Form from Function: Applying Flow Driven Experiential Learning to The Integration of Immersive Technology in Formal Military Aviation Training Programs

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ABSTRACT

The rapidly advancing world of immersive technology offers seemingly boundless opportunities for increases in effectiveness and efficiency of training in virtually any field. In combination with the ever-present constraints of reduced budgets and limited resources, there is a real temptation to see lower-cost alternatives of immersive learning tools applied through virtual, augmented, and mixed reality as a one-size-fits-all solution. While there is value in rapid fielding and testing of potential virtual, augmented, and mixed reality capabilities, without a parallel assessment of when and how the technology should be woven into a training plan, or syllabus, users run the risk of at best failing to capitalize on the benefits of immersive learning, and at worst, negatively impacting learning efficacy. To maximize the benefits of immersive learning technologies, it is necessary to 1) assess their application through the lens of flow theory with respect to learning experience design, 2) evaluate their impact on student learning, and 3) guard against the temptation to simply "pull and replace" live training environments with virtual ones. This paper proposes a framework for instructional design which integrates experiential learning theory and the principles of flow for the purpose of considering the expected efficacy of immersive environments throughout formal military training programs. This framework should assist leaders in identifying which objectives or events may benefit from delivery in an immersive versus live environment while increasing student learning and performance.

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Since the start of the 20th century, aviators have searched for ways to improve their performance in the air through preparation on the ground. From a rudimentary steering trainer made of a barrel and an Antoinette VII rudder assembly, to "Link" flight instrument trainers with no visuals, to exact cockpit replicas with 360-degree graphics, realistic and valuable aviation training in simulated environments has improved as a result of rapidly emerging technology (Zazula et al., 2013). There are clear opportunities to leverage this kind of technology in the form of immersive learning environments in today's formal military training programs. Several Air Force programs, including Pilot Training Next and Maintenance Next are doing just that. While there is no question of the potential value of utilizing immersive environments to enhance or in some cases perhaps replace live training, simply applying virtual, augmented, or mixed reality technology to existing syllabi or programs may or may not result in improved cognition. The integration of immersive learning environments as a delivery method in formal military training programs should consider the desired learning objective, or event, and the point at which it occurs in the overall training program. Applying a framework based on experiential learning theory and the principles of flow to learning experience design (LXD) will inform the intentional use of immersive technologies to prevent a loss of training effectiveness and maximize the potential benefits of increased student performance and program efficiency.

The first section of this paper will define key immersive learning simulations (ILS) and virtual learning environment (VLE) terms and provide an explanation of learning experience design (LXD), Experiential Learning Theory (ELT) and Flow Theory. Next, this paper will propose a LXD framework for formal military training based on ELT and flow which might assist in determining when and for which events immersive environments present the greatest opportunity for student learning. The final section of this paper will make recommendations for leveraging existing technology today and identify areas in need of further study.

FLOW DRIVEN LEARNING EXPERIENCE DESIGN

The Terms

Due to the rapidly evolving nature of the technology, ILS/VE terminology is often used interchangeably which can cause confusion. While this paper does not go into details of specific technology and the differences in various terms, it is necessary to start with a baseline understanding of what is meant by the terms "immersive technology" or "virtual environment."

Immersive Environments

This paper does not focus on the specific attributes of various emerging technology in the immersive learning and simulation sphere. However, it is important to understand that the use of the term "immersive technology" throughout is intended to reference a range of potential virtual, augmented, and mixed reality solutions for conducting training in an immersive environment. According to Milgram and Kishino (1994), varying levels of immersive environments can be described along a *virtuality continuum*. This continuum helps to explain not only definitions of individual immersive environments, but also illustrates the spectrum that exists from a fully real to fully virtual environment. Virtual Reality (VR) is a fully virtual environment, Augmented Reality (AR) is an environment in which the real environment is enhanced with virtual objects, and Mixed Reality (MR) describes the range between the real and virtual environments in which the user interacts simultaneously with both (Milgram & Kishino, 1994).

Learning Experience Design

The term Instructional Design (ID) is commonly used to describe "the preparation of work-related instruction and other strategies intended to improve worker performance" (Rothwell et al., 2016, p. 3). ID, and its principles, are often utilized when developing or updating course curriculum across a wide range of subjects and it is focused on "performance, efficiency, and effectiveness" achieved through a "structured step by step process which is often linear" (Rothwell et al., 2016, p. 5; Floor, 2021, Methods section). A relatively new concept, LXD has emerged within the last few years as an alternative to the process driven method of ID. Whereas ID "aims to gather comparable and quantifiable data on cognitive aspects of learning, LXD aims to empathize with the people you design for and connect with them on an emotional, personal and educational level" (Floor, 2021, Methods section). While designing curriculum for formal military training does require consideration of a standard outcome and the cognitive aspects of learning, a framework for determining the optimal environment for a given event would benefit from a weight of focus during design on the experience for each student which is the foundation of LXD.

Experiential Learning Theory

In any technical training environment, students are constantly building upon physical and mental experiences towards a standard level of performance on various tasks or events. The requirement to complete a task with defined proficiency with increasing complexity as the student progresses through the program, makes this type of training uniquely suited for examination through the lens of Experiential Learning Theory (ELT). In *Experiential Learning: Experience as the Source of Learning and Development*, David Kolb (1984) describes learning as a continuous process grounded in experience. This continuous process, or cycle, includes four stages which Kolb says learners must be able to operate in to be effective (see Figure 1).

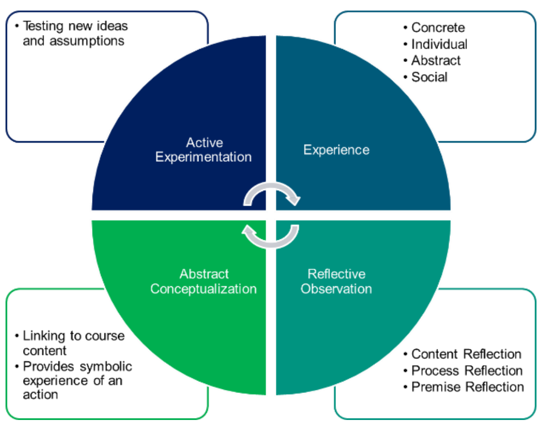

Figure 1. Experiential Learning Theory (ELT)

The first stage, *concrete experience*, requires learners to have new experiences which they will build upon as they enter the ELT cycle. Next, during *abstract conceptualization*, learners must be reflective and make observations about their experiences. In the third stage, *reflective observation*, learners should be challenged to translate observations about different types of experiences into logical theories that they then use to make decisions and problem solve during the fourth and final stage which is *active experimentation* (Kolb, 1984).

Though described above as four unique stages, it is critical to note that ELT is cyclical and continuous. The benefits of an experiential learning environment will not be fully reaped without a design that encourages learners to build on each stage both within and between course events. Instead of a focus solely on outcomes, a framework based on the process of ELT "allows for the transformation of new knowledge by blending experiences, cognition (cognitive and social), perceptions, and behaviors" (Clayton, 2017, p. 117).

Flow Theory

While the process of ELT offers a construct for the instructional design of a technical training program, Flow Theory presents a concept for achieving and sustaining optimal learning and performance by considering the learner's affective state. "To motivate a student so that he/she performs learning activities with complete immersion, it is necessary that his/her affective state provide an optimal experience. This affective state is denominated flow, and it is a mental state of operation characterized by a feeling of energized focus, full involvement, and success in the task being performed" (Csikszentmihalyi, 2013). According to Csikszentmihalyi, flow may only be achieved under the following conditions: 1) clear goals with defined rules and expectations are established, 2) direct and immediate feedback for the purpose of adjusting behavior is provided, and 3) there is balance between the challenge and student capability (Challco et al., 2016).

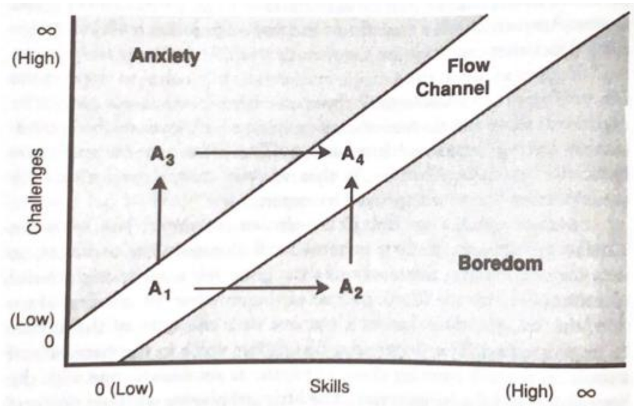

Figure 2. Flow Channel

To understand why flow occurs only when the above conditions are met, it is useful to look at flow in terms of what Csikszentmihalyi (2008) defines as the "two most important dimensions of the experience – challenges and skills" (p. 74). As illustrated in figure 2, these two dimensions range along the vertical and horizontal axes of the Flow Channel. For the purposes of this discussion, the letter A in the diagram represents any learner engaged in a technical training event. When the student begins the training event (A_1), they are ideally challenged at a level appropriate to their skill which will likely place them into a state of flow. As the event progresses, there are two possibilities: 1) the challenges presented during the event remain constant or increase at a rate below the student's growing skill level or 2) the challenges presented increase at a rate that exceeds the student's present skill level (Csikszentmihalyi, 2008). In the first case, where skill exceeds challenge, the student will move from a flow state into boredom (A_2) which, according to flow theory, will result in less cognition. At this point there two options: 1) the student disengages from the learning experience, or 2) they are presented with greater challenges to meet their increased skill level which drives them back into a state of flow (A_4). In the second case, where challenge exceeds skill, the student will experience anxiety (A_3) as a result of decreased performance. Again, here there are two options: 1) challenges are reduced to allow the student to return to flow at a lower skill level (A_1), or 2) the student increases their skill level until they return to flow in a more complex environment and at a higher level of cognition (A_4) (Csikszentmihalyi, 2008).

This cycle could in theory repeat indefinitely with the goal of guiding the student back into flow at an even higher level of complexity. "It is this dynamic feature that explains why flow activities lead to growth and discovery. One cannot enjoy doing the same thing at the same level for long. We grow either bored or frustrated; and then the desire to enjoy ourselves again pushes us to stretch our skills, or to discover new opportunities for using them" (Csikszentmihalyi, 2008, p. 75).

Transactional Distance Theory

According to Gorsky and Caspi (2005), there are three criteria that should be applied in the development of virtual or immersive curriculum content to a traditional training program which are (1) structure (2) dialogue and (3) learner autonomy. Structure, according to Gorsky and Caspi (2005), describes how dialogue and transactional distance are inversely proportional to one another. For example, the less dialogue a learner has with other learners or the instructor, the more transactional the course material becomes. Dialogue can describe the relationship between the type of structure of the course and the relationship dialogue has to the structure of the course. The more structure in a course, the less dialogue occurs between the learners. According to Gorsky and Caspi (2005), when a program is highly structured and instructor learner dialogue is non-existent, the transactional distance between learners and instructors is high. Learner autonomy and transactional distance is the third criteria and are directly proportional to each other. The greater the structure and the lower the dialogue in a program, the more autonomy the learner has to exercise (Gorsky & Caspi, 2005).

The Need

The rapidly growing world of immersive technology offers endless opportunities for application in various educational settings. This is especially true in formal military training programs which demand curriculum that addresses the needs of learners with varied backgrounds and experiences and are built to achieve a minimum level of competency and performance in complex environments. As do many organizations, the Air Force has sometimes approached the use of immersive technology in formal training with a *trial-and-error* type methodology. This tactic can be valuable when resources are abundant, the sample size of the trial is relatively small or finite, and the charge from leadership is to "fail forward" through aggressive and rapid innovation (Hawkins, 2019, Title). However, when resources are limited and the design must be scaled to consistently support large numbers of learners, it is critical to use the lessons learned from "failing forward" to methodically develop effective and efficient training programs.

Two examples of this challenge are the Air Force's Pilot Training Next (PTN) and Maintenance Next which are both programs aimed in part at leveraging advanced and emerging technologies to improve the quality and efficiency of training (Woodward, 2020). As these trial efforts are scaled for the entire force, there is a need for a framework to assist in determining how to facilitate training most effectively in the range of immersive environments instead of seeing the technology as a one-size fits all solution for every training scenario.

The Framework

Overview

With advances in immersive technology, a learning theory anchored by experience and student interaction, and an understanding of how to harness learner engagement through the concept of flow, learning experience (LX) designers have all the tools necessary to capitalize on immersive learning environments. The challenge is linking these tools to determine the optimal environment for cognition throughout formal military training programs. Instead of simply transferring training events from a live environment to a virtual platform, this paper proposes a framework grounded in experiential learning theory and driven by the concept of achieving and maintaining flow which also meets several criteria used to develop learning in a virtual or immersive learning environment. These criteria include those defined by Transactional Distance Theory and Ehrlich's (2002) four criteria for virtual learning which are: (1) Learner to Interface – the ability for the learner to interact with the immersive technology (2) Learner to Content – the ability for curriculum to be applied within the immersive learning environment (3) Learner to Learner – the ability for the learner to learn from other learners and (4) Learner to Instructor – the ability for the learner to learn from the instructor.

At the center of Flow Driven Learning Experience Design (FLXD), are the four stages of Kolb's ELT, surrounded and shaped by three principles of flow (see Figure 3). Additionally, Transactional Distance Theory under girths the framework for the FLXD. Transactional Distance Theory provides us an understanding of the importance of structure when developing distance education or in the case of this paper immersive learning. The rigidity and flexibility of flowing between different methods of immersive, traditional, and live training heavily influences the autonomy, connection, and dialogue a learner will encounter and as a result underpins the foundation of the LXD model. Structure within immersive or traditional learning influences the autonomy of the student (Giossos, Koutsouba, Lionarakis, & Skavantzos, 2009). Autonomy provides control of the learning process to the student. How that control is created is crucial to understanding when to incorporate traditional training approaches or immersive training approaches such as the use of virtual reality or augmented reality.

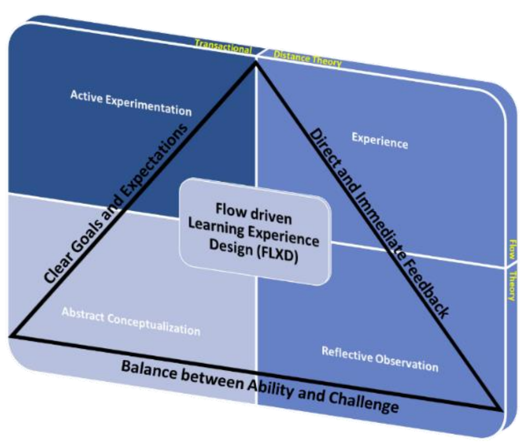

Figure 3. Flow driven Learning Experience Design.

To utilize the framework, a training event should be constructed so that the flow principle of Defining Clear Goals with Expectations underpins the Concrete Experience step of ELT. The student should then take that experience into the second stage of Reflective Observation and the third stage of Abstract Conceptualization. For both the second and third stages, to set the conditions for flow, the student must receive feedback from instructors as well as other students. After synthesizing their experience into concepts and theory, the student should move into Active Experimentation. This is an opportunity to fulfil the final and most critical condition of flow – leading the student into an event with "a good balance between the perceived challenges of the task at hand and the learner's own perceived ability to solve it" (Challco et al., 2016, p. 218). This is where Transactional Distance Theory comes into the model. The structure developed to allow the student to engage the challenge at the right level with the proper amount of autonomy must be taken into consideration. Different types of immersive technology can provide the learner with different levels of autonomy and structure. The use of virtual reality (VR) or augmented reality (AR) learning approaches can be quite structured as well as quite flexible, thus creating different levels of autonomy and ability to complete the task in the training program.

As a result, Transactional Distance Theory then requires us to determine the optimal environment, virtual or otherwise, for conducting training. To meet this challenge, FLXD proposes that LX designers conduct an "environmental assessment" in parallel with the cycle described above. When verifying that a training event creates the desired experience with clear goals, LX designers should ask *how immersive must the environment be to create a given experience?* Next, when ensuring a means of direct and immediate feedback to promote reflective observation and abstract conceptualization, the question is, *what is the mechanism for the feedback* (i.e., direct feedback from a human instructor vs automated programmed feedback) and *what is the type of feedback required for the student to relate their experience to concepts for the given task or learning objective?* Finally, when building a training event that will move a student into the final stage of active experimentation, LXD should ask *which environment, live vs. simulated, presents the most appropriate challenge to match student ability for where they are in the overall course and their proficiency.* The following sections describe each stage in the FLXD model in more detail.

Concrete Experience

The FLXD model starts with the first of "four distinct but interrelated stages" – Concrete Experience (McCarthy, 2016, p. 96). LX designers must determine the type of experience the student should have based on the desired learning objective or specified task. According to Duff (1998), "learners acquire information by immediate concrete experience from full involvement, without bias, in the new experience" (p. 337). To apply the FLXD model, with the purpose of enhancing the basic ELT with the principles of flow and determining the appropriate medium for content delivery on the virtual reality spectrum, the following steps may be used as a guide.

The first step in the FLXD Model is to identify clear goals with expectations for the training event. In a technical training program these will likely be formalized and based on a minimum standard of performance. Establishing a mechanism for communicating goals and expectations is a key element to the first step in the FLXD model. Additionally, defining what the concrete experience should also be defined in this first step. This should include a clear statement of the training event itself that the learner will experience. Developing a specific concrete experience will help in determining the optimal point on the virtual reality spectrum for content delivery. An example of this process using pilot training is determining the concrete experience which then determine is the simulation or training should be conducted the aircraft itself, in a full-motion simulator, or in a head mounted device. There are several questions to help determine the fidelity of the concrete experience as well as the medium for delivery. Those questions are listed below:

1. How immersive must the environment be to create the concrete experience?
2. What benefits/drawbacks might there be from one end of the virtual reality spectrum to the other?
3. Potential benefits of a live environment: spontaneous real-world influences on training may be desired to increase complexity, all senses engaged, higher induced stress level, no question as to the authenticity of the experience.
4. Potential drawbacks of a live environment: may not be possible to precisely replicate scenarios, resource constraints (i.e., cost and availability of actual aircraft), unable to "pause" training to deliver immediate and focused feedback.
5. Potential benefits of a virtual environment: scenarios are precisely replicable, access to training less resource constrained, ability to "pause" training to deliver focused and immediate feedback.

6. Potential drawbacks of a virtual environment: challenges with achieving the necessary state of immersion, potential lack of real-world, real-time spontaneous inputs, lack of a developed program for managing and maintaining required equipment (varies from unit to unit)

The questions and examples above are not all inclusive, but rather provide a starting point to aid LX designers in determining how best to create concrete experiences for learners. This is just one part of the solution; next it is necessary to address what is required for a learner to accomplish reflective observation.

Reflective Observation

The second step in the FLXD model to consider is reflective observation. This is where the learner reflects on the concrete experience and "organizes and examines the experiential data from a different perspective" (Duff, 1998, p. 337). To do this, while maintaining flow, a learner requires direct and immediate feedback. Below are questions to guide the instructional design of any given event to help determine the type of environment most conducive to flow in this step of the ELT:

1. What is the mechanism for providing feedback to the learner following their concrete experience?
2. Is direct and immediate feedback available?
3. Is the required feedback qualitative, quantitative or both?
    a. Quantitative feedback may be better gathered and communicated in a virtual environment (see benefit above of the ability to "pause" training) and may not require a live instructor while qualitative feedback is more likely to require a live instructor in the loop.
        i. Advances in simulation technology and artificial intelligence may offer opportunities for true qualitative and interactive feedback meaning a live instructor may eventually not be required.

Next, beyond organizing and examining data from their experience, learners should be guided to the next stage of abstract conceptualization (Duff, 1998).

Abstract Conceptualization

After having a concrete learning experience and gathering observations from that experience through feedback that allows for reflection, the ELT cycle suggests that the learner should experience abstract conceptualization. As driven by flow, in this step of the FLXD learners "develop generalizations that help them integrate their "observations into sound theories or practices" (Duff, 1998, p. 337). Kolb's (1984) definition of learning as the "process whereby knowledge is created through the transformation of experience" makes this a critical part of the ELT cycle (p. 38). The questions that should guide course development using the FLXD model for this step are very similar to those for the previous step of Reflective Observation – however, answering them to determine the proper delivery method for lesson or event content is potentially even more dependent on the quality and fidelity of the virtual technology. FLXD recommends the following questions as a starting point to maximize flow during this part of the ELT cycle:

1. What was the mechanism for providing feedback to the learner during the reflective observation step?
2. How is the student encouraged to develop their own thoughts in preparation for adjusting their behavior?
3. Is live instructor facilitation required to identify when learners have had an opportunity to transform their previous concrete experience into concepts and connections they are prepared to apply in new experiences?

Answering the above questions is likely the most critical, and most challenging, task of applying this model. It will be difficult to determine if synthesis of the experience has occurred until the student goes on to the next step of active experimentation.

Active Experimentation

The last step of the FLXD model (before starting again with a new concrete experience) is active experimentation. During this part of the learning cycle the student should be able to apply the theories they have synthesized for problem solving and decision making during new training and learning experiences. This is the point at which LX designers must intentionally balance student skill with increased challenges to create the greatest opportunity for learning. Again, in order to determine the optimal environment for the training event to take place, it is helpful to ask questions that arise from looking at ELT through the lens of flow.

1. Which type of environment (live versus simulated) presents the most appropriate challenge to balance student skill?
    a. This may be live, simulated, or any combination of the two that produce the environment where a student is challenged to *experiment* by applying the theories they have constructed from learning throughout the cycle.

The Model as a Whole

Much like ELT, FLXD is not a finite set of four stages. Rather it is a continuous and cyclical framework that is intended for application within individual learning experiences as well as from event to event in a formal, syllabus-driven military training program. Learner experience throughout the cycle should be supported by design that allows students to remain in a state of flow. FLXD is a theoretical and conceptual framework which combines two educational learning theories: ELT and Flow Theory and is underpinned by Transactional Distance Theory. The application of FLXD will be unique to various different military training programs. Two recent military training programs that have applied a process similar to the proposed FLXD are Pilot Training Next (PTN) and Maintenance Training Next, which is now referred to as Technical Training Next Transformation.

Application of FLXD

During the initial development and research of the FLXD, Air Education and Training Command (AETC) had begun a revolutionary approach to pilot training called Pilot Training Next (PTN). In September of 2020, the third iteration of PTN was conducted at Joint Base San Antonio-Randolph Air Force Base (AFB), Texas. Through PTN learners used a student-centered approach using a variety of virtual reality immersive training devices. PTN allows for self-paced academics to occur through competency-based learning allowing learners to progress at an individual pace. One unique aspect of PTN is the relationship, structure, and autonomy between the instructor pilot and the student pilot. These aspects of PTN demonstrate the FLXD in action. How the instructor pilot and student pilot interact through out the PTN program has been critically reviewed by those who run PTN. Creating a coach-athlete style of instruction while the student pilot is using virtual reality equipment (virtual reality simulation) demonstrates the use of the FLXD. This coach-athlete approach requires immediate and didactic dialogue between the instructor pilot and student pilot. Examining the flow of what skills or objectives should be demonstrated in a virtual reality simulator as compared to a traditional simulator or live training event has been a staple in PTN. Providing augmented reality curriculum content on mobile devices has also allowed PTN students to self-pace through PTN course content. These three examples demonstrate already established and applied aspects of the FLXD. Another training program within AETC that began a journey of including and revolutionizing training was Maintenance Training Next.

With success of PTN, AETC looked to expand and experiment with virtual and immersive learning in other formal training programs. Similar approaches and use of immersive technologies became known as Learning Next. During 2019-2020, AETC broadened the use of immersive learning technology into expanding this approach to enhance training for maintenance and other technical training as part of Learning Next. The initial implementation of similar approaches to maintenance training from PTN became known as Maintenance Training Next.

During the initial iterations of Maintenance Training Next, several subject matter experts in virtual reality, augmented reality, instructional designers, and consultants worked together to assess the initial development and application of virtual and augmented reality technology and course development to ensure self-efficacy and effectiveness of this new approach to training was meeting the mark for formal maintenance training. Initial development of Maintenance Training Next program used virtual reality, augmented reality, video-based content, group discussions, instructor lead instruction, and self-paced content. Figure 4 provides a basic overview of the initial flow of Maintenance Training Next, describing when the learner used virtual reality or augmented reality content, structure of the training program, and interaction with instructors.

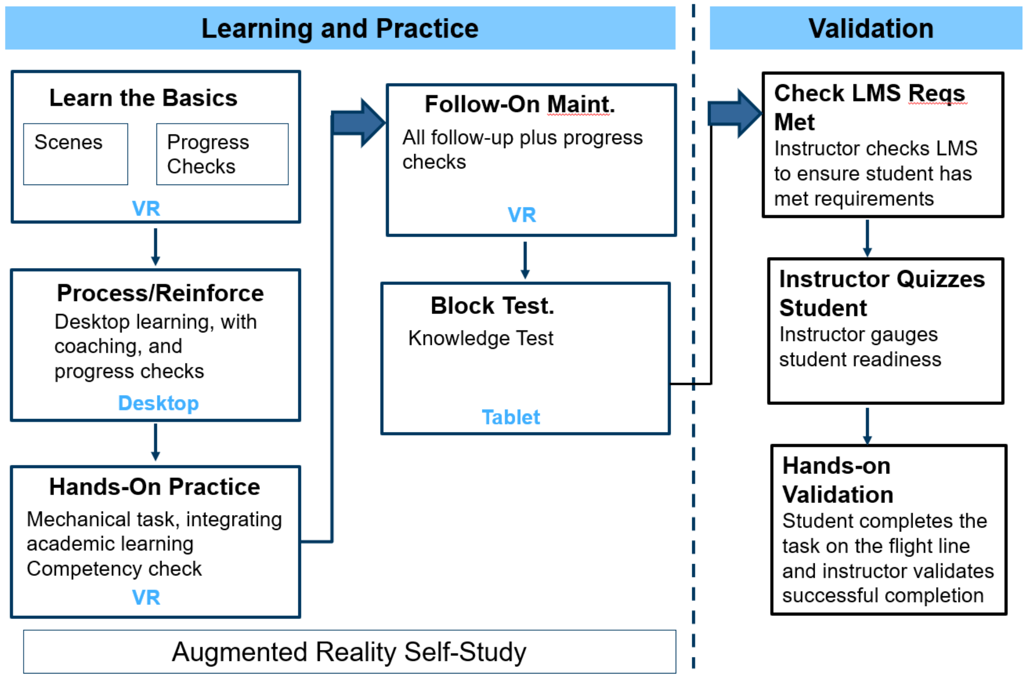

Figure 4. Initial Flow of Maintenance Training Next Program.

The goal of ensuring an effective Maintenance Training Next program is understanding how these different learning approaches are implemented and when to use virtual reality, augmented reality, or self-paced curriculum. Using the FLXD provides a roadmap and conceptual framework to assess and understand the best approach to developing and using immersive technology in a training program. Maintenance Training Next employed virtual reality, augmented reality, and video-based content for several aspects within formal maintenance training. Those areas of formal maintenance training within Maintenance Training Next included: (1) 781 Form Series (2) Fire Extinguisher Inspection (3) Marshalling Signals (4) Operation Flight Controls (5) Pre-Inspection and Operating Equipment (6) Remove, Install, & Secure Hardware (7) Select and Use Tools (8) Servicing Landing Gear & Shock Strut (9) Wheel and Tire. These areas of maintenance training developed virtual reality and augmented reality content, video content, and a particular flow, process, and structure for each of these training tasks through the initial flow depicted in Figure 4. During initial research and use of Maintenance Training Next, feedback from Airmen who went through the initial stages of Maintenance Training Next was gathered. The End of Course (EOC) question provided to those who went through Maintenance Training Next was, "Were there differences, if any, between the hands-on in the virtual environment and the hands-on evaluation in the actual environment?" Based on this EOC question, the following qualitative comments were captured in Table 1.

Task	Qualitative Feedback
781 Form Series	Student likes being with the instructor with the forms rather than getting the videos because the first-hand accounts from the instructor are better for correctly filling them out. Got some more clarity from the actual hands-on. The main difference is that it is a job for two people so that is not in the VR. The VR you just lift the brake assembly out and do not know how heavy it is. When you put the hydraulic fluid hose back on to the actual brake assembly you must torque it back on, not just use the safety wire like in the VR.
Fire Extinguisher	In virtual reality, you can zoom in but in the actual environment you can physically touch it

Marshalling Signal	Some of the signals are misleading in the reading material. Arrows hard to see on paper, 2D. Video would have been easier to tell what exactly the signals were (rather than pictures) In hands-on, was told to extend arms fully (e.g., extend fully above head) to make signal clearer for pilot.
Operation Flight Controls	Ario was helpful with information, explaining the science behind how planes fly. But the hands-on was a little hard because they had to learn so much in that section. That made the student anxious but when they got the hang of it, it was good. Nice having the instructor because they give you cool tips and/or analogies to remember information; really helped them.
Pre-Inspection	Feel like the videos in Ario did not prepare you at all for the hands-on task, did not really use the information that it gave you in the video. The way the instructors explained it was way more helpful. I didn't go by the TO when I was completing hands-on". Evaluator/instructor walked student through task immediately prior to evaluation, and then student did it. Reasoning: instructor said Ario video had shown not to be informative for students who went before.
Remove, Install, & Secure Hardware	Felt I needed a lot more information prior to hands-on (safety wire). Was shown the safety wire in training material, but video did not really explain what he was doing with it and why. No previous experience with safety wires. Knew basics from training materials but did not know how to do a lot of it.
Select and Use Tools	Tools pretty much looked the same, VR and AR. Only difference was physically using the tools rather than just picking them up in VR. VR does not set you up for the actual usage task; videos are not the same as physically holding them.
Servicing Landing Gear, & Shock Strut	Hard to understand why I am doing the task. VR does not explain why/what they are doing, just shows you procedural steps. First step in VR was to take off valve dust cap off and discard it… during the hands-on, evaluator corrected student and said never to discard valve dust cap.
Wheel & Tire Assembly	Can follow steps from learning in the VR but would not be able to tell you what I am doing/why I am doing it or use correct verbiage to explain process.

Table 1: ***Qualitative Feedback – Maintenance Training Next***

Analysis from the EOC feedback of the Maintenance Training Next initial training program yielded initial indication and need to ensure incorporating immersive learning technology into a formal training program is applied. The FLXD model provides that guidance and framework. Within the feedback several qualitative data points support the framework of the FLXD model. For example, within the 781 Forms Series task, students are provided a video-based content approach to comprehend the proper documentation for completing 781 Forms. However, from the initial feedback, instructor to student dialogue on how to complete the 781 Forms documentation would be more effective for student learning of the 781 Forms task. This type of feedback supports Transactional Distance Theory, where structure and dialogue of the course and instructor involvement is key when determining what task and at what level of the task the course program is requiring the student to achieve or master. Within the Select and Use Tools task, students had conflicting experiences with the use of the virtual reality to provide authentic real visualization of specific tools but were not able to use the tool in virtual reality. This conveys the FLXD with respect to Flow Theory. In this example, what is the virtual reality trying to achieve? Having a virtual visualization of the tool maybe useful or is the use of the virtual reality to allow for the student to complete the task? Similar examples can be found in the Servicing Landing Gear, & Shock Strut task. The feedback indicates the virtual reality task of taking the dust cap off and discard it was a different procedure than what the instructor instructed the student to do. This provides another example of the importance of what level of challenge and skill is needed to be completed and what level of immersive or other form of learning is needed to ensure completion to acquire that specific skill or task. There are several other examples that can be extrapolated from the captured feedback in areas of structure of the course content, what level of task completion is needed, what experience does the learner need or require, and how much autonomy does the student have in the content or task completion in virtual reality, augmented reality, or video-based content. The most impactful data point from this qualitative feedback that came up several times is "why". Students commented often about wanting explanation of why a task was to be completed a certain way or why the information was presented in a particular form. This provides insight into one of the main parts of the FLXD, connection of purpose to the training program structure. Connection to purpose or why the training program has been designed a specific way must be taken into consideration to ensure experience, reflection, behavior change and the flow of the program with instructor and student dialogue must all be present in various means to ensure self-efficacy in the training program outcomes.

Virtual reality, augmented reality, video-content based curriculum are immersive learning approaches that have been proven to be effective means for immersive learning. However, students must process through the stages of experiential learning as well when introducing immersive learning technology into a training program. Students can be given concrete, social, and abstract experiences as the Experiential Learning Theory suggests. However, students must also process through introspection and self-reflection from those experiences. This process of reflection to engage in future behavior change requires not just immersive technology, but dialogue between instructor to student and student to student. Without developing structure into the course to allow for dialogue between instructor to student and from student to student, the course material can become transactional resulting in reduce efficacy in the program. Transactional Distance Theory, the foundation of the FLXD model reminds us that developing or adopting immersive technology into a training program also requires connection between instructor and learner to ensure the "why" behind the task at hand in the virtual, augmented, or other immersive enviornment has meaning and purpose behind the desired end state of the task. The experience of using immersive technology cannot be the starting point. The experience along with reflection through experiential learning with immediate feedback to learners through various communication mechanisms and proper task-to-challenge (Flow Theory) within various immersive technologies is needed to create self-efficacy in any type of formal training program.

Conclusion

There is no question that the world of emerging immersive technology is expanding exponentially by the day. This growth presents opportunities in many areas, not least of which is the field of formal military training. The Air Force recognizes the potential to increase both the efficiency and effectiveness of training through the application of immersive technology, however, there is a lack of resources and tools for those integrating this technology into existing curriculum to guide them in determining the optimal delivery method for a given training event or task. Trial and error, while sometimes valuable and even necessary when innovating, is not sustainable in the current resource and time constrained environment. As a potential solution, this paper proposes a framework based on experiential learning theory and the principles of flow applied to the concept of learning experience design to inform the intentional use of immersive technologies to prevent a loss of training effectiveness and maximize the potential benefits of increased student performance and program efficiency.

Though there is a need for a methodology that will help scale efforts such as Pilot Training Next and Maintenance Training Next, something that should start today is the intentional and focused education of Airmen at every level about emerging immersive technologies. A better understanding of what technologies exist, and their potential benefits and drawbacks, will aid in ensuring immersive technology is leveraged where and when it provides the most benefit as opposed to simply "pulling and replacing" live events with virtual ones. An effort to ensure form is determined by required function will improve process and outcomes for both learners and the institution.

ACKNOWLEDGEMENTS

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Form from Function:

Applying Flow Driven Experiential Learning to the Integration of Immersive Technology in Formal Military Training Programs

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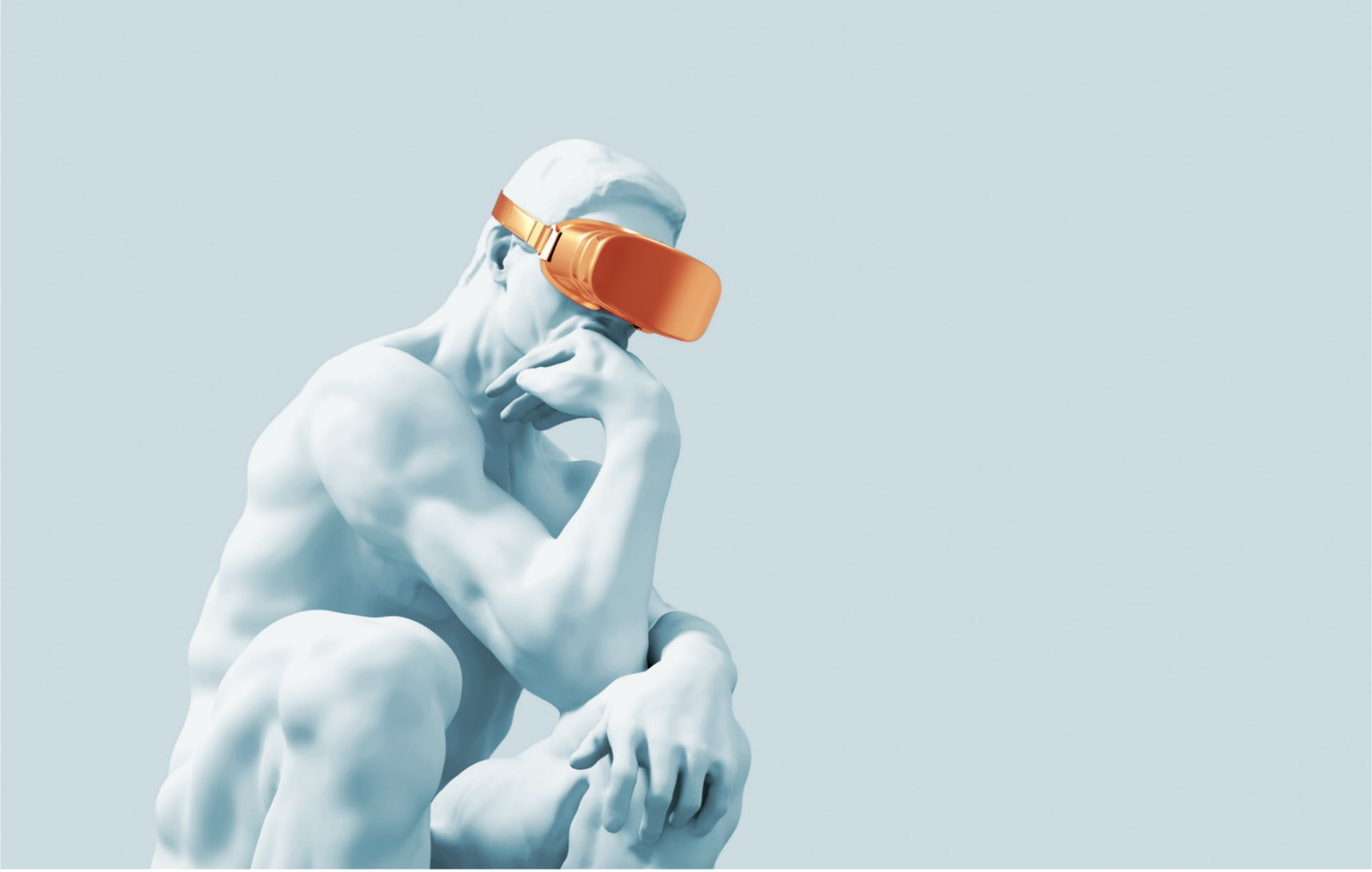
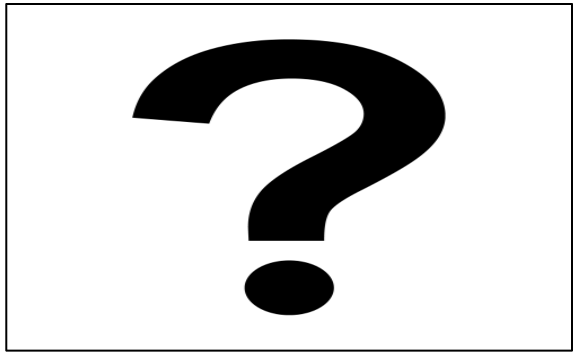
Dr. Andrew S. Clayton, Air University, Maxwell AFB, AL

Overview

- Why
- Flow Driven Learning Experience Design
  - Experiential Learning
  - Flow Theory
  - Transactional Distance Theory
- Maintenance Training Next
  - Issue
  - Apply FLXD
  - Qualitative Data Analysis from Maintenance Training Next
- Conclusion

Why



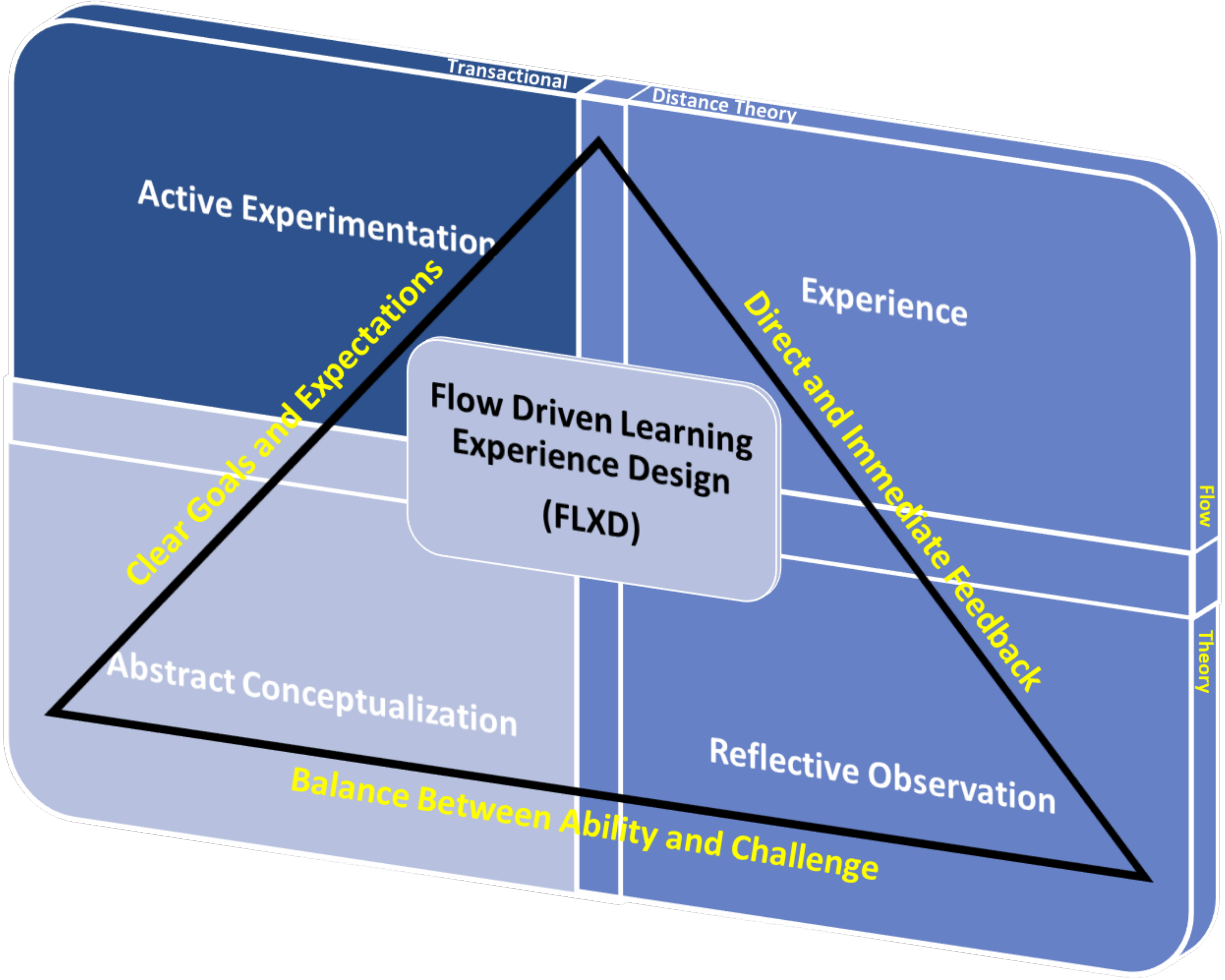


Instructional Design Vs Learning Design Experience

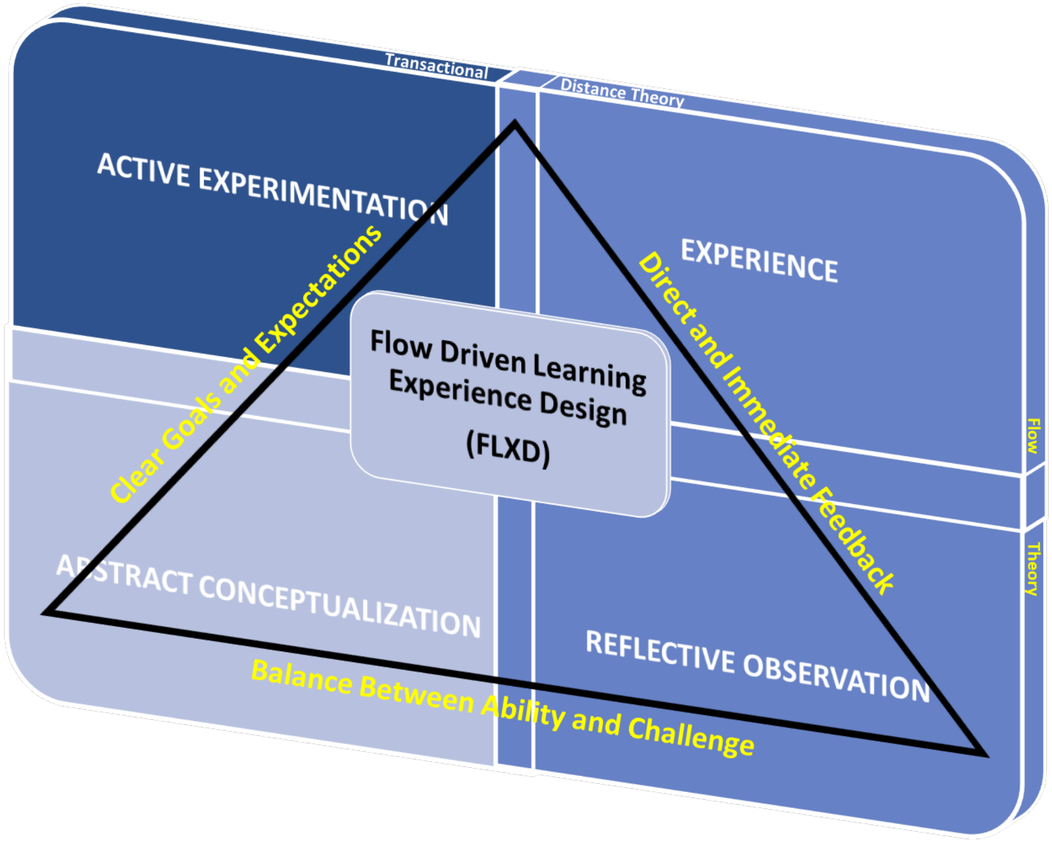
Instructional Design	Learning Experience Design
• The preparation of work-related instruction and other strategies intended to improve worker performance	• Aims to gather comparable and quantifiable data on cognitive aspects of learning
• Utilized when developing or updating course curriculum across a wide range of subjects and it is focused on "performance, efficiency, and effectiveness"	• Aims to empathize with the people you design for and connect with them on an emotional, personal and educational level
• Achieved through a "structured step by step process which is often linear"	• Achieved through a "fluid process which is often more circular"

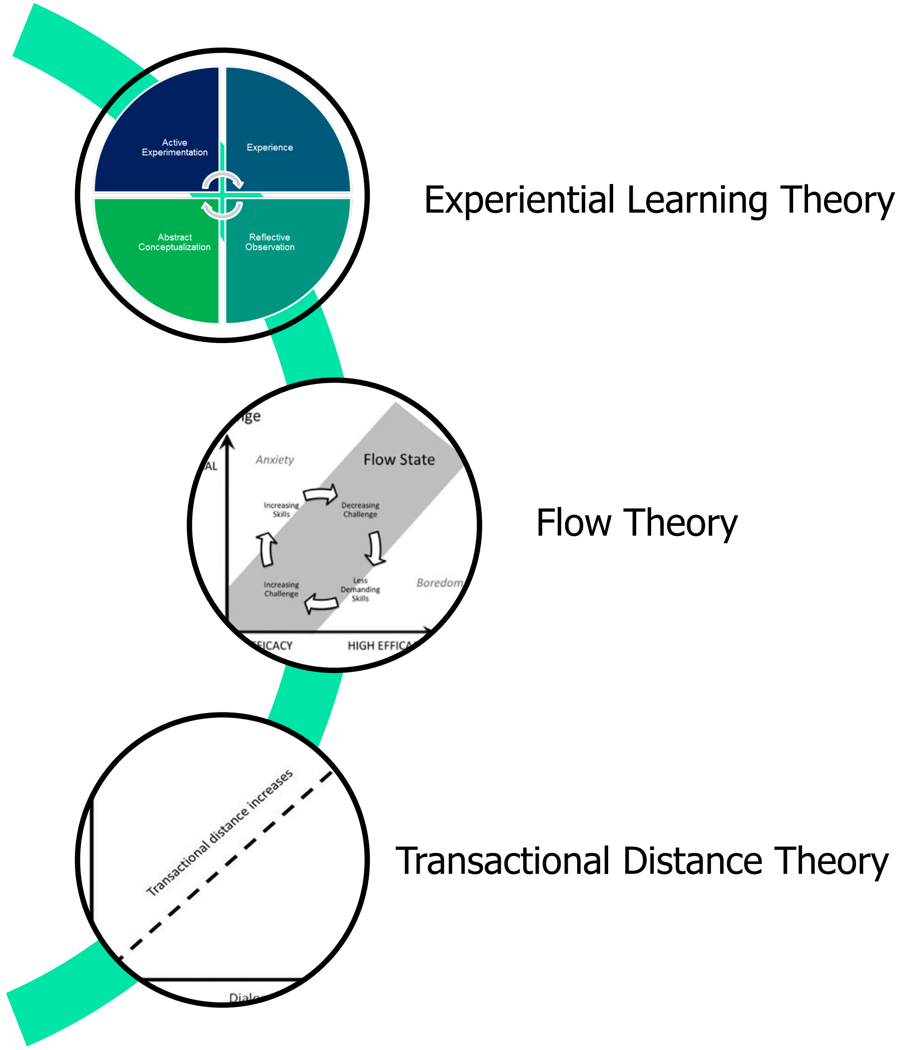
Flow Driven Learning Experience Design (FLXD)

- FLXD is not a finite set of stages. Rather it is a continuous and cyclical framework that is intended for application within individual learning experiences as well as from event to event in a formal, syllabus-driven military training program.
- Learner experience throughout the cycle should be supported by design that allows students to remain in a state of flow.
- FLXD is a theoretical and conceptual framework which combines two educational learning theories: ELT and Flow Theory and is underpinned by Transactional Distance Theory.
- The application of FLXD will be unique to various military training programs.



Flow Driven Learning Experience Design (FLXD)





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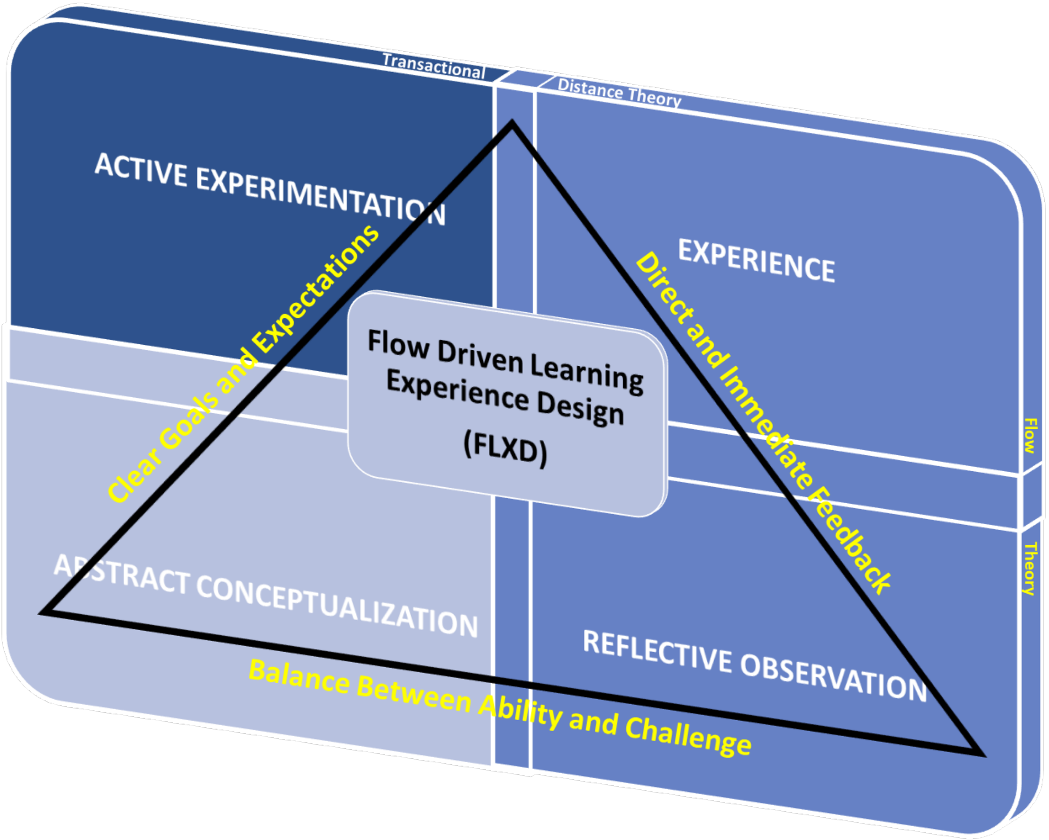
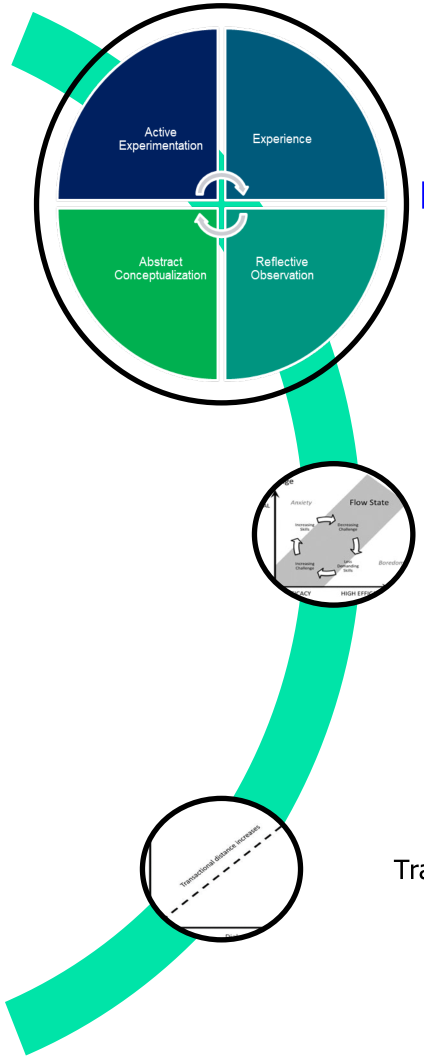


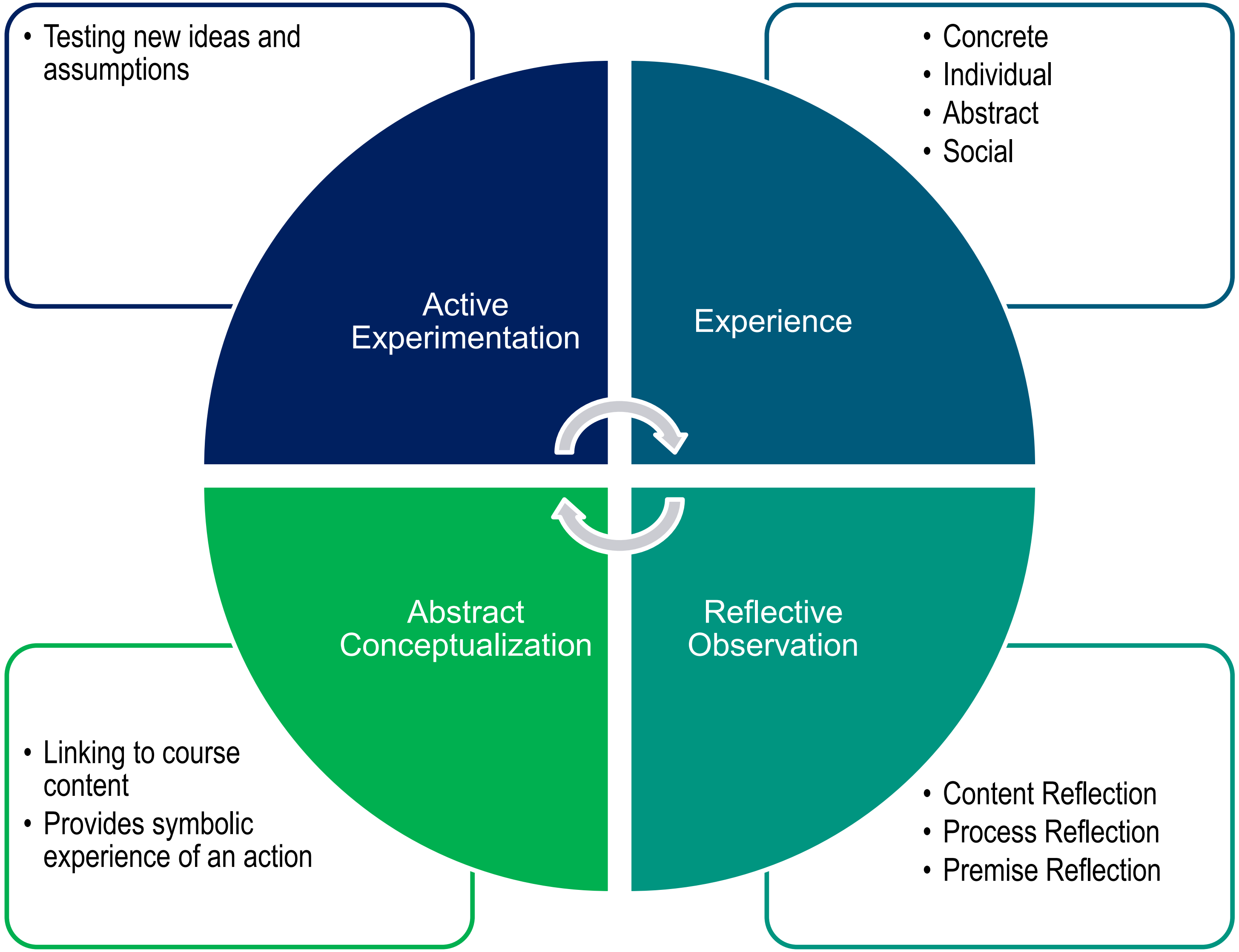


Experiential Learning Theory

Flow Theory

Transactional Distance Theory

Experiential Learning Theory



Experiential Learning Theory

- Testing new ideas and assumptions

Active Experimentation

Experience

Abstract Conceptualization

Reflective Observation

- Linking to course content
- Provides symbolic experience of an action

- Content Reflection
- Process Reflection
- Premise Reflection

Experiential Learning Theory

- Testing new ideas and assumptions

Active Experimentation

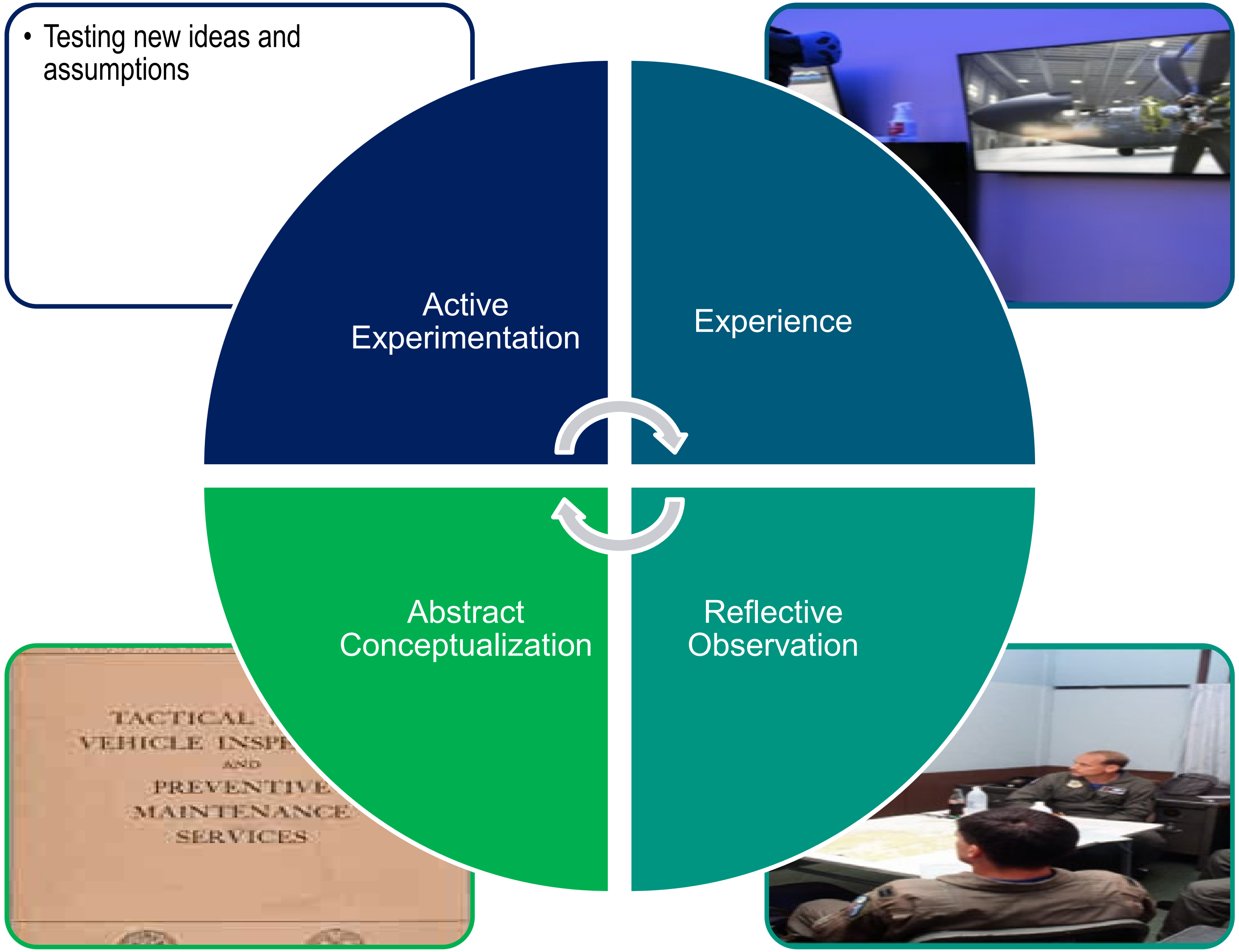
Experience

Abstract Conceptualization

Reflective Observation

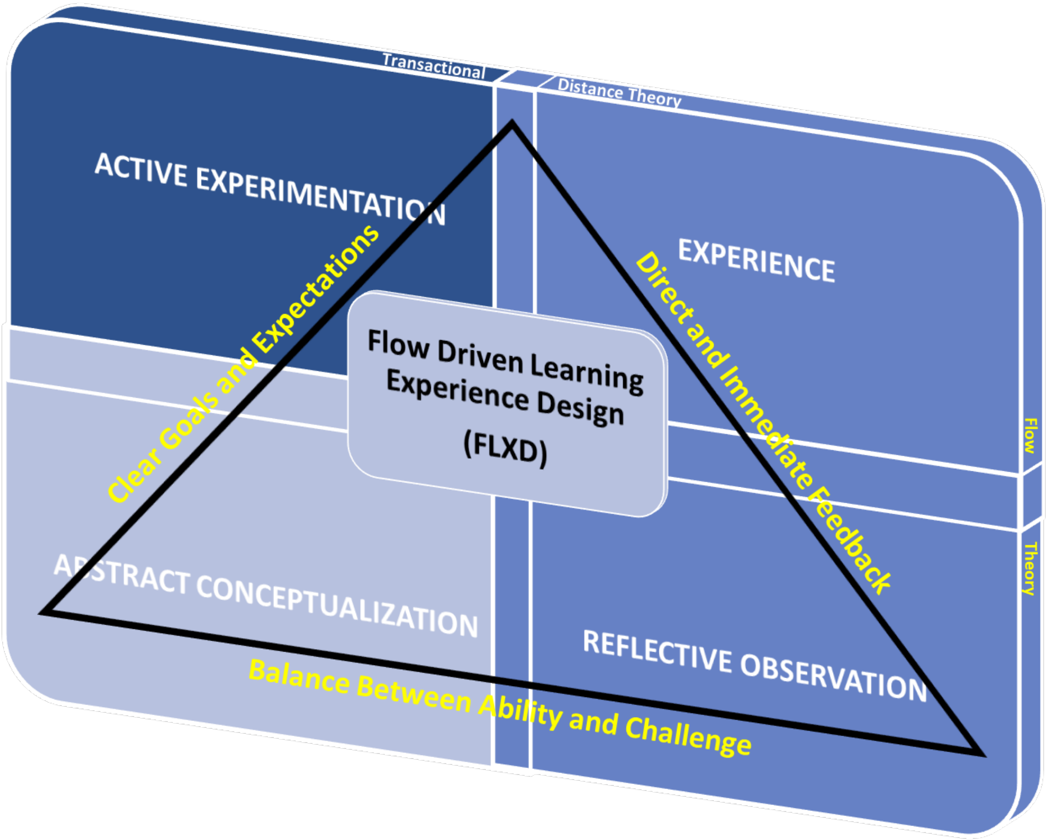
- Linking to course content
- Provides symbolic experience of an action

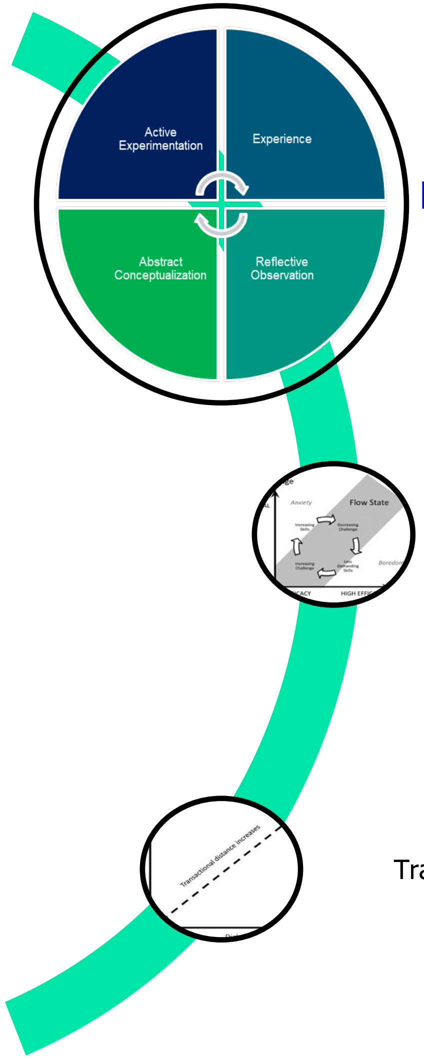
Experiential Learning Theory



Experiential Learning Theory

Flow Driven Learning Experience Design (FLXD)



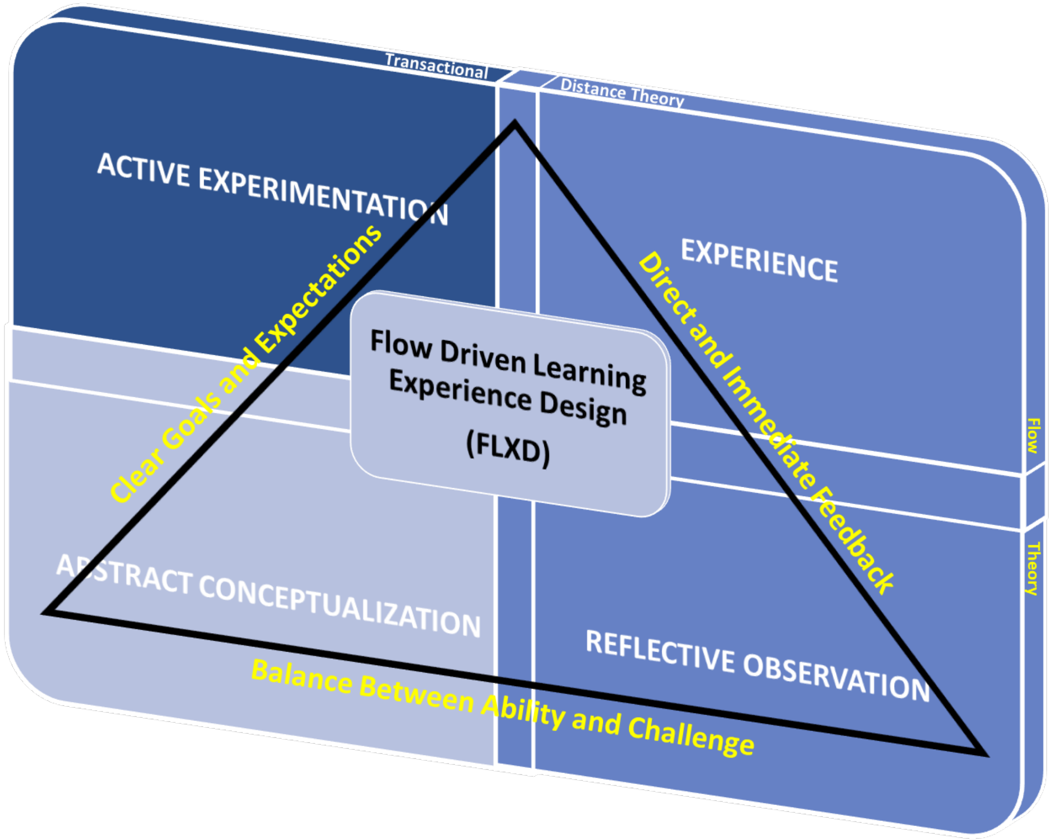


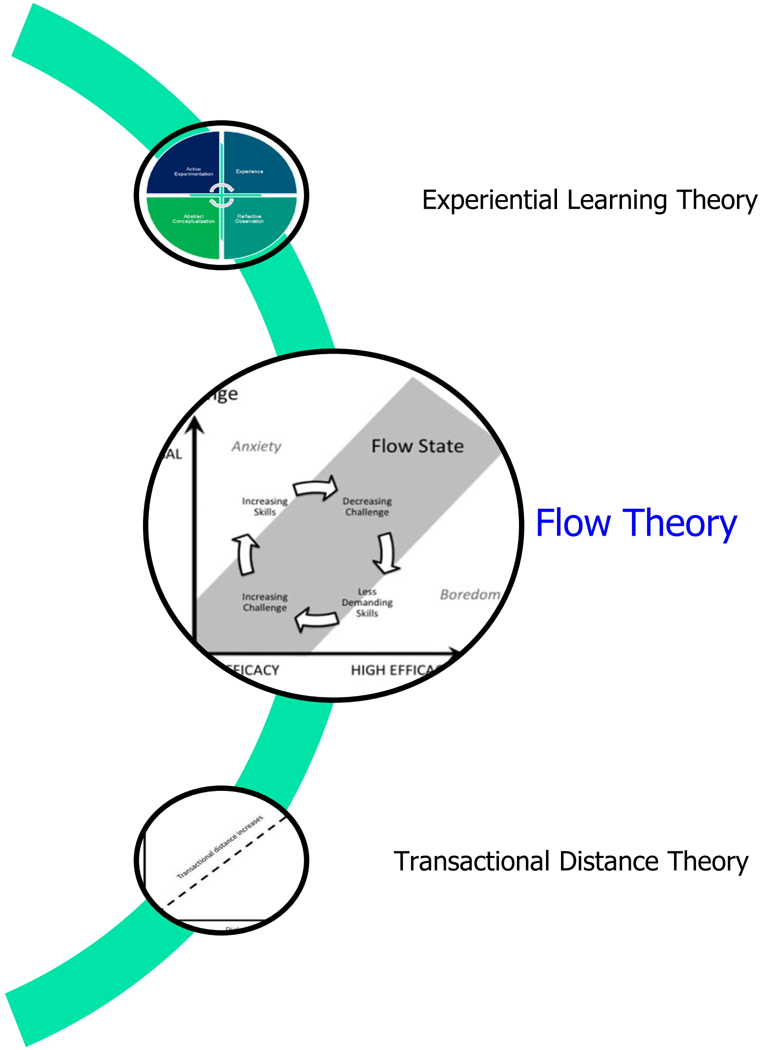
Experiential Learning Theory

Flow Theory

Transactional Distance Theory

Flow Driven Learning Experience Design (FLXD)



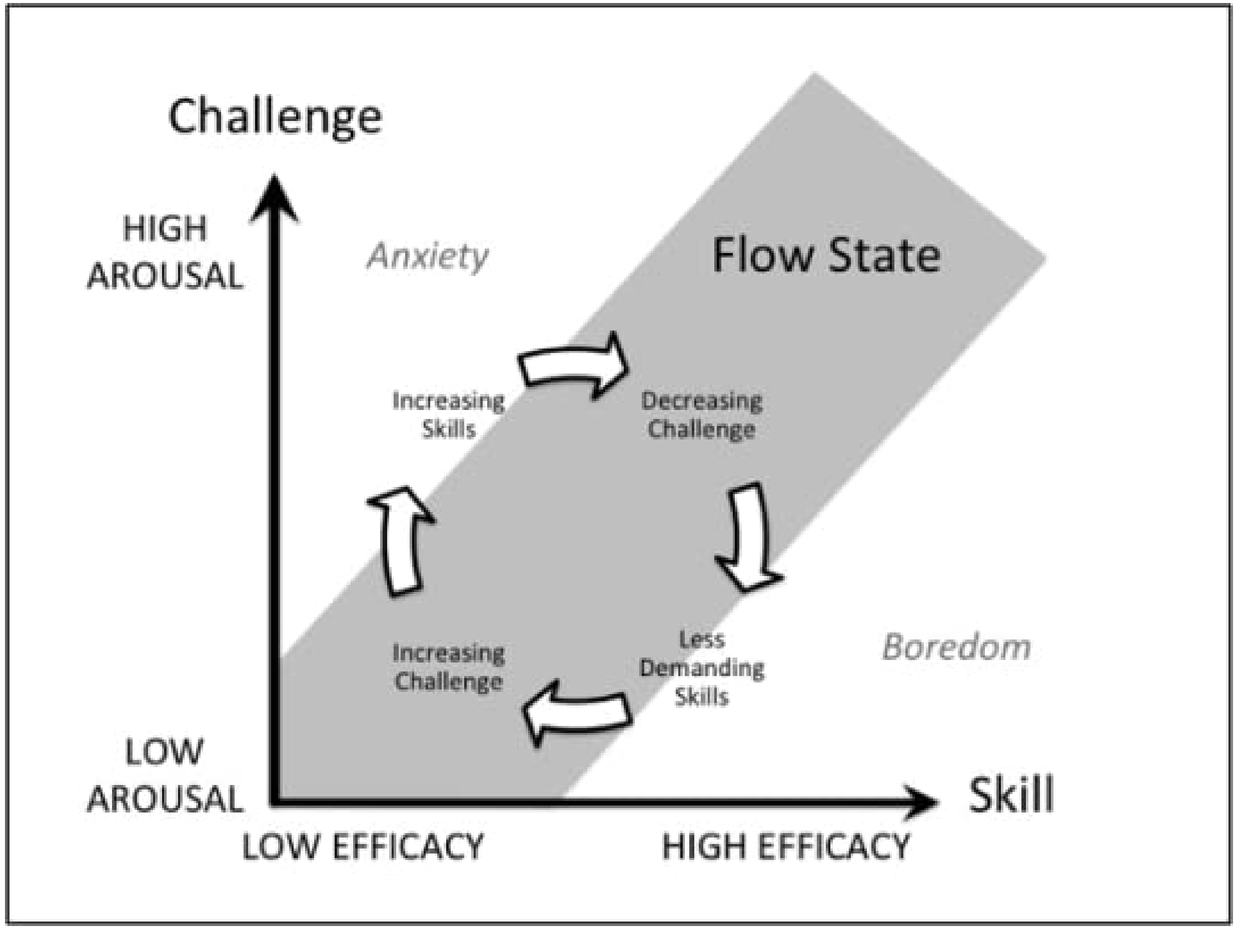


Flow Theory

- Flow Theory presents a concept for achieving and sustaining optimal learning and performance by considering the learner's affective state.

- "To motivate a student so that [they] perform learning activities with complete immersion, it is necessary that [their] affective state provide an optimal experience.

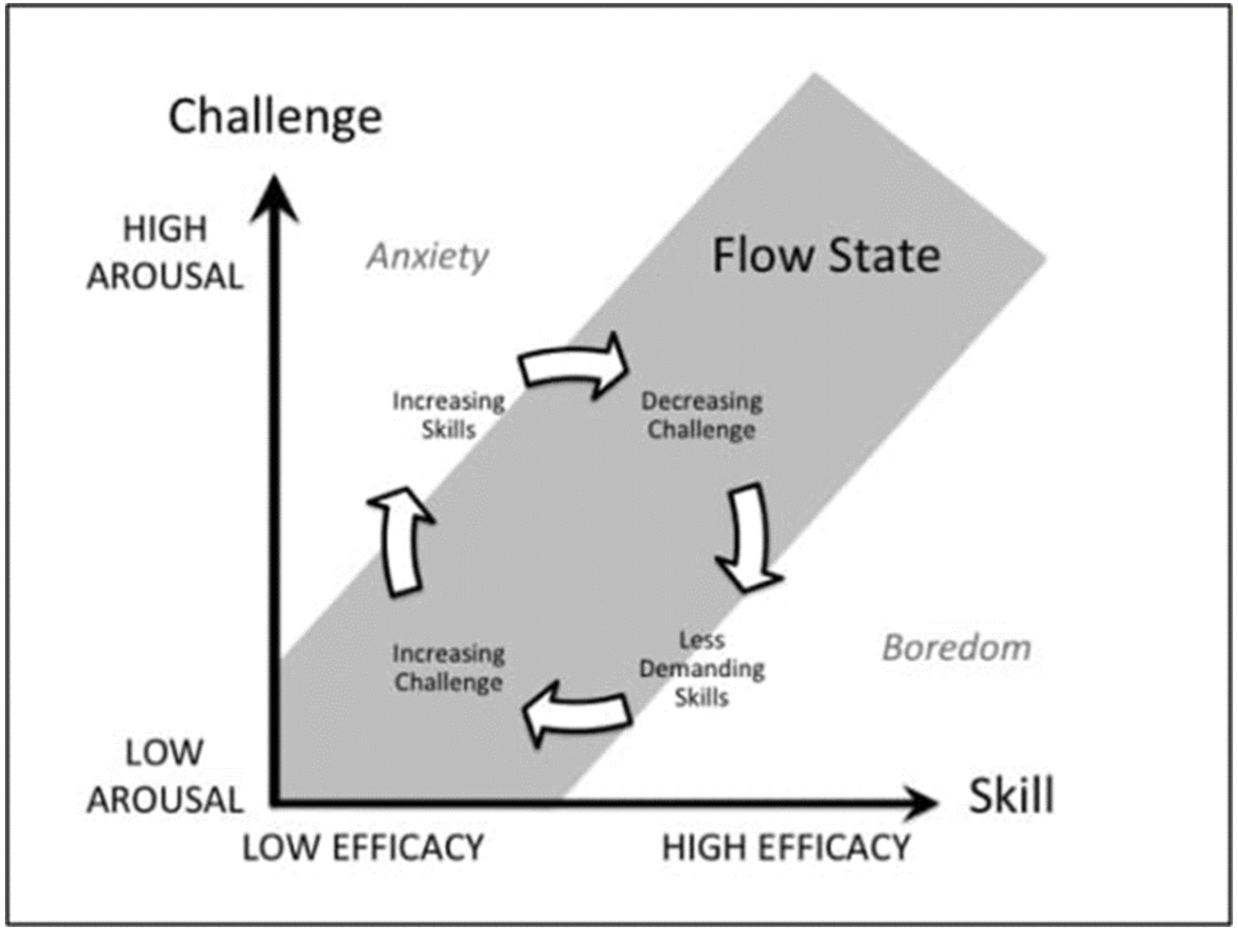
- This affective state is denominated flow, and it is a mental state of operation characterized by a feeling of energized focus, full involvement, and success in the task being performed" (Csikszentmihalyi, 2013).



Three Conditions - Flow Theory

Achieved Under Three Conditions:

1. Clear goals with defined rules and expectations are established
2. Direct and immediate feedback for the purpose of adjusting behavior is provided
3. There is balance between the challenge and student capability



Interactivity Factors driven from Flow Theory

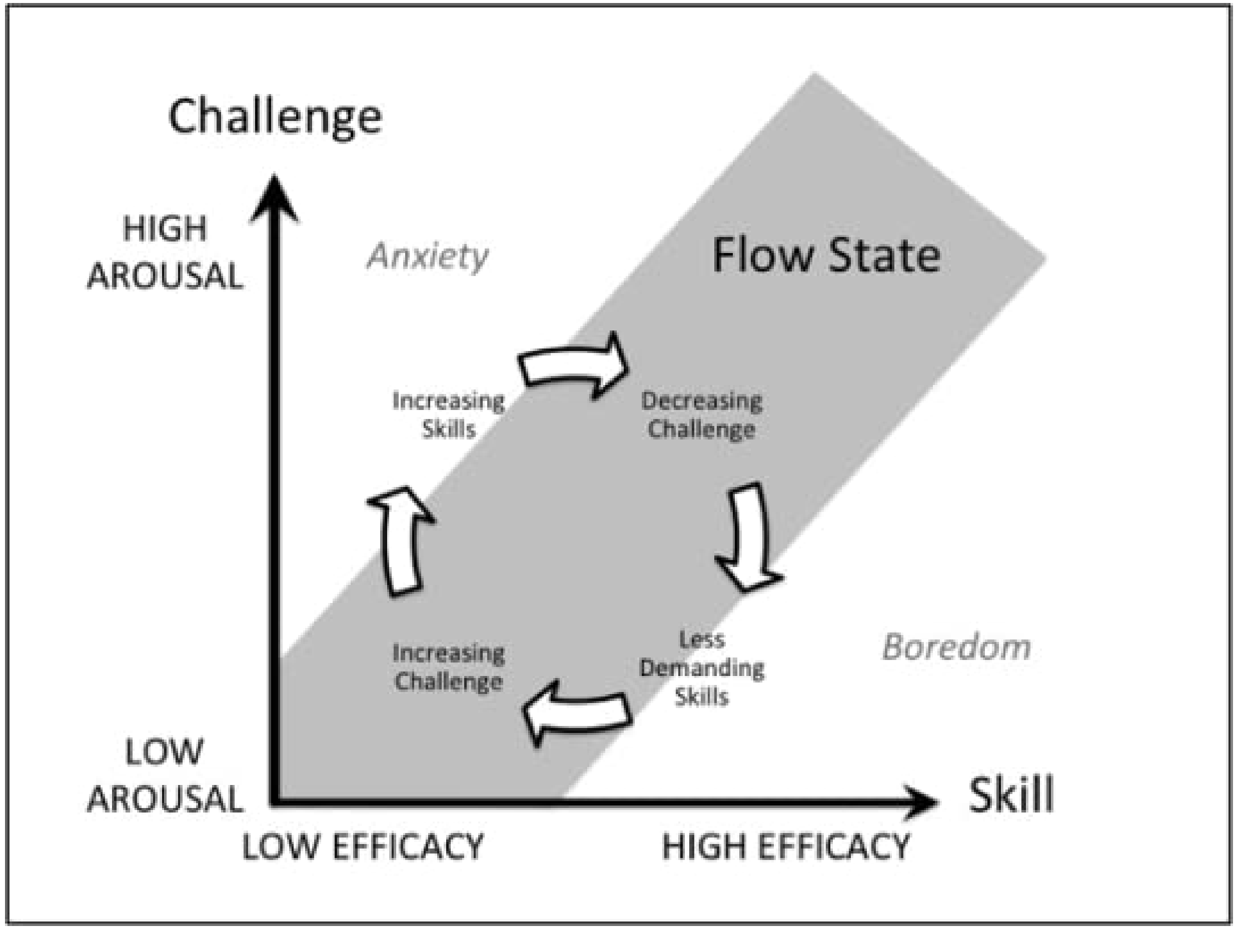
Developing Immersive Learning

1. Learner to Interface – the ability for the learner to interact with the immersive technology

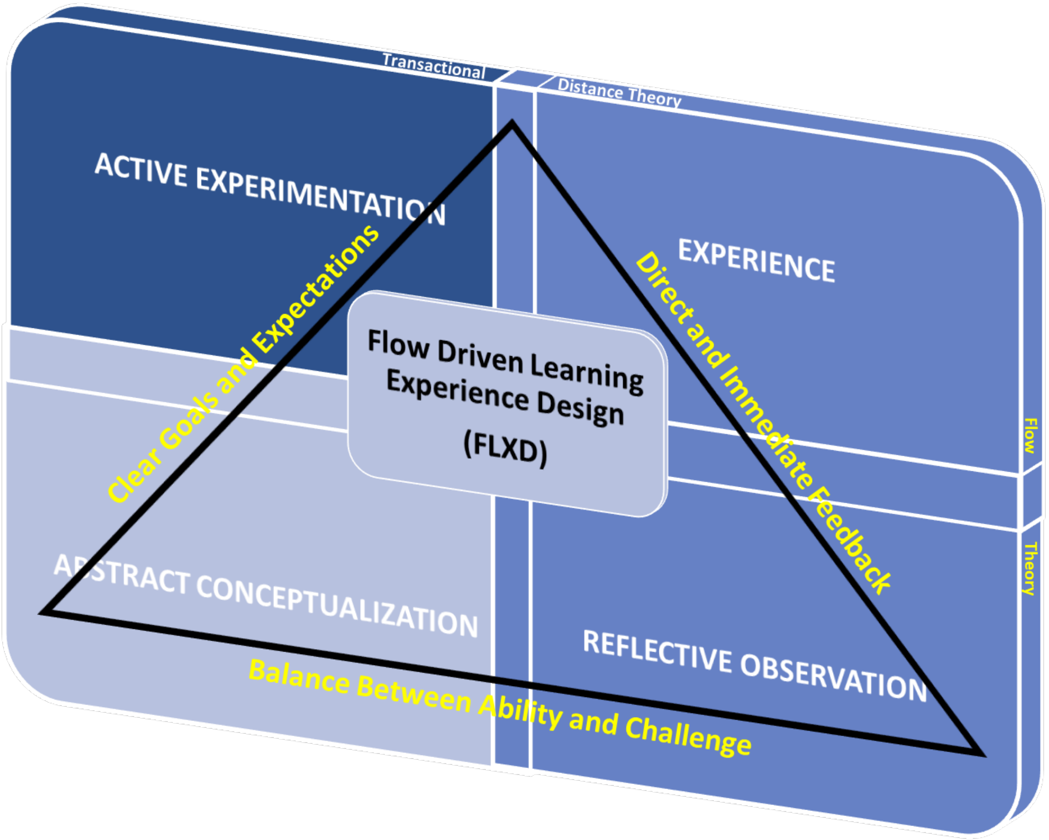
2. Learner to Content – the ability for curriculum to be applied within the immersive learning environment

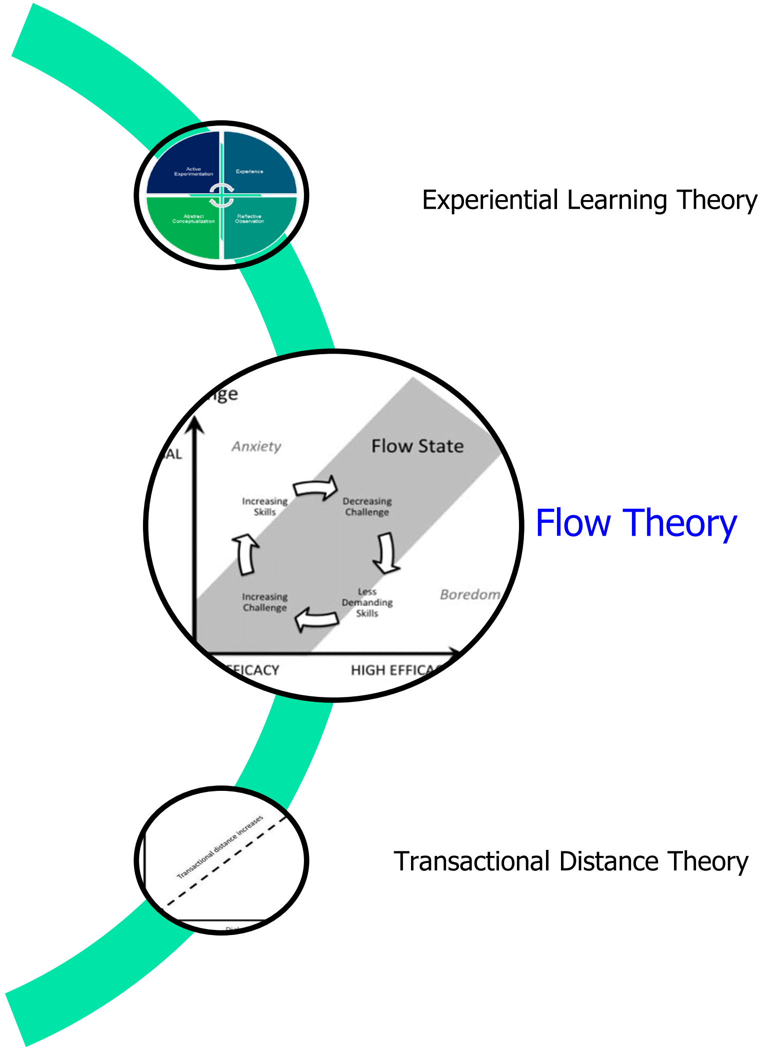
3. Learner to Learner – the ability for the learner to learn from other learners

4. Learner to Instructor – the ability for the learner to learn from the instructor.



Flow Driven Learning Experience Design (FLXD)





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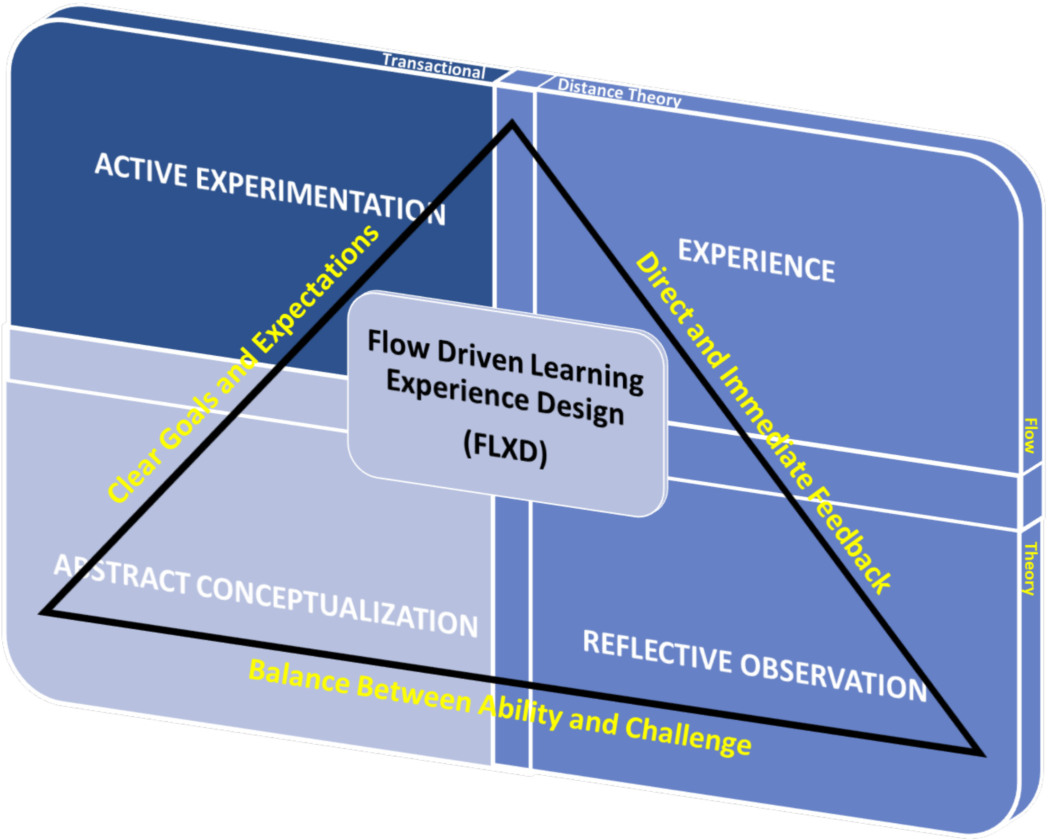
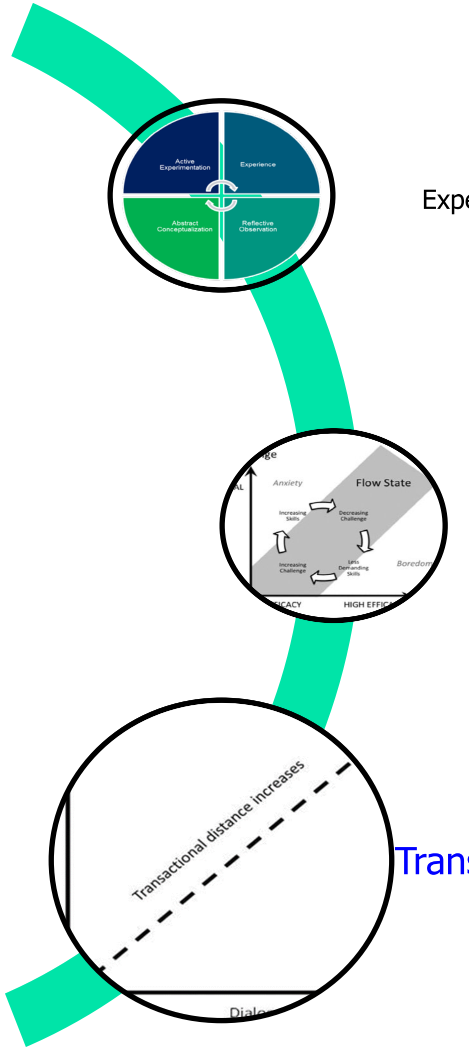




Experiential Learning Theory

Flow Theory

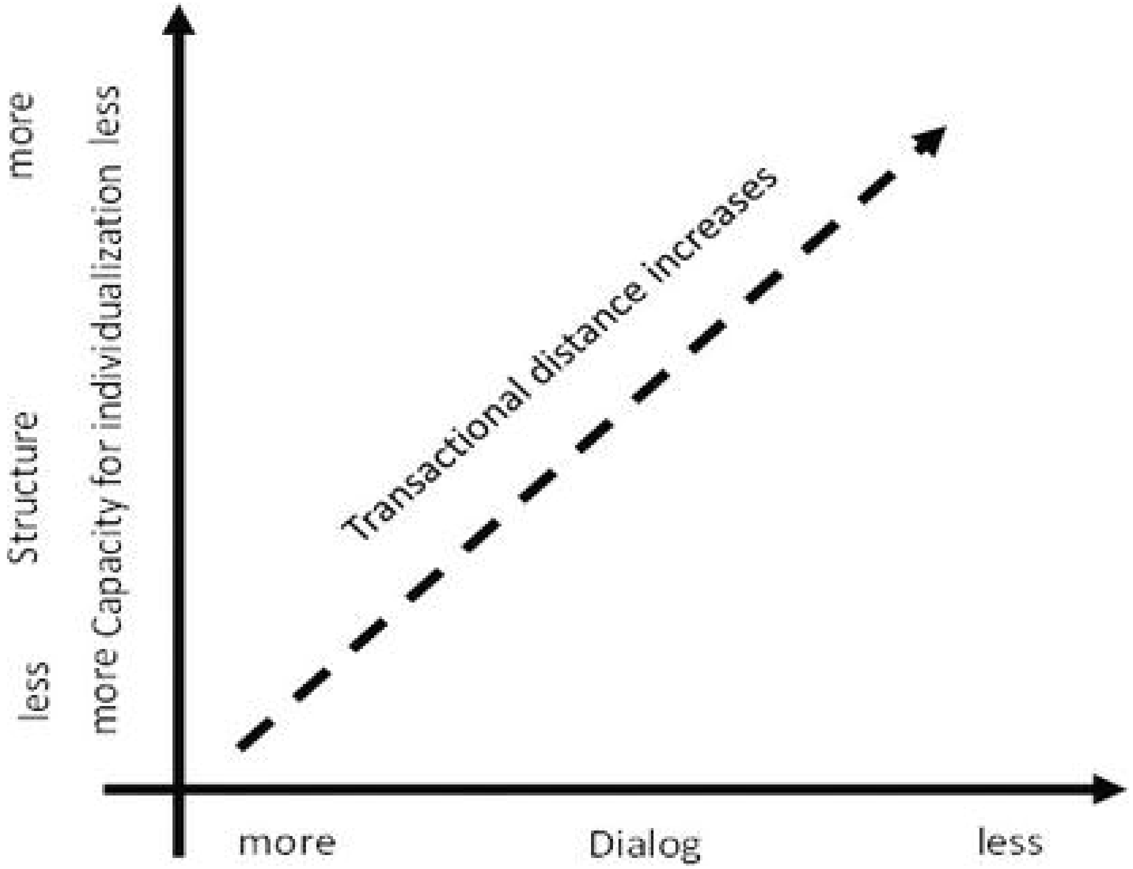
Transactional Distance Theory

Transactional Distance Theory

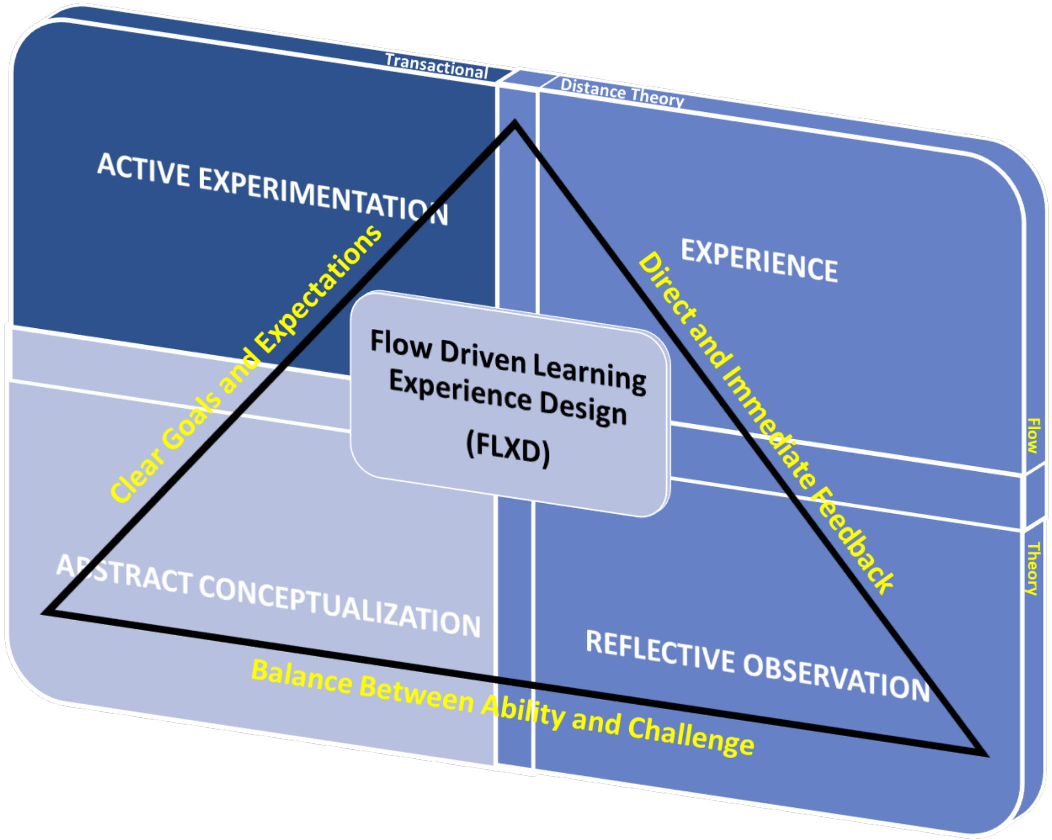
A psychological and communication space between the instructor and the learner

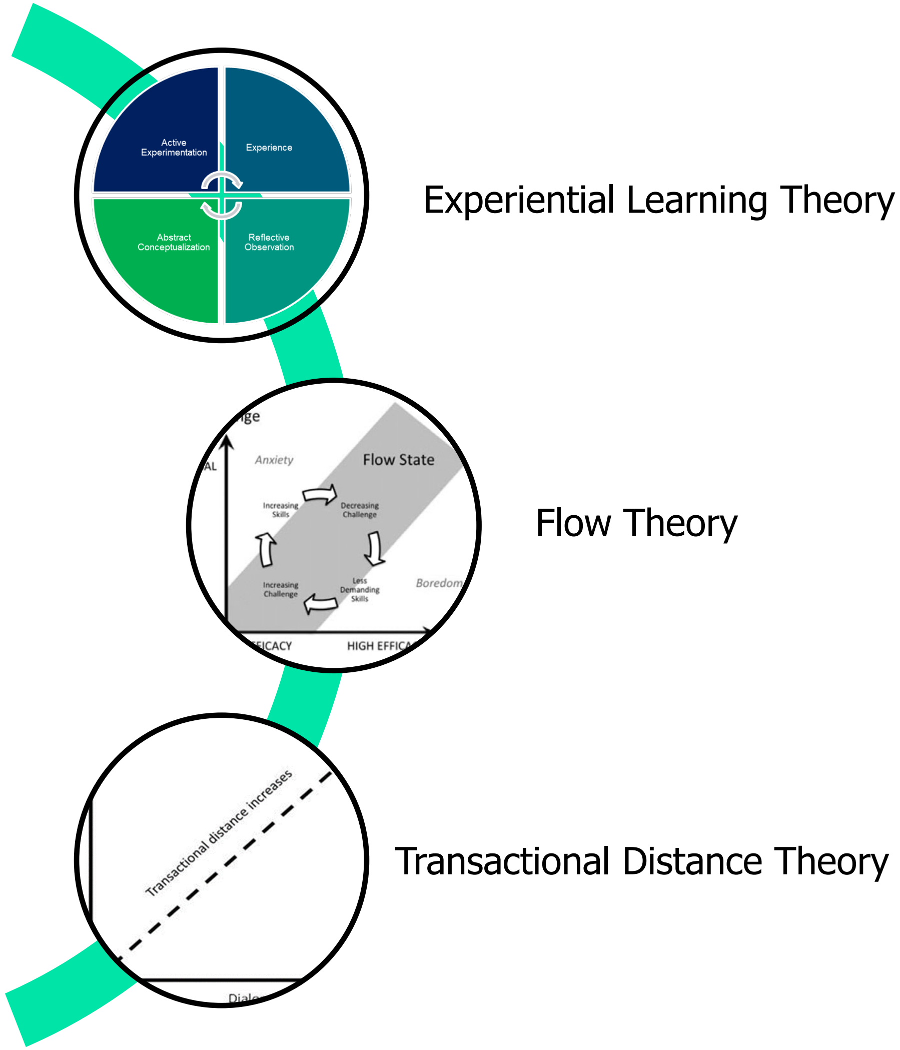
Three Criteria

1. Structure
2. Dialog
3. Learner Autonomy

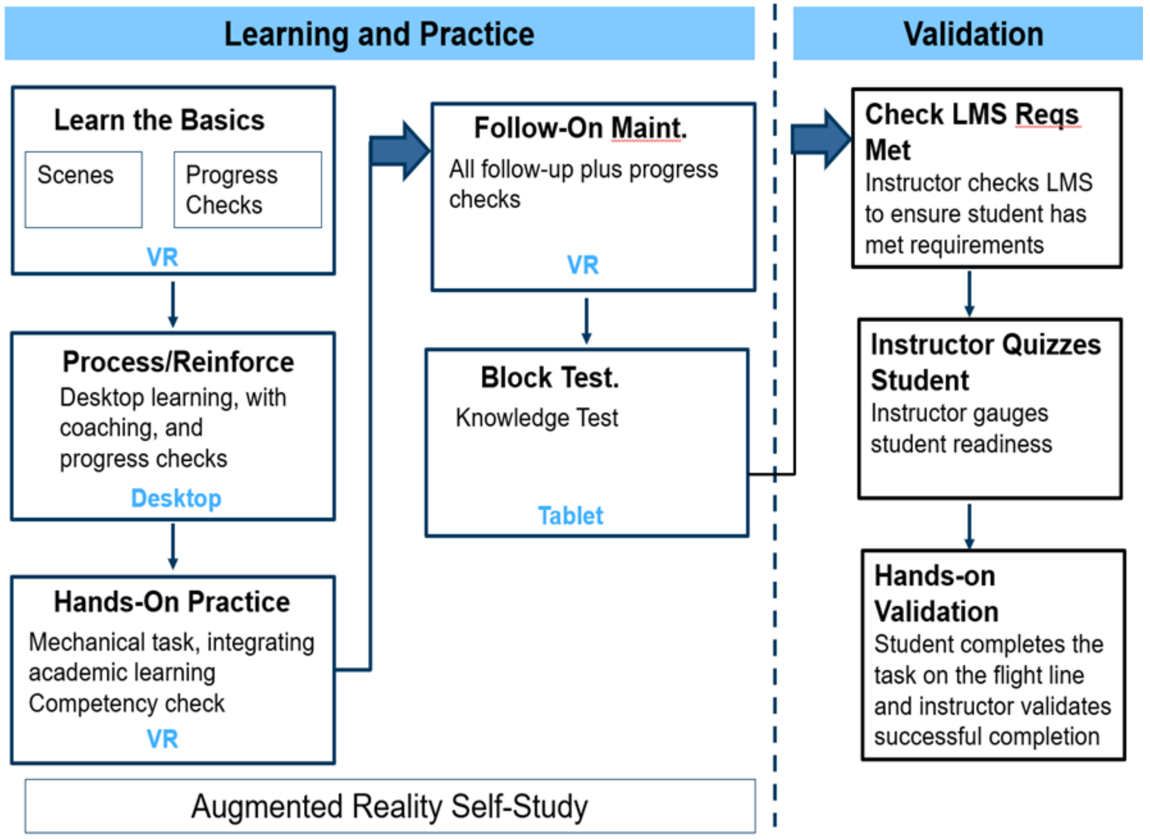


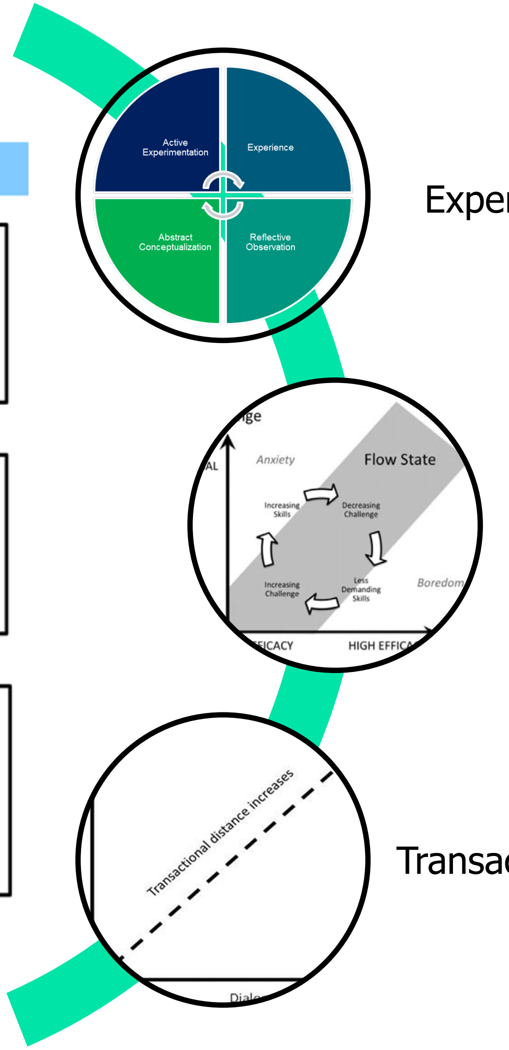
Flow Driven Learning Experience Design (FLXD)





FLXD – Maintenance Training Next





Experiential Learning Theory

Flow Theory

Transactional Distance Theory

FLXD – Maintenance Training Next

Learning and Practice

Learn the Basics
Scenes | Progress Checks
VR

Process/Reinforce
Desktop learning, with coaching, and progress checks
Desktop

Hands-On Practice
Mechanical task, integrating academic learning
Competency check
VR

Follow-On Maint.
All follow-up plus progress checks
VR

Block Test.
Knowledge Test
Tablet

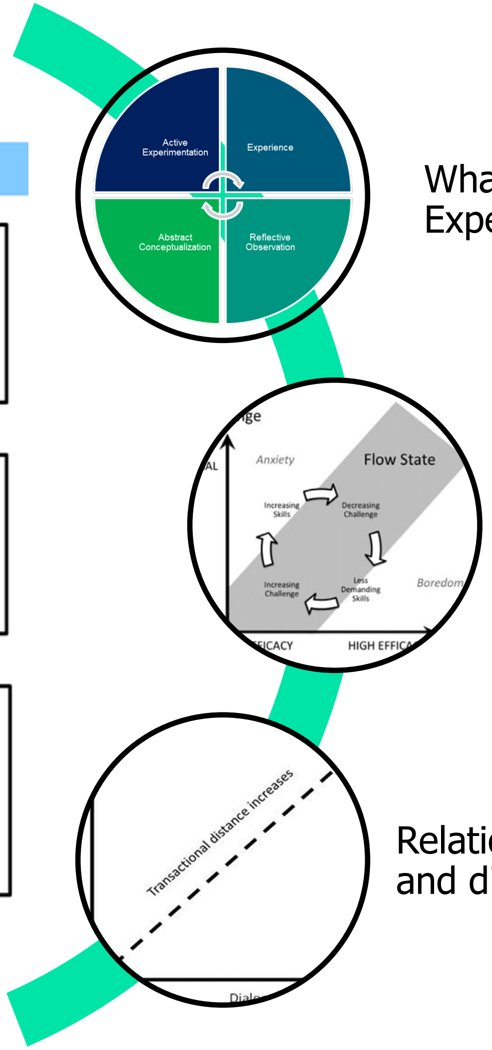
Augmented Reality Self-Study

Validation

Check LMS Reqs Met
Instructor checks LMS to ensure student has met requirements

Instructor Quizzes Student
Instructor gauges student readiness

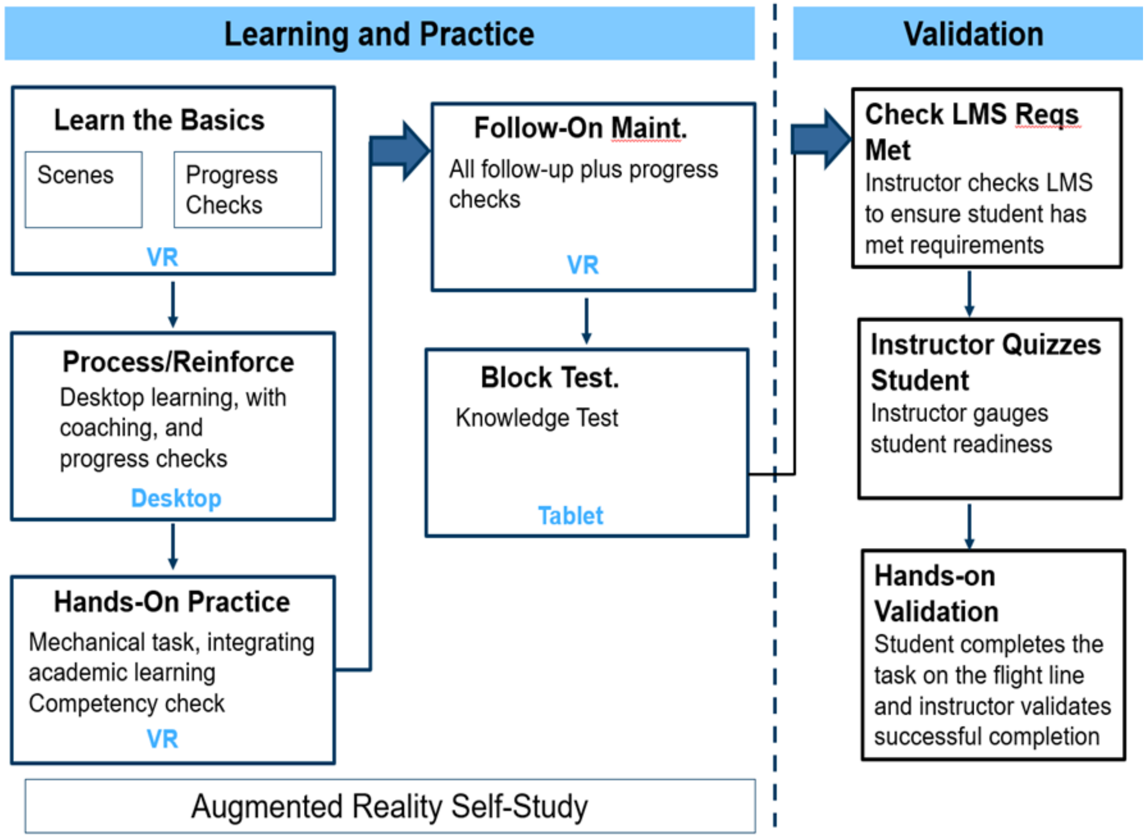
Hands-on Validation
Student completes the task on the flight line and instructor validates successful completion



What is the Purpose of the Experience?

Must include the optimal learning performance through the learner's affective state.

Relationship between structure and dialogue



Flow Theory

1. Clear goals with defined rules and expectations are established
2. Direct and immediate feedback for the purpose of adjusting behavior is provided
3. There is balance between the challenge and student capability

Interactivity Factors – Flow Theory

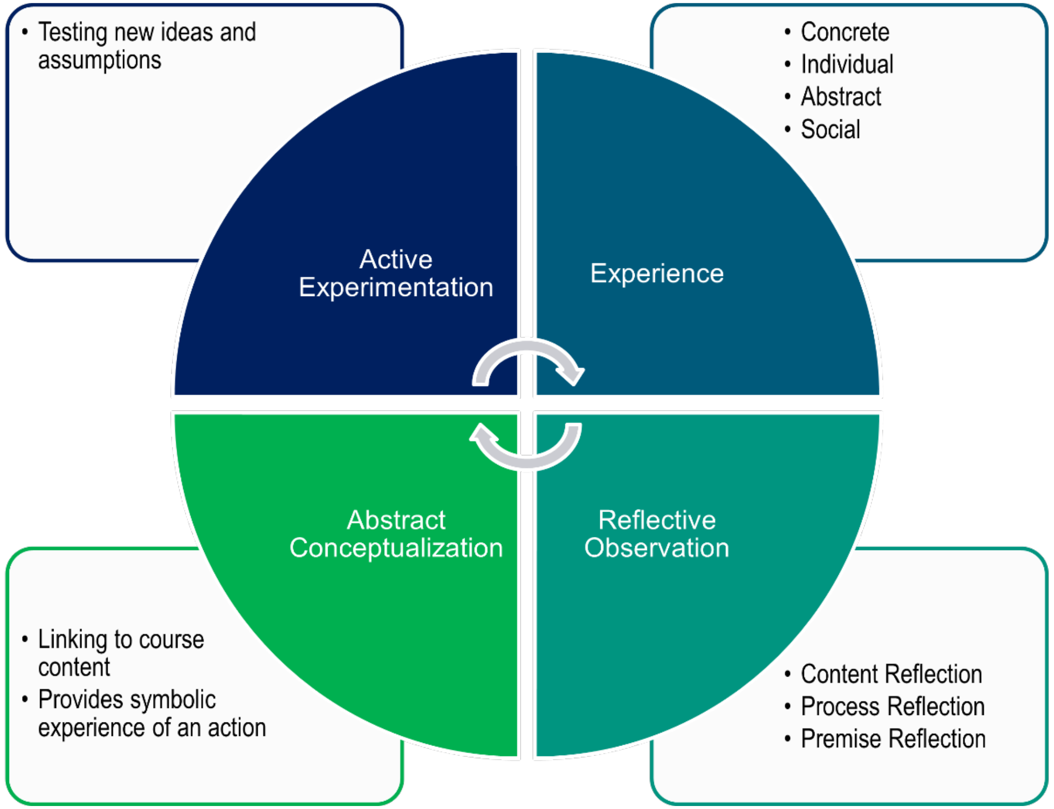
1. Learner to Interface – the ability for the learner to interact with the immersive technology
2. Learner to Content – the ability for curriculum to be applied within the immersive learning environment
3. Learner to Learner – the ability for the learner to learn from other learners
4. Learner to Instructor – the ability for the learner to learn from the instructor.

Transactional Distance Theory - Three Criteria

1. Structure
2. Dialog
3. Learner Autonomy

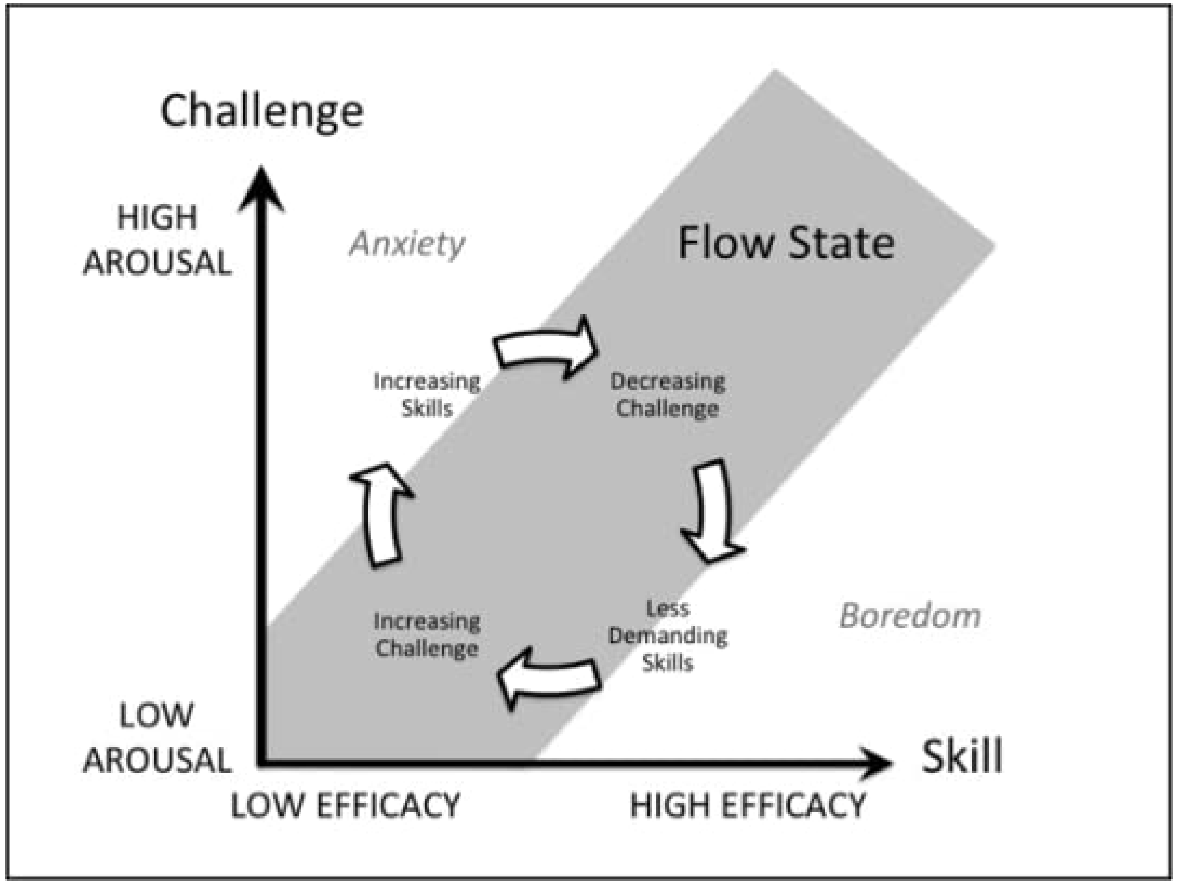
Experiential Learning Analysis - Mx Trng Nxt

Task	Qualitative Feedback
781 Form Series	Got some more clarity from the actual hands-on. The main difference is that it is a job for two people so that is not in the VR. The VR you just lift the brake assembly out and do not know how heavy it is. When you put the hydraulic fluid hose back on to the actual brake assembly you must torque it back on, not just use the safety wire like in the VR.
Fire Extinguisher	In virtual reality, you can zoom in but in the actual environment you can physically touch it
Marshalling Signal	In hands-on, was told to extend arms fully (e.g., extend fully above head) to make signal clearer for pilot.
Remove, Install, & Secure Hardware	No previous experience with safety wires. Knew basics from training materials but did not know how to do a lot of it.
Select and Use Tools	Tools pretty much looked the same, VR and AR. Only difference was physically using the tools rather than just picking them up in VR. VR does not set you up for the actual usage task; videos are not the same as physically holding them.



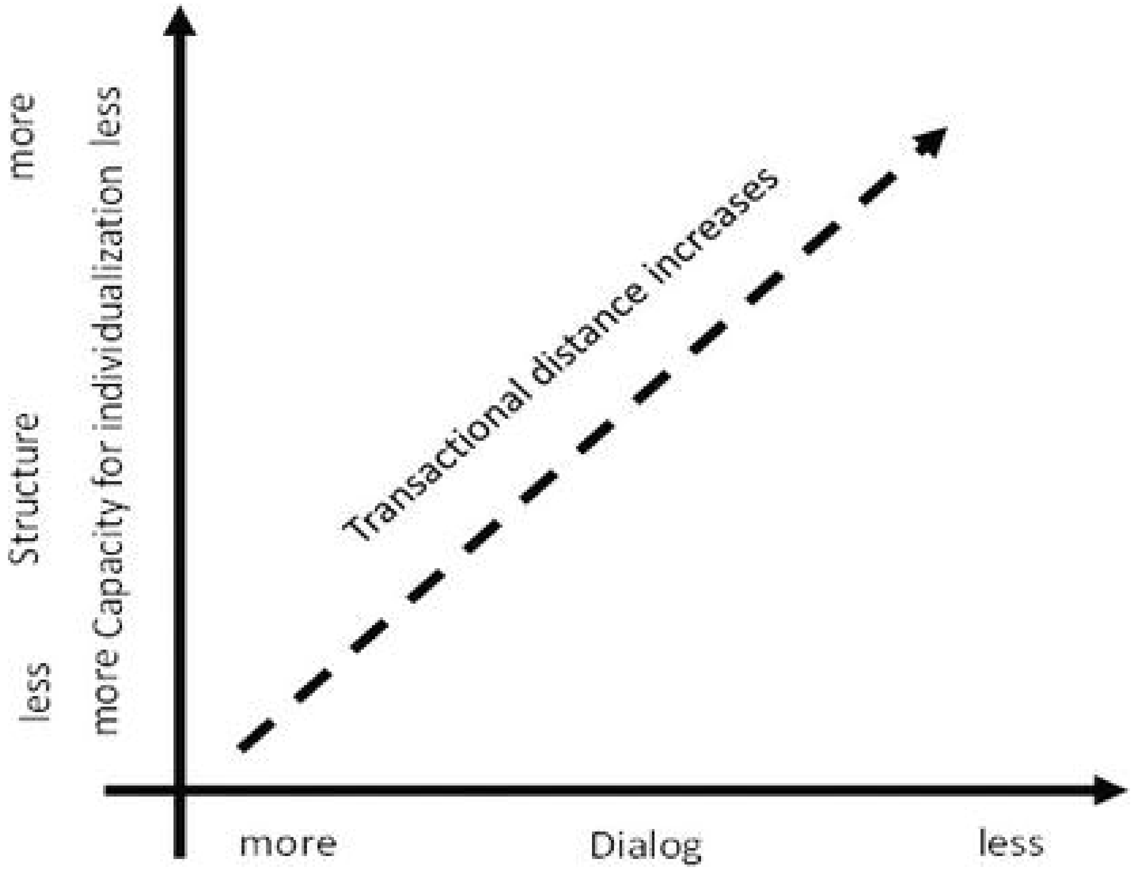
Flow Theory Analysis - Mx Trng Nxt

Task	Qualitative Feedback
Operation Flight Controls	Ario was helpful with information, explaining the science behind how planes fly. But the hands-on was a little hard because they had to learn so much in that section. That made the student anxious but when they got the hang of it, it was good.
Pre-Inspection	Feel like the videos in Ario did not prepare you at all for the hands-on task, did not really use the information that it gave you in the video. The way the instructors explained it was way more helpful.
Remove, Install, & Secure Hardware	Was shown the safety wire in training material, but video did not really explain what he was doing with it and why.
Servicing Landing Gear, & Shock Strut	Hard to understand why I am doing the task. VR does not explain why/what they are doing, just shows you procedural steps.
Wheel & Tire Assembly	Can follow steps from learning in the VR but would not be able to tell you what I am doing/why I am doing it or use correct verbiage to explain process.

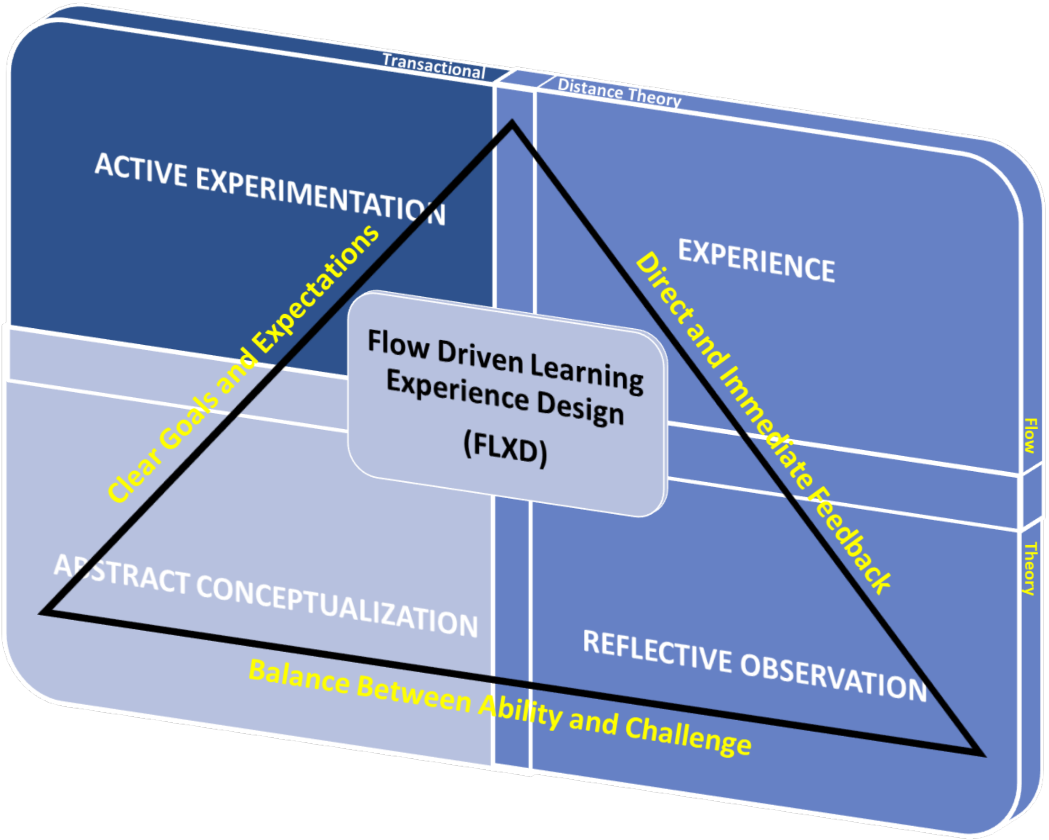


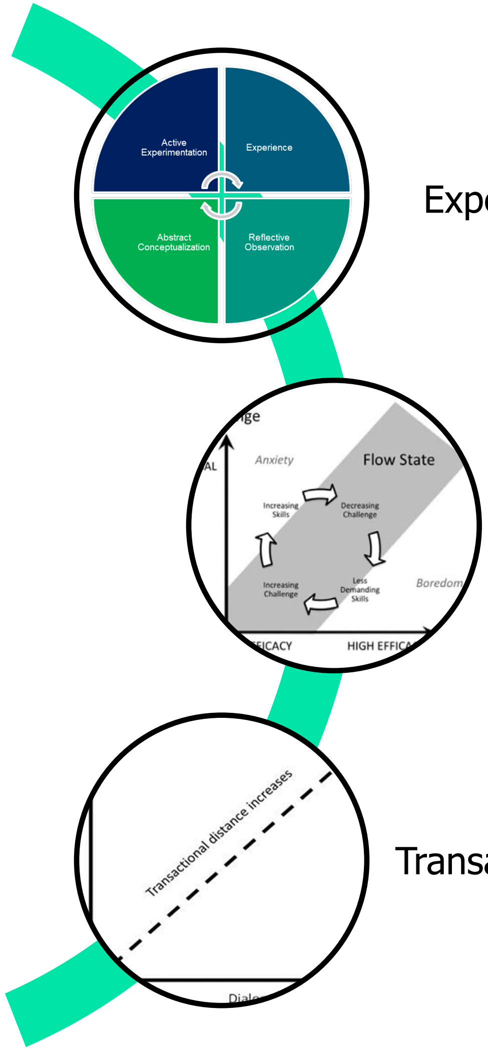
Transactional Distance Analysis - Mx Trng Nxt

Task	Qualitative Feedback
781 Form Series	Student likes being with the instructor with the forms rather than getting the videos because the first-hand accounts from the instructor are better for correctly filling them out.
Marshalling Signal	Some of the signals are misleading in the reading material. Arrows hard to see on paper, 2D. Video would have been easier to tell what exactly the signals were (rather than pictures)
Operation Flight Controls	Nice having the instructor because they give you cool tips and/or analogies to remember information; really helped them.
Pre-Inspection	I didn't go by the TO when I was completing hands-on". Evaluator/instructor walked student through task immediately prior to evaluation, and then student did it. Reasoning: instructor said Ario video had shown not to be informative for students who went before. Felt I needed a lot more information prior to hands-o (safety wire).
Servicing Landing Gear, & Shock Strut	First step in VR was to take off valve dust cap off and discard it… during the hands-on, evaluator corrected student and said never to discard valve dust cap.



Flow Driven Learning Experience Design (FLXD)





Experiential Learning Theory

Flow Theory

Transactional Distance Theory

Conclusion

The experience of using immersive technology cannot be the starting point. The experience along with reflection through Experiential Learning with immediate feedback through various communication mechanisms (Transactional Distance Theory) and proper task-to-challenge (Flow Theory) is needed to create self-efficacy in any type of formal training program.

A Taxonomy for Immersive Experience Design

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Abstract—**Immersive technology platforms such as virtual reality (VR) are used by many to create experiences that allow for efficient training, visceral encounters, and faithful reproduction of places and times. This work investigates the various elements that contribute to the design of an effective immersive experience and proposes a taxonomy that establishes levels (ranks) for each of these elements.**

Index terms—immersive learning, simulation, virtual reality

I. Introduction

For decades, simulated and virtual environments have been used by many for purposes of training, learning, and education. From animated war rooms for military strategists to flight simulators for pilots and astronauts, and from immersive molecular and anatomy lessons to critical and interpersonal skills training; virtual environments have been employed to simulate real-world scenarios without disrupting real-world systems. Such platforms have become increasingly popular in various arenas including maintenance [1], nursing [2], music [3], therapy [4, 5], behavioral disorders [6, 7], surgical training [8], and journalism [9, 10], among many. Some have, more recently, utilized such platforms to assist with training and decision making related to the ongoing pandemic [11, 12].

As an idea, realm, and technology, virtual reality (VR) is hardly new. The concept of enhancing human perception via computer generated synthetic environments was pioneered by Ivan Sutherland in 1968 [13]. Subsequently, several attempts at head-mounted display (HMD) systems followed and included sophisticated technology such as stereoscopic displays, 3-dimensional audio, as well as head and hand tracking. The Atari Research team, formed in 1982, introduced novel 3-dimensional computer interfaces that would soon become crucial for commercializing VR. Among that team, it was Jaron Lanier who coined the term "*virtual reality*" in 1987. He provides an extensive review of VR's early days in his book [14].

Advancements in graphics and computing power paired with the decrease in cost and form factor of sensory electronics caused a consequential adoption and accessibility of the technology. Today, a standalone VR system with a stereoscopic display, wide field-of-view, six degrees of freedom head tracking, and hand tracking costs a few hundred dollars and weighs 500 grams. This same system in the early 2000s would have cost more in the order of hundreds and would have been much heavier and clunkier. In the early 1990s, it would have cost even more and would have taken up the size of an entire room.

Although still far from being free of usability and fidelity issues, this attributed to the wider use of immersive technology and environments in many disciplines. It is often argued that such platforms primarily aim to increase the level of immersion. However, a successful and satisfactory immersive environment platform needs not only be a highly immersive one, but also one that increases the sense of presence. Although two distinct definitions, *immersion* and *presence* are often confused or used interchangeably. In the following sections, we address the distinction of these two concepts and discuss attributes that can compose a successful design for immersive environments. This work expands on and advances previous research that studied aspects that affect immersive experiences including immersion, presence, interactivity, and others.

II. Immersion, Presence, and Immersive Learning

A. A Look at the Literature

Many have formally defined immersion and presence in the context of virtual environments. The work of Mel Slater is among the most recognized and well established. *Immersion* is the objective degree of projecting stimuli onto the sensory receptors of a user. Slater specifies a number of qualities that enhance immersion: the process should be extensive (stimulates multiple senses), matching (consistent stimuli is perceived by various senses), surrounding (visuals and audio surround the user), vivid (high resolution and quality), interactable, and consistent with the story/plot [15].

A system with a high level of immersion, however, is hollow without a user to experience it. The effect that this immersion has on a user's cognition and psychological response is defined as *presence*. This refers to the sense of residing in the simulated environment with an illusion of being transported to a place/time different than where the user actually is. This distinction of presence from immersion is evident in the discussion that took place via the presence-l listserv in 2000 among scholars of the field [16]. In a later work [17], Slater uses a simple analogy to distinguish presence from immersion. A color can be objectively defined in terms of a wavelength distribution, whereas how the color is perceived and described by one person can be different than that of another.

In addition to Slater's extensive work on the topic, many addressed the distinction between immersion and presence [18-24]. To synthesize these ideas, we provide a summary that compares the two against relevant criteria shown in Table I. A truly immersive experience, therefore, is not only one that stimulates various senses, but one that additionally involves the

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user in a manner that decreases (or disconnects) their awareness of the real world. We would add here that, if one were to take a true and satisfactory immersive experience that engages the user in a visceral manner, and strip away from it the aspects that the technology delivers, what remains can be defined as presence. The work presented in this paper relies on these concepts, doesn't compete with them, but rather expands upon them.

Relevant to this discussion and the work presented in this paper are the efforts made to define and advance educational virtual environments (EVEs), also referred to in the literature as virtual learning environments (VLEs). In this context, an EVE or VLE is a virtual environment that has an educational, learning, or pedagogical objective. It typically involves the use of artificial or synthetic environments through which the learners' senses are stimulated inside an altered reality for the purpose of embodied cognition and visceral learning. An *immersive learning* platform is an EVE or VLE that has a high level of immersion. Although mostly theoretical at the time, the use of virtual reality for learning is a concept that was explored as early as 1990 [25]. The potential of such environments was described in [26], factors influencing learning outcomes were explored in [27], and the role of presence in such platforms was studied and presented in [28]. More recently, Beck *et al.* presented an extensive and well visualized literature survey on immersive learning environments to identify literature gaps [29]. Their work identifies a need to pursue research in multiple areas of immersive learning such as in platforms that are non-immersive or have low immersion, platforms that achieve immersive via challenges and some level of technology, and those that combine high-tech with strong interdisciplinary aspects. This justifies a need for a taxonomy that classifies immersive experiences (educational or otherwise) compatible with various levels of immersion, narrative, and technology.

B. Contribution

This work recognizes the literature discussed in the previous section identifying immersion and presence as distinct qualities, interconnected, and correlated. We expand this discussion by defining a "*successful immersive experience*" as one that transcends a highly immersive one and encompasses the benefits of immersion, presence, and other qualities. In this paper, we investigate aspects that make up such a platform and introduce a taxonomy that strives to classify and establish the elements of a successful immersive experience. We hypothesize that this taxonomy includes dimensions that attribute to various qualities described by previous works, immersion and presence included. To our knowledge, a similar holistic classification for elements of immersive experiences has not been introduced to date.

TABLE I. ATTRIBUTES THAT DISTINGUISH IMMERSION FROM PRESENCE.

	Immersion	**Presence**
In simple terms	Stimuli/mediums provided by the technology	Sense of "being there"
Nature	Objective and can be observed	Subjective and can only be experienced
Facilitated by	Characteristics of technology and its technical capabilities to render sensory stimuli	Story, context, and user's psychological response
A function of	The hardware/software used	The level of immersion + the type of user and their state of mind
Model Human Processor *[30]*	Perceptual	Cognitive
Interfaces with and targets user's	Senses and engageability	State of mind and ability to disconnect from surroundings
Measurement and assessment	Can be quantified by describing the number and types of stimuli	Difficult to quantify as it is an internal psychological and physiological state
Its degree depends on	Level of sensory captivation and involvement	Level of visceral communication and degree that the synthetic nature of environment goes unnoticed
Increases with	Number of sensory channels/modalities and degree of their involvement	Success of the telepresence illusion
Considered achieved when	Multiple human senses are involved in a high fidelity and faithful form	User experiences temporary unawareness or agnosia of the real world

III. PROPOSED IMMERSIVE DESIGN TAXONOMY

We propose a breakdown, analysis, and taxonomy for the design of immersive experiences by specifying nine categories (Table II). These categories (or elements) contribute to the success and effectiveness of an immersive experience. This breakdown is provided as a guide to assist in designing new immersive experiences or analyze existing ones. This model is of particular importance for immersive learning environments.

The proposed taxonomy includes categories of interactivity, embodiment, co-participation, story, dynamics, gamification, technology, meta-control, and didactic capacity. For each category/element, a rubric of five levels (0 to 4) is constructed to indicate the depth of each element and specify the degree to which the element is utilized. Each level is considered autonomous and does not necessarily include the preceding level, i.e., advancing from one level to the next doesn't assume all lower levels are aggregately implemented as well, although it may sometimes be the case. Each element is described in the following sections.

A. Interactivity

This element addresses the user's level of involvement and the type of tasks they are doing within the experience. When a user has no ability to interact with or influence the experience, they are considered *passive*, such as an audience member watching a movie. Providing the user with the opportunity to answer a question before a lesson or before the story proceeds enables the experience to become *participatory*. When the user has a physical representation, or avatar, that is engaged throughout the experience, the interaction becomes *physicalized*. This is the case for most video games that have a character the user can see and move through a location, world, or setting. The next level is *problem-solving*, where the user is given challenges or tasks requiring solutions within the experience. Finally, when the user is able to communicate with or relate to someone or something else within the experience, it becomes *interpersonal*. A massive multi-player online (MMO) game like "World of Warcraft" (WoW), although not an immersive experience, can be considered an interpersonal one. The player has an avatar that they move through the world, often solving various puzzles and problems, while other real people are also present in the larger game, enable the player to interact both with the game and /or other players.

TABLE II. A TAXONOMY FOR ELEMENTS/DIMENSIONS OF AN IMMERSIVE EXPERIENCE. THE NUMBER OF STARS EQUATES TO THE LEVEL FOR THE CORRESPONDING ELEMENT AND INDICATES ITS RANGE OF DEPTH.

Level	Interactivity	Embodiment	Co-Participation	Story	Dynamics	Gamification	Immersive Tech	Meta Control	Didactic Capacity
☆☆☆☆	Passive	Detached	Single-Player	No Story	Pre-determined	Ungamified	None	No Meta-Control	Elemental
★☆☆☆	Participatory	Watcher	One-on-One	Setting	Choice	Instruction	AR	Journey	Explicit
★★☆☆	Physicalized	First-Person POV	Secondary Perspective	Pre-Created	Multi-Thread	Reinforcement	360º media	Character	Implicit
★★★☆	Problem Solving	Movement	Group	Choose Your Own	Free Will	External Process	VR	World Builder	Recall
★★★★	Interpersonal	Human2Human Interaction	MMO	Interactive Story	Convo-Reality	Reward System	XR	World Master	Synthesis

B. *Embodiment*

This element describes the aesthetic distance between the user and the experience. A user or viewer is considered *detached* when they have a disembodied, external voyeuristic view of the experience, such as most television shows or movies. When the user is part of the experience, but is still an outsider, they are considered a *watcher*. This could take place in a 360º video or a virtual experience, but the user is but a "fly on the wall" with no interaction with events other than to witness them. The experience becomes a *first-person point of view (POV)* when the action within the event is taken by or directed at the user. Games like "Beat Saber" have this type of experience. The user can interact with the blocks coming towards them, but there is very little in the way of movement within the environment. When *movement* throughout the environment is added, the user gains a higher level of choice and a sense of personal will. This movement can manifest in various ways including locomotion, room-scale, or others. The final level incorporates *human-to-human interactions*, where users can explore relationships with other users, as avatars, within the experience.

C. *Co-Participation*

The number of users in an experience can differ from one purpose to another. This multiplayer aspect is addressed in this element to specify whether the experience is designed for or involves the participation of only one or more users at any given time. An experience where the user is alone with no other real person contact is a *single-player* experience. When two people are able to interact with each other, this provides the first level of multiplayer experience, *one-on-one*. A simple chess game has this level of co-participation. *Secondary perspective* is when the two users are able to view a physicalized experience. When more than two users can experience the environment at the same time, it becomes a *group experience*. An *MMO* game is a large online experience in which people play synchronously in a story-driven world.

D. *Story*

In this element, the context and through-line of the experience that gives it a beginning, a middle, and an end is addressed. This also includes the manner in which the character or plot evolves within the experience. An experience does not rank in this category when *no elements of story* are present. In the *setting* level, aspects necessary to establish a context for time and place are present. An example might be "Diner Dash" where you are in a themed location but there is no evolution of character or plot. The second layer involves a *pre-created* story like a movie or television show that the watcher has no influence over. The third level of story allows the user to *make choices* in the experience, similar to classic "Choose Your Own Adventure" books where the reader has the opportunity to make branching decisions that influence the culmination of the story. The final level is *Interactive Story*, where the user is the protagonist within the story, can influence events, and can make independent choices that will determine the outcome.

E. *Dynamics*

This element addresses the user's ability to influence the outcome of the experience, whether in the form of decision making, path selection, or predetermined events. This classification is specifically related to the user and how they interface with the experience and does not focus on the dynamics of the story and how interactive it is. When the user is unable to influence the outcomes of the experience, it is considered *pre-determined*. Movies, television shows, and books are examples. No matter how many times you watch the "Titanic" movie, the boat is still going to sink. The first level of dynamic influence is *choice*, where the user can make a decision when faced with one or more possibilities. *Multi-thread* is where a user can choose the sequencing of the experience. An example might be the game Diablo 3, where the user chooses a location to clear monsters on the map. In a *free will* level, users perceive either real or imagined unfettered ability to choose their own experience. Such a design prevents two experiences from being exactly the same. In *conversational reality*, interpersonal communication allows the user to develop deeper relationships and live through conflict-driven situations.

F. Gamification

This category focuses on the level of gamification in the experience, typically realized by a set of external rules or outcomes intended to induce play or competition. When an experience exists without the framework of instructions or rules, it is considered *ungamified*. The first level is merely *instruction*, where the user has a set of guidelines to follow in order to participate in the experience. The second level is *reinforcement*, where the user is given, often unconscious, sensory cues that encourage their participation and reinforce moments of success or failure (e.g., slot machines). The third level is an *external process*, where the user is given a set of rules as a means to interact with the experience. In some experiences, you may have to stack dishes, make food, and feed your patrons; whereas in others you must capture the flag or kill your opponents. Finally, a *reward system* offers users rewards for passing levels or accomplishing goals. A VR platform that tracks the user's physical activity and provides scores and rewards based on calories burnt is an example. Rewards and scoreboards are great ways to engage participation through competition. It is important to note, however, that competition interferes with experiences that are intended to be empathic.

G. Immersive Technology

In this element, the type of technology and its sophistication is considered. An immersive technology is one that attempts to emulate a physical world through the means of a surrounding simulated world. Live-action simulations, board games, and desktop video games that *do not involve a type of immersive technology* do not earn a rank from this element. The first level of this element is assigned to *augmented reality (AR)*, where computer-generated imagery is superimposed on top of the real world, thus augmenting the user's view. Applications like "Pokémon Go" function at this level as Pokémon characters are superimposed onto the real world. The second level is *360^o media*, where immersive videos allow users to be surrounded by a photo-realistic environment, typically involving three degrees of freedom of motion. The experience "An Atmosphere of Hate" is an example [31]. *Virtual Reality* is considered the next level, where an artificial, computer-generated environment surrounds the user and engages their audio, visual, and at times haptic, senses. Finally, *extended reality (XR)*, is a synthesis of immersive technologies that bring virtual and real worlds together. Such experiences are offered by businesses like "The Void" where extended reality activities mix virtual components into a real-world environment.

H. Meta-Control

This element looks specifically at the user's control over the experience itself. When a user has no control over the experience, there is *no meta-control*. The first level is *journey* control, where the user can choose events to participate in. The second level is *character* control. In this case, users can customize their character or avatar, which can have dramatic effects on empathy. MMO's often have this feature allowing users to modify how their avatars look to others. The next level is *world builder*, where the user can build and edit the levels of the environment they inhabit. Games like "Minecraft" have this level of meta-control as users can design and build their environment using assets they find within the game. Finally, the highest level is achieved when the user has the ability to become a *world master*, where they can affect the global functionality of the world and impact other users' experiences. "Minecraft" is, once again, a good example here where advanced users can create modifications (mods), that define and expand the capabilities of other players in their world.

I. Didactic Capacity

This category reveals the degree to which the experience contains a learning moment or component. At the *elemental* level, no knowledge is conveyed beyond the functionality of the experience. This describes an experience that explains its controls and rules, but these have no use or application outside the experience. The *explicit* level is one where learning is direct and instructional, as is present in a typical classroom lecture. *Implicit* learning is derived and discovered; this is where assumptions are formed and connections are made between pieces of facts and information previously presented. When prior information is required to succeed or proceed in the experience, this is the *recall* level. The final level is *synthesis*, where incorporating multiple ideas or components empowers the learner to develop new, original, and complex interpretations or solutions. This is observed in games or experiences where the user is expected to assimilate, combine, and synthesize different obtained insights (abilities) to succeed (win).

IV. Discussion

Each category/element described in the taxonomy can be used as an analysis lens to evaluate a specific aspect of an immersive experience. Furthermore, this taxonomy provides a rubric against which many types of games, teaching tools, or experiences can be scored. Since each element has a score (level) of zero to four, each suggesting a deeper implementation of the corresponding element, experiences can be scored from zero to thirty-six. This can be illustrated by contrasting a basic game like tic-tac-toe against one like "WoW". Tic-tac-toe receives a zero for elements of embodiment, story, immersive technology, meta-control, and didactic capacity; but does score in interactivity, co-participation, dynamics, and gamification; yielding a score of four. On the other hand, a game like "Wow" is interpersonal, involves human-to-human interactions, is an MMO, has an interactive story, presents conversational reality and a reward system, and has synthesis learning. It falls short in the immersive technology and scores only a two in meta-control as the user can customize their character but cannot impact or build in the virtual world; which results in a score of thirty.

Although a higher level implies a deeper implication for each element, this taxonomy doesn't claim that the highest level of each element constitutes the best fit for every application. The purpose, goal, and story of an experience can necessitate a specific combination of these elements that may not always be level four. Furthermore, vividness of the experience, quality of delivered stimuli, and the user experience (UX) are recognized to have an external impact on any combination. For a fair comparison, analyzing experiences via this taxonomy should assume those aspects maximized or indifferent.

Finally, assuming that a higher score from this rubric implies an increased overall quality of the experience is not entirely sound. A better way to utilize this taxonomy is to view it as thirty-six individual options across nine categories to choose from. Naturally, this results in a large number of possible combinations for creative and design choices. Furthermore, there is an overlap among elements. In some cases, achieving a particular level of one element implicitly achieves a level in another. For instance, the *choose your own* level of story clearly achieves a certain level of dynamic. This can be observed in other categories as well.

V. Conclusion

This work explored the various aspects that contribute to the success and effectiveness of an immersive experience. This yielded a taxonomy that classifies elements that make up the design of immersive experiences regardless of their purpose, application, audience, or technology. Nine design elements were discussed and a level-ranking was established for each element. The combination of various element levels can be used to classify experience designs. When evaluated as an integrated whole for an immersive experience, these elements and their comparative rankings are hypothesized to deliver a notional indication, classification, and gauge of the effectiveness and success of an experience. Future work will address validation and implications of element combinations with regard to time, cost, audience, and scalability. In addition, future efforts will include the development of an interactive platform (website) where example experiences for various combinations are presented and a design templating wizard is provided.

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Taxonomy of Immersive Experience

Obeid, M, Ph.D. Ruscella, J. (June 2021). "A Taxonomy for Immersive Experience Design."

LEVEL	INTERACTIVITY	EMBODIMENT	CO-PARTICIPATION	STORY	DYNAMICS	GAMIFICATION	IMMERSIVE TECH	META CONTROL	DIDACTIC CAPACITY	DATA
0	Passive	Detached	Single-Player	None	Pre-determined	None	None	None	Elemental	Anonymous
1	Interactive	Watcher	One-on-One	Setting	Choice	Instruction	Augmented Reality (AR)	Journey	Explicit	Identity
2	Problem Solving	First-Person Point-of-View	Group	Pre-Created	Free Will	External Process	360° Media	Character	Implicit	In-Game
3	Physicalized	Movement	MMO	Choose Your Own	Convo-Reality	Reinforcement	Virtual Reality (VR)	World Editor	Recall	Personalized
4	Interpersonal	Human-to-Human Interaction	Secondary Perspective	Interactive Story	Adjustable Point-of-View	Reward System	Extended/Mixed Reality (XR)	World Builder	Synthesis	Biometrics

How Do I Create Immersion?

The Taxonomy of Immersive Experience (above) is a guide to assist in designing new immersive experiences or analyzing existing ones.

It is intended to help you understand the different factors of immersion and provide inspiration for ways you can leverage these factors.

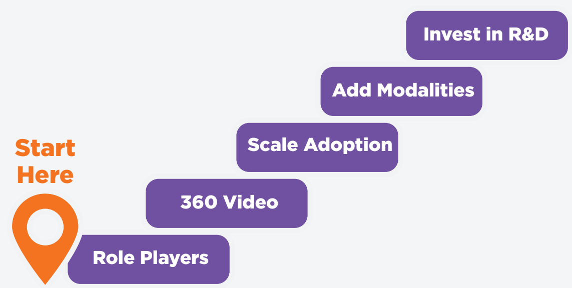
The taxonomy includes categories of interactivity, embodiment, co-participation, story, dynamics, gamification, technology, meta-control, didactic capacity and data. For each category/element, a rubric of five levels (0 to 4) is constructed to indicate the depth of each element and specify the degree to which the element is utilized. Each level is considered autonomous and does not necessarily include the preceding level, i.e., advancing from one level to the next doesn't assume all lower levels are aggregately implemented as well, although it may sometimes be the case.

Learn More
https://framework.accessvr.com

SCAN ME

Roadmap to Scale

There is a logical progression to adding immersive experience to your training program.



Begin by introducing simulations with live role players to increase immersion in your existing training. 360 video is a great first step for introducing immersive technology into your program. This will provide you with the insights you need to scale adoption within your organization. Next, expand your program with different modalities of experience and engagement. With this foundation, you can now invest in research and development with clarity and purpose.

AccessVR

Immersive Experience
Design and Development

A framework for adopting immersive technology for experiencial learning at scale

Institutions and organizations are increasingly looking to immersive technology to improve their training and collaboration.

This guide provides a framework for designing and evaluating immersive experiences and adopting immersive technology for experiential learning.

What is Immersive Experience?

An experience where a person feels a deep sense of presence, created by sensory stimulation.

This deep sense of presence can increase our ability to learn, when applied to experiential learning.

What is Experiential Learning?

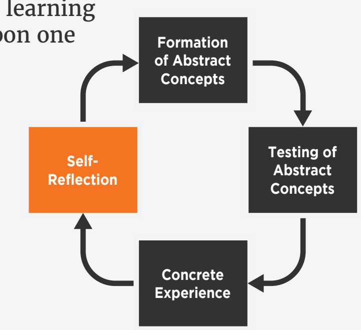
We learn 80% of what we experience
The Disney Way

Every person has learned much of what they know through personal experience, much of it occurring naturally.

Simply put, experiential learning is the process of learning by doing.

Experiential Learning Model (ELM)

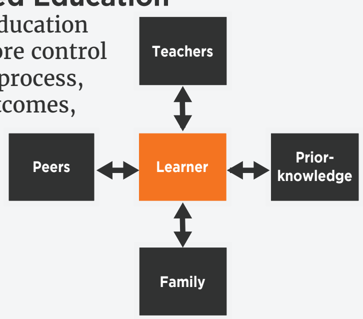
David Kolb's ELM is a learning continuum in which learning experiences build upon one another to advance learning.



The most critical feature is learner self-reflection.

Learner-Centered Education

Learner-Centered Education gives the learner more control of the instructional process, leading to better outcomes, by transfering the responsibility from the teacher to the learner of both design and assessment.



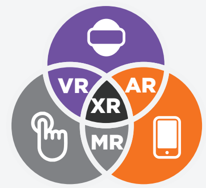
How Can Technology Help?

Immersion does not depend on technology

However, new technologies can be highly effective at delivering immersion and benefit business by enabling scale and increasing ROI.

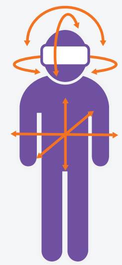
Extended Reality (XR)

XR technologies provide many benefits when transitioning from real-life simulations to immersive experiences, enabling scale accessibility, cost effectiveness, and rapid iteration, among others.



Virtual Reality (VR) is the most widely adopted XR technology. There are two kinds of VR applications today: 3 Degrees of Freedom (3DoF) and 6 Degrees of Freedom (6DoF).

3DoF
Show Me Tell Me



6DoF
Let Me Try

Choosing the Right Technology

To determine which technology to use and how to apply it, we have to ask the right question.

"Given our learners and learning objectives, which immersive technologies will be most effective?"

Cognitive Load

Cognitive load is a function of instructional design and describes the ways in which our limited working memory is consumed by cognition.

Intrinsic load: inherent difficulty of the subject
Extraneous load: method and design of instruction
Germane load: integrating/storing new knowledge

It is important to consider how introducing a novel technology can impact the learner's cognitive load.

Instructional designers should reduce Extraneous Load to increase available Germane Load.

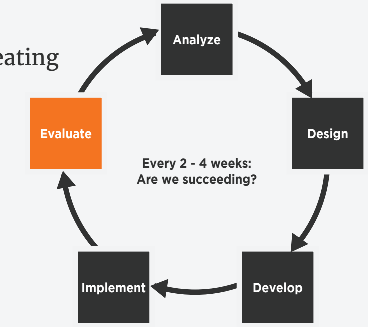
Designing Immersive Experiences

Designing immersive experiences for instruction does not require a wholesale reinvention of instructional design.

Instructional design for immersive technology must embrace shorter production cycles, increasing the frequency of evaluation of how well the solution is delivering to learning objectives.

ADDIE Model

A framework for creating and improving instructional content.



Agile Mindset

Make it.
Make it right.
Make it better.

Apply a flexible, iterative approach that prioritizes the impact to the learner over other preconceived ideas about success.

Remember: Technologists are not your instructional designers; your instructors are.

Evaluating Immersive Experiences

Immersive experiences are best evaluated through the eyes of actual learners. Apply the following steps before, during and after each product iteration.

1 Establish a baseline for learners
Guage existing familiarity with immersive technology in advance of the learning moment.

2 Formatively assess learning
Establish which data to collect to determine what the learner has learned.

3 Stimulate self-reflection
Incorporate engagement opportunities for self-reflection during and after the experience.

4 Determine the cognitive-affective state of the learner
Interest: Was their interest activated?
Motivation: Were they engaged?
Self-Efficacy: Did they believe they'd learn?
Embodiment: Did they have presence/control?
Cognitive-Load: Was load well-managed?
Self-Regulation: Did they focus on learning?