196). Elsevier.

Laird, J. E. (2008). Extending the Soar cognitive architecture. In P. Wang, B. Goertzel, & S. Franklin (Eds.), *Proceedings of the First Artificial General Intelligence Conference* (pp. 224-235). Amsterdam, Netherlands: IOS Press.

Madore, K. P., & Wagner, A. D. (2022). Readiness to remember: predicting variability in episodic memory. *Trends in Cognitive Sciences*, *26*(8), 707-723. https://doi.org/10.1016/j.tics.2022.05.006

Pause, B. M., Zlomuzica, A., Kinugawa, K., Mariani, J., Pietrowsky, R., & Dere, E. (2013). Perspectives on episodic-like and episodic memory. *Frontiers in Behavioral Neuroscience*, *7*, 33. https://doi.org/10.3389/fnbeh.2013.00033

Piolino, P., Desgranges, B., & Eustache, F. (2009). Episodic autobiographical memories over the course of time: Cognitive, neuropsychological and neuroimaging findings. *Neuropsychologia*, 47(11), 2314-2329. https://doi.org/10.1016/j.neuropsychologia.2009.01.020

Wray, R. E., Folsom-Kovarik, J. T., Schmorrow, D., Jones, R. M., & Marineir, R. (2017). Using stories to deepen shared human-computer understanding of PMESII systems. In S. Schatz & M. Hoffman (Eds.), Advances in Cross-Cultural Decision Making: *Proceedings of the Applied Human Factors & Ergonomics 2016 International Conference on Cross-Cultural Decision Making*. (Advances in Intelligent Systems and Computing, Vol. 480; pp. 29-42). Springer. https://link.springer.com/content/pdf/10.1007/978-3-319-41636-6.pdf

Episodic Memory Concepts in Aviation (e.g., Narrative, Reflection, Prospection)

Efklides, A. (2001). Metacognitive experiences in problem solving: Metacognition, motivation, and self-regulation. In A. Efklides, J. Kuhl, & R. M. Sorrento (Eds.), *Trends and Prospects in Motivation Research* (pp. 297-323). Springer. https://doi.org/10.1007/0-306-47676-2_16

Jentsch, F. G. M. (1997). *Metacognitive training for junior team members: Solving the copilot's catch-22* (Dissertation manuscript, University of Central Florida). https://www.proquest.com/dissertations-theses/metacognitive-training-junior-team-members/docview/304397282/se-2

Embedded, Embodied, Extended, & Enactive (4E) Cognition

Fiore, S. M., & Wiltshire, T. J. (2016). Technology as teammate: Examining the role of external cognition in support of team cognitive processes. *Frontiers in Psychology*, *7*, 1531. https://doi.org/10.3389/fpsyg.2016.01531

Gabbard, C. (2013). The role of mental simulation in embodied cognition. *Early Child Development and Care*, *183*(5), 643-650. https://doi.org/10.1080/03004430.2012.681649

Lyre, H. (2018). Socially extended cognition and shared intentionality. *Frontiers in Psychology*, *9*, 831. https://doi.org/10.3389/fpsyg.2018.00831

McGowin, G., Fiore, S. M., & Oden, K. (2022). Me, myself, and the (virtual) world: A review of learning research in 4E cognition and immersive virtual reality. In J. Y. C. Chen & G. Fragomeni (Eds.), *Virtual, Augmented and Mixed Reality: Applications in Education, Aviation and Industry*. HCII 2022. Lecture Notes in Computer Science, vol 13318. Springer, Cham. https://doi.org/10.1007/978-3-031-06015-1_5

Newen, A., Gallagher, S., & De Bruin, L. (2018). 4E cognition: Historical roots, key concepts, and central issues. In A. Newen, L. De Bruin, & S. Gallagher (Eds.), *The Oxford Handbook of 4E Cognition* (pp. 3-16). Oxford University Press. https://doi.org/10.1093/oxfordhb/9780198735410.013.1

Experiential Learning in Aviation Contexts

Cordell, T. (1991). Computer-based procedural training. *SAE Transactions: Journal of Aerospace*, 100(2), 2346-2351. https://www.jstor.org/stable/44548096

Dietz, A. S., Keebler, J. R., Lyons, R., Salas, E., & Ramesh, V. C. (2013). Developing unmanned aerial system training: An event-based approach. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, *57*(1), 1259-1262. https://doi.org/10.1177/1541931213571279

Fowlkes, J., Dwyer, D. J., Oser, R. L., & Salas, E. (1998). Event-based approach to training (EBAT). *The International Journal of Aviation Psychology*, *8*(3), 209-221. https://doi.org/10.1207/s15327108ijap0803_3

Graesser, A., Hu, X., & Ritter, S. (2019). History of distributed learning. In Walcutt, J. J.& Schatz, S. (Eds.), *Modernizing Learning: Building the Future Learning Ecosystem* (pp. 301-316). Washington, DC: Government Publishing Office. http://files.eric.ed.gov/fulltext/ED603521.pdf

Longridge, T. M. (1997). Overview of the advanced qualification program. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, *41*(2), 898-901. https://doi.org/10.1177/107118139704100240

Meyers, P. L., Star A.W., & Mullins, K (2018). Flight simulator fidelity, training transfer, and the role of instructors in optimizing learning. *International Journal of Aviation, Aeronautics, and Aerospace*, *5*(1). https://doi.org/10.15394/ijaaa.2018.1203

Prince, C., Oser, R., Salas, E., & Woodruff, W. (1993). Increasing hits and reducing misses in CRM/LOS scenarios: Guidelines for simulator scenario development. *The International Journal of Aviation Psychology*, *3*(1), 69-82. https://doi.org/10.1207/s15327108ijap0301_5

Sonnenfeld, N., Nguyen, B., Boesser, C. T., & Jentsch, F. (2021). *Modern practices for flightcrew training of procedural knowledge* [Paper presentation]. Presented at the 84th International Symposium on Aviation Psychology. https://youtu.be/ofSjw5RKTcE

Instructional Considerations

Desmarais, M. C., & Baker, R. S. D. (2012). A review of recent advances in learner and skill modeling in intelligent learning environments. *User Modeling and User-Adapted Interaction*, *22*, 9-38. https://doi.org/10.1007/s11257-011-9106-8

Malone, N., Hernandez, M., Reardon, A., & Liu, Y. (2020). *Advanced Distributed Learning: Capability Maturity Model – Technical Report*. Advanced Distributed Learning Initiative. https://adlnet.gov/assets/uploads/ADL%20CMM%20Technical%20Report.pdf

Mohammad, S. M. (2021). Sentiment analysis: Automatically detecting valence, emotions, and other affectual states from text. In H. L. Meiselman (Ed.), *Emotion Measurement* (2nd ed., pp. 323-379). https://doi.org/10.1016/B978-0-12-821124-3.00011-9

Mott, B., Lee, S., & Lester, J. (2006). Probabilistic goal recognition in interactive narrative environments. *Proceedings of the National Conference on Artificial Intelligence*, *21*(1), 187-192. https://fileadmin.cs.lth.se/ai/Proceedings/aaai06/03/AAAI06-030.pdf

Neville, K. J., & Folsom-Kovarik, J. T. (2019). Recommendation across many learning systems to optimize teaching and training. In T. Ahram, & D. Nicholson (Eds.), *Advances in Human Factors in Cybersecurity* (AHFE 2018. Advances in Intelligent Systems and Computing, vol 782). Springer, Cham. https://doi.org/10.1007/978-3-319-94782-2_21

Paas, F., & Sweller, J. (2014). Implications of cognitive load theory for multimedia learning. In R. E. Mayer (Ed.), The Cambridge Handbook of Multimedia Learning (2nd ed., pp. 27-42). https://doi.org/10.1017/CBO9781139547369.004

Robson, R., & Ray, F. (2012). Applying semantic analysis to training, education, and immersive learning. *Proceedings of the Interservice/Industry Training, Simulation, and Education Conference*, 12151. https://s3.us-west-2.amazonaws.com/us-west-2.files.campus.edublogs.org/sites.gsu.edu/dist/5/1153/files/2019/02/ApplyingSemantics-18c2si1.pdf

Sitzmann, T., & Weinhardt, J. M. (2019). Approaching evaluation from a multilevel perspective: A comprehensive analysis of the indicators of training effectiveness. *Human Resource Management Review*, 29(2), 253-269. https://doi.org/10.1016/j.hrmr.2017.04.001

Skulmowski, A., Nebel, S., Remmele, M., & Rey, G. D. (2021). Is a preference for realism really naive after all? A cognitive model of learning with realistic visualizations. *Educational Psychology Review*, *34*, 649-675. https://doi.org/10.1007/s10648-021-09638-1

Smith, B., Gallagher, P. S., Schatz, S., & Vogel-Walcutt, J. (2018). Total learning architecture: Moving into the future. *Proceedings of the Interservice/Industry Training, Simulation*, and Education Conference, 18224. https://adlnet.gov/assets/uploads/Paper%20IITSEC%202018%20Smith,%20Gallagher,%20Schatz,%20Vogel-Walcutt.pdf

Smith, B., Schatz, S., & Turner, J. (2021). Total learning architecture: Data model for analytics and adaptation. *Proceedings of the Interservice/Industry Training, Simulation, and Education Conference*, 21358. https://www.adlnet.gov/assets/uploads/2021%20---%20(IITSEC)%20Total%20Learning%20Architecture%20Data%20Model%20for%20Analytics%20and%20Adaptation.pdf

Smith, B., & Ram, P. (2019). Interoperability. In J. J. Walcutt & S. Schatz (Eds.), *Modernizing Learning: Building the Future Learning Ecosystem* (pp. 107-126). Washington, DC: Government Publishing Office. License: Creative Commons Attribution CC BY 4.0 IGO https://adlnet.gov/assets/uploads/Modernizing%20Learning.pdf

Sweller, J., & Chandler, P. (1994). Why some material is difficult to learn. *Cognition and Instruction*, *12*(3), 185-233. https://doi.org/10.1207/s1532690xci1203_1