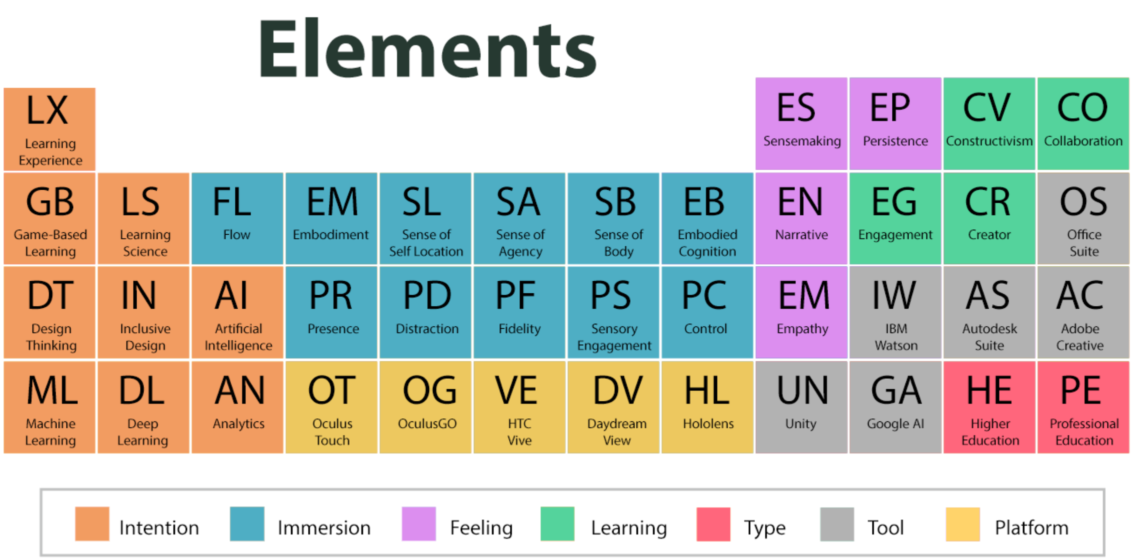
An Engaged Learning Technologies White Paper on Designing Intelligent Immersive Learning for Professional and Higher Education

Immersive Learning Experience Design (ILXD)



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Executive Summary

Intelligent immersive learning is a paradigm shift that is already underway in higher education. The legacy focus of designing and implementing learning products for institutional needs, practices, and structures is outdated beyond revision or adaption. A fundamental shift in focus is required, with the learner's experience at the core and the learner's personalized instructional needs as the overarching guiding framework.

This paper is the first in a three part series that addresses design, production, and research for intelligent immersive learning experiences for professional education and higher education.

The ILXD model has been developed to serve the shift in focus from producing learning products to producing learning experiences. The model is used to guide and inform the design, production, and research for intelligent immersive learning experiences for professional education and higher education.

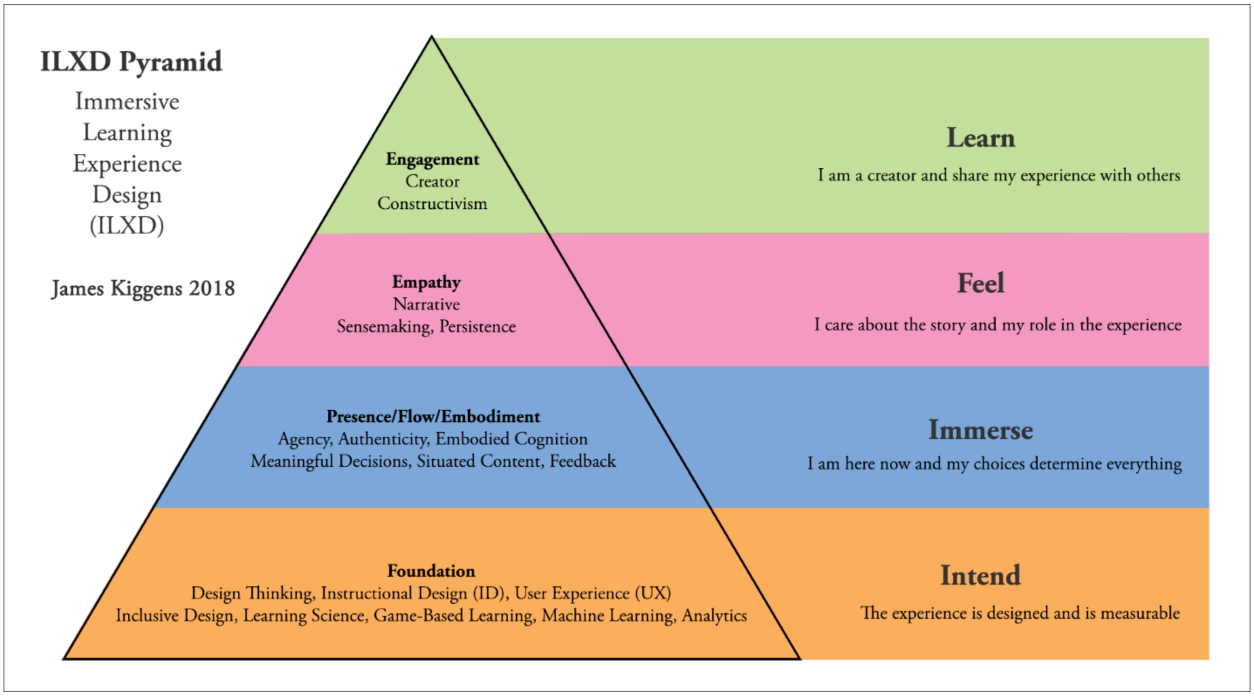
The elements of the ILXD model are drawn from a broad array of pedagogy and educational technology topics, including; cognition and learning sciences, game-based learning, design thinking, virtual reality (VR), and artificial intelligence for education (AIEd).

Introduction

Since April of 2016, Engaged Learning Technologies at Adtalem Global Education (ATGE) has been exploring a production process to create and deliver intelligent immersive learning experiences for use in professional education and university classes throughout the seven ATGE institutions.

Our experience has been that the technologies, tools, and processes are available, affordable, and can go to scale. It is possible to design, produce, and deliver a personalized learning experience with immersion, empathy, and a hereto unseen level of engagement. In order to fully realize the potential, a radical change in intention and practice is required.

The ILXD model is our design method that we are using as a response. The model is intended to empower our team and client institutions to fully leverage the power of learning experiences delivered in VR using artificial intelligence (AI). It is a springboard for a collegial conversation for those interested in furthering the efficacy and best practice regarding ILXD.



The ILXD Pyramid© illustrates the scaffolding method of the ILXD model. While each of the layers in the scaffold contain individual elements that contribute significantly toward learning in their own right, it is the scaffolded sum that we are striving toward for each immersive learning experience. Any of these elements that are missing or underdeveloped diminish or prevent achieving that ultimate objective.

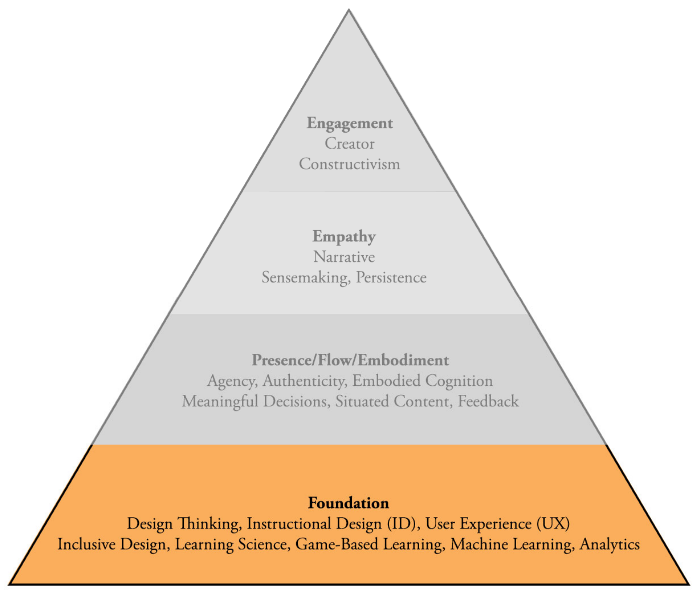
The base is the design **intent**, integrating both familiar and new processes and resources to provide a foundation upon which the learning experience is enabled.

The **immerse** layer is then supported by that intention, which has been optimized to leverage the affordances of VR and AI. Without this solid design foundation, the impact of the immerse layer components is meaningless. Designing for agency and feedback are two components in the immerse layer that we apply extra attention toward.

The immerse layer then presents a unique support for the **feel** layer, where the learner develops and nurtures an emotional connection with the learning activities and content. The importance of story in the feel layer cannot be overstated.

The three underlying layers then support the pinnacle of the pyramid, which is the **learn** layer where the learner is an active creator in their learning experience and shares their understandings and experiences with others.

Given the rate of change and advances in these technologies, tools, and processes, and the unending insights that we are gaining from our intelligent immersive learning experiences deployed in the classroom, our goal for this paper is to introduce our experience in using the ILXD model as a starting reference point for discussion and collaboration in a community of practice. We hope that you will find it useful and we look forward to learning about your work and discussing your comments, suggestions, and questions.



Intend

"The experience is designed and it is measurable."

The intend layer (design foundation) for the ILXD model is organized by three primary topics; **Learning Experience Design** (LXD), **Artificial Intelligence for Education** (AIEd), and **Analytics**. In our experience, this foundation layer is where the greatest flux has been occurring. Our LXD process has been under nearly constant revision in response to advances and insights gained regarding the layers above it in the scaffold. AIEd has evolved from a simple text-based chatbot to a full-blown intelligent enterprise. Analytics have advanced from being reflective to being a formative input for precision learning. Despite the constant changes, these three key elements of Intention have fundamental guiding principles we use in our design.

Learning Experience Design (LXD)

Introduction to Learning Experience Design

Learning Experience Design (LXD) enables education creators to better meet the needs of the student. The fundamentals of instructional design are present, but LXD improves the delivery, structure, and, most importantly, focus of the learning experience.

The fundamental shift to LXD signals a focus on the learner. Instructional design focuses the best product that can be used for instruction, but LXD focuses on the best experience the learner can have while reaching their learning goals. Behind that change is a shift to empathy, from what the learner is going to know to how the learner is going to feel throughout their learning experience.

Traditional courses are designed in modules and delivered in event-based or rigidly delivered episodic increments. LXD delivers learning experiences through content curation in chunked, a la carte pieces using innovative platforms that meet the learner where they are and take them where they need to be.

The learning methods in LXD are varied and appropriate for the outcome. Each learning element has context, so there is no fluff or ineffective learning events that don't help the learner achieve the learning goals. A key element of LXD is learner control. The learner controls pacing, sequence, review opportunities, modality, practice opportunities, assessment methods, and reflection or processing time, among others.

Through experiential learning and a constructivist approach, we design human-centered, holistic learning experiences so that learners are empowered to create enjoyable, engaging, relevant, informative, enriching, immersive learning experiences for themselves.

The Learning Experience Designer is an instructional architect who looks at how systems operate and how each learning component fits into the overall learning experience. It starts with big picture thinking, a careful consideration of how the learner will experience the instruction we design. The designer focuses on what the learner wants to know and what they should be able to do after completion. Both the content and the user experience are designed around the learner.

LXD in Game Development

The gaming environment is fertile ground for LXD. Humans respond to experiences and learn from them, and there is no better modality for personalized learning than Game Based Learning (GBL). It is inherently learner-centric, has the ability to reach diverse learners, and can expose learners to environments and situations they may not have access or opportunity to otherwise.

Thoughtful design can made GBL more effective to enable deeper learning and more engaged, empowered learners. The combination of effective LXD in GBL is a product differentiator that businesses would be wise to capitalize on.

For us, LXD in GBL means that we create effective, engaging learning experiences by taking advantage of the virtual reality environment. This is the "I" in ILXD. The immediate immersion and entry into flow state activates empathy and creates a different kind of learner engagement. Games can use artificial intelligence to add to the highly personalized environment, providing expertise, guidance, remediation, and knowledge extension based on the learner's zone of proximal development.

ILXD Creation Process

As with any good design, we start with the learner first. We have to understand our audience and their unique needs before we design our experience. We serve a very broad, diverse audience, and one solution does not apply to any one set of learners.

We start by asking key questions that guide our design. We want to know about their knowledge, skills, confidence, motivation, resources and tools, and learning preferences.

1. What drives our learners? What are their motivations and how can we access that? Why do they care?
2. How can we connect to our learners on a personal level?
3. How can we capitalize on the learner's previous experience?
4. What do they want to see in how they experience the learning?
5. What prevents our learners from engaging with the information? What would they change?
6. How can we connect our learners to the big ideas so they are able to construct experiences that bring the learning outcomes within their zone of proximal development?

The ADDIE development method in a waterfall of prescribed steps is too rigid for game development. Instead, we design the experience before the product based on audience needs. Design thinking guides our process through research, experimentation, ideation, conceptualization, prototyping, iteration, and testing. These steps occur in various orders and overlap. The learner co-creates the experience and we build their feedback into the product.

The reason for this is the shift in perspective from instructional design to learning experience design. In instructional design, we assume that designers and subject matter experts know best. We rarely audience test or involve the learner in design or production. As learning experience designers, however, we start with the idea that we don't know what the learner wants or needs and work through our design process, including compulsive play testing, with the goal of learning the most effective design structure will be.

Application of ILXD in GBL

We have created several games and simulations that exemplify the efficacy of ILXD in GBL. In Cold Case, the learner solves a crime through interrogations, evidence collection, and lab tests and is guided by a Sergeant to reflect, review, and complete processes. The system empowers the course instructor to facilitate learning through the environment. In Take Control, the learner, guided by an AI agent, determines their own conflict management style and uses that style to manage conflicts in an office environment. Their own choices determine their experience, what challenges they encounter, and how well they meet the learning objectives. Our Microscope simulation provides learners with unlimited opportunities to learn and practice microscopy fundamentals. AI supports the learning and instructors can use the environment to facilitate learning outcomes. Our Pathology Engaged Learning Objects (ELOs) immerse learners in a hospital room and enable them to experience each body system through chart analysis, medical tests, and exploration. The content varies for each ELO, and the spaced repetition of key concepts ensures retention and reinforces application of knowledge.

AI has been an effective element of the learning experiences we have designed. It is a fundamental element in designing for the ILXD Pyramid, and understanding its capabilities and uses is key to successful ILXD creation.

Artificial Intelligence for Education (AIEd)

Introduction to Artificial Intelligence

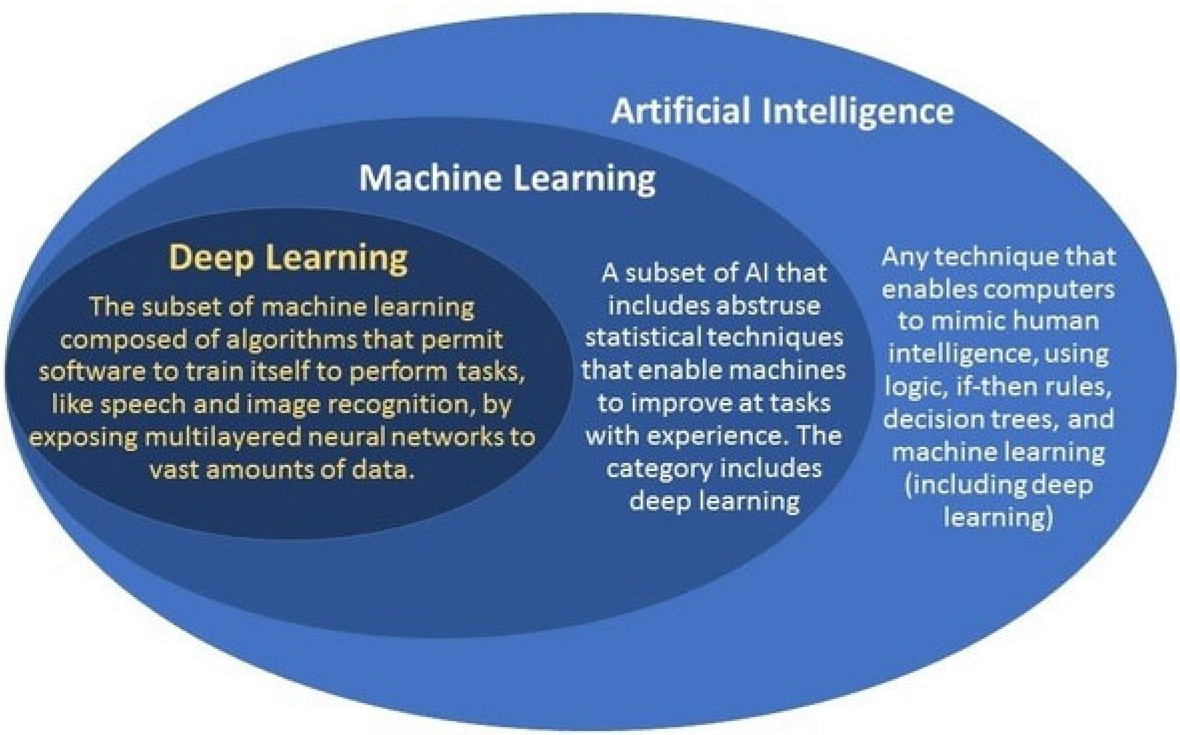
AI involves computer software that has been programmed to interact with the world in ways normally requiring human intelligence. This means that AI depends both on knowledge about the world and algorithms to intelligently process that knowledge (Luckin, Holmes, Griffiths, Forcier, 2018).

In AIEd, this knowledge about the world is represented in three key models: the pedagogical model, the domain model, and the learner model.

An AIEd system that is designed to provide appropriate individualized feedback to a learner requires that the AIEd system knows something about:

- Effective approaches to teaching (which is represented in a pedagogical model)
- The subject being learned (represented in the domain model)
- The learner (represented in the learner model)

AIEd functionality is often described as Machine Learning and Deep Learning, which can be understood as subsets of Artificial Intelligence. This relationship can best be illustrated with a diagram of concentric rings, where Machine Learning is subset of AI, and Deep Learning is a subset of Machine Learning.



Machine Learning is the practice of using algorithms to sort data, learn from it, and make a determination or prediction about something in the world.

Deep Learning is typically a practical application of Machine Learning. Driverless cars, medical diagnosis, and shopping recommendations are all examples of Deep Learning.

What AIEd Can Now Deliver

Affordable, accessible AIEd technologies and tools are now available to support 1:1 learning at scale. Every learner, in every subject, can learn what they need to know, at their own pace, in a context that is most meaningful to them, working in collaboration with classmates that are ideally matched to suit their needs.

AIEd can provide each learner with a personalized intelligent tutor that accompanies them throughout their entire program of study, accessing real-time analytics that measure learning outcomes to shape each learning experience real-time to best suit the learner.

AIEd can provide each learner with personalized experiences that precisely address their individual needs and progress. It can provide learners with specific, actionable, relevant feedback in real-time for every challenge and task along the way.

AIEd is capable today of providing inspiration, communicating with emotion, listening to the learner's voice, reading their facial expressions, and responding to the learner's successes with a continuum of ideally suited levels of challenge.

Our initial AIEd application was a text-based ChatBot in an online game for a university English course. Our first playtest immediately revealed two important findings regarding this feature:

1. Gameplay soon came to a complete halt for the entire class. They became engrossed in conversation with the ChatBot. This deep engagement did not dissipate, they continued dialogue with the ChatBot until we finally had to intercede in order to complete the playtest.
2. With few exceptions, the students were asking the ChatBot probing questions. They were most captivated by exploring the knowledge boundaries of the AI, to see if they could ask questions that it could not answer and they were sharing with their neighbors what they were observing.

A few months later, a new AIEd that we deployed was a non-player character in a VR soft-skills training product for professional education. This NPC, named "Victoria", spoke to the learner in response to dialogue choices that they made. Victoria had been designed to misbehave in a scenario-based learning challenge. Our first playtest with this AIEd revealed that learners left the scenario with a strong emotional response to the NPC, talking about Victoria as if it were human. We later demonstrated the product at a large education conference in our expo booth, and by the second day of the conference we had attendees coming to the booth because someone had told them about “Victoria” and they wanted to try the VR experience and meet her.

Scenario-based experiences using dialogue with AIEd non-player characters is a primary focus for our products. Our small in-house team designs, develops, and delivers these intelligent immersive experiences using off-the-shelf tools from IBM, Google, and the Unity game engine. An important aspect that our learning experience designer has been focusing on for these experiences is imbuing a wide range of emotional responses in the dialogue designs that comprise the ‘brain’ that powers the AI characters. In this way, we constrain the possible responses for the AI characters to only the content and emotion desired for the scenario based upon the decision-making of the learner.

One of our newest intelligent immersive learning products is an enterprise effort using Scriyb, an AIEd product resulting from research conducted by the Virginia Serious Games Institute. This AIEd tool optimizes and supports collaborative learning groups. Each learner has an intelligent tutor that gains insight about them and assigns them to a group most suited for their needs. Scriyb adjusts these assignments dynamically as the term progresses, to maintain the optimum group for each learner.

An argument against the use of AIEd that we occasionally hear is that it will replace professors. Our intention is the inverse, we see AIEd empowering professors. In large courses and programs, one size can’t fit all. Inevitably, some students fall behind and eventually fail. An individual professor can’t possibly engage in a the 1:1 interaction that is most effective. This is especially true for online courses. As a result, the professor has little choice but to use the lecture-style approach for the large group - which is the least effective way to learn. Unfortunately, the demands of assessing large groups of learners has also led to ‘auto-grading’, multiple choice exams that are extremely poor instruments for measuring learning outcomes beyond the basic recall of facts.

In providing 1:1 personalized, real-time learning support for each learner, and by providing real-time learning assessments, AIEd empowers the professor to assist learners when they need it, precisely targeting specific areas where they need that assistance the most. The AIEd empowers the professor to use a wide range of assessments based on what the learner finds most effective. Also, the AIEd assists the professor in collaborative group assignment and facilitation, again making the professor available to assist when and where it is needed the most.

Building and maintaining trust in AIEd is an important new dynamic that is critical in gaining acceptance for and continuing to progress and develop AIEd.

The level of trust a person has in someone or something can determine that person's behavior. Trust is a primary reason for acceptance. Trust is crucial in all kinds of relationships, such as human-social interactions, seller-buyer relationships, and relationships among members of a virtual team. Trust can also define the way people interact with technology.

Trust is viewed as: (1) a set of specific beliefs dealing with benevolence, competence, integrity, and predictability (trusting beliefs); (2) the willingness of one party to depend on another in a risky situation (trusting intention); or (3) the combination of these elements.

Trust building is a dynamic process involving movement from initial trust to continuous trust development. Continuous trust in a learning experience will depend on the performance and purpose of the artificial intelligence. AI applications that are easy to use and reliable — and can collaborate and interface well with humans, have social ability, facilitate bonding with humans, provide good security and privacy protection, and explain the rationale behind conclusions or actions — will facilitate continuous trust development (Siau and Wang, 2018).

To build and maintain trust for AIEd in our products, we have adopted design criteria and Quality Assurance (QA) criteria for AIEd. We communicate these to client institutions and solicit their assistance and feedback for their application.

In our ILXD process and throughout production and deployment, we are using the following six metrics for regarding AIEd:

1. Privacy and security: AIEd must comply with privacy laws that regulate data collection, use and storage, and ensure that personal information is used in accordance with privacy standards and protected from misuse or theft.
2. Transparency: We must provide contextual information about how AIEd systems operate so that people understand how decisions are made and can more easily identify potential bias, errors, or unintended outcomes.
3. Fairness: When AIEd systems make decisions or recommendations they must be fair. We must understand how bias can affect AI systems.

4. Reliability: AIEd systems must be designed to operate within clear parameters and undergo rigorous testing to ensure that they respond to unanticipated situations and do not evolve in ways that are inconsistent with original expectations. Humans should play a critical role in making decisions about how and when AIEd systems are deployed.
5. Inclusiveness: AIEd solutions must address a broad range of human needs and experiences through inclusive design practices that anticipate potential barriers in products or environments that can unintentionally exclude people.
6. Accountability: When we design and deploy AIEd systems we must be accountable for how the systems operate.

Part of building trust includes responsible treatment of the learner data that AI provides. Our standards ensure we can be this data conscientiously to enhance the learning experience.

Analytics

A common definition of Learning Analytics is *the measurement, collection, analysis, and reporting of data about learners and their contexts for the purposes of understanding and optimizing learning and the environments in which it occurs*.

Learning analytics uses the data associated with a learner's interactions with content, other learners, and the educational institution to make decisions and evaluations about teaching practices, personalized content, and needed interventions for learner success. The field draws on and integrates research and methodology related to data mining, social network analysis, data visualization, machine learning, learning sciences, psychology, semantics, artificial intelligence, e-learning, and educational theory and practice. Learning analytics focuses on the interpretation of the educational data from a learner and teacher orientation. This places as much emphasis on understanding the pedagogical context from where the data is derived as developing statistically robust interpretive and predictive models.

Learning Analytics Cycle

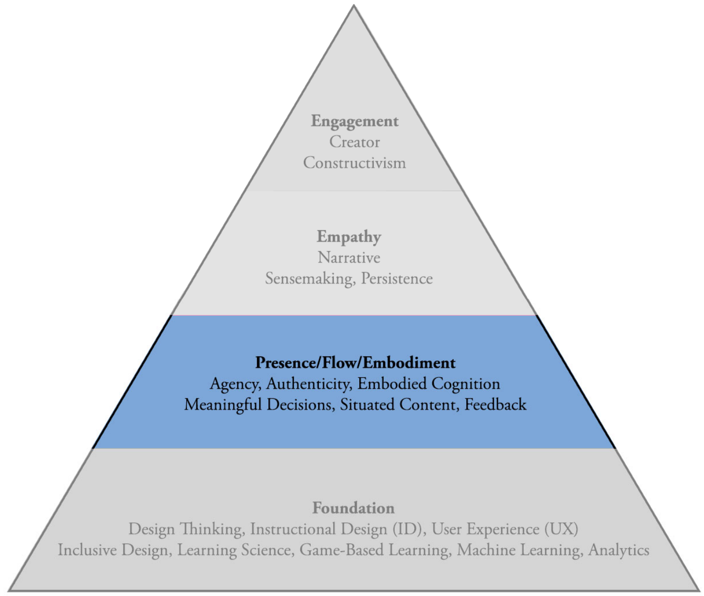
Learning Analytics are developed in a multi-step, cyclical process of data collection and pre-processing, analytics and action, and post-processing. Data collection and pre-processing involves the gathering of educational data from different learning tools or applications and preparing and translating it into an appropriate format.

The analytics and action phase denotes the actual application of analytic methods (e.g. structure discovery, relationship mining etc.) to extract meaningful patterns and information from the data and to make use of the obtained results, (e.g. visualization, feedback, recommendations, adaptation).

Post-processing refers to the idea of continually improving analytics, by refining analytics methods, using new methods, including new data sources, etc..

In the context of an intelligent immersive learning experience, learning analytics empowers AIEd through the use of intelligent data, learner-produced data, and analysis models to discover information and connections, and to predict and advise on learning. That data mining and analysis enables AIEd to provide real-time assessment of learning experiences. Predictions can be drawn on the basis of patterns of behavior as each learner follows in their individual learning pathway, and it can find hidden patterns in interactions that can be meaningfully interpreted and then fed back to learners in a way that supports their learning.

The intend layer of the ILXD pyramid is essentially the fundamental design phase. The elements are designer/developer-focused and structural. The use and process of learning experience design creates the learner-focused experience. Employing powerful tools such as AIEd and analytics flesh out the experience to make it truly engaging and immersive.



Immerse

"I am here now and my choices determine everything."

Immersion considers how three psychological variables: **presence**, **flow**, and **embodiment** contribute to interest in empathy and learning.

Presence is an antecedent to flow, and flow has a significant influence on enjoyment as well as performance. Presence and flow have a positive influence on embodiment.

Embodiment is the experience of self-presence as a psychological state in which the virtual self is experienced as the actual self in either sensory or nonsensory ways.

Presence, flow, and embodiment all contribute toward empathy and engagement. We use our knowledge and study of these elements to inform our immersive learning experience design.

Presence

"If you are there and what appears to be happening is really what is happening, then this is happening to you."

For first time users of VR, presence is a phenomenon that is profound and not soon forgotten. The feeling of actually 'being there' inside the medium, rather than looking at the medium from the outside through the 2D plan of a screen, elicits universal amazement and wonder.

Presence is the psychological perception of being (involved and immersed) in a virtual environment despite being physically situated in reality. Presence occurs when a person is unable to differentiate the sensory information from a hardware-mediated environment from that of reality, interpreting the virtual input as though it were from the real world.

Four factors determine presence: distraction, fidelity, sensory engagement, and control (Witmer and Singer, 1998). Those factors are listed in the order in which they are usually realized by the learner, each becoming more significant as the learner develops more VR literacy.

Distraction can occur from an improper fit or focus, display interruptions, or from physical distractions from the real world such as loud noises, an entangled tether cable, or bumping into furnishings or people.

Fidelity relates to the clarity and believability of the virtual environment. This includes resolution, color, accuracy of modeling, the extent to which the environment matches the learner's expectation for that content.

Sensory engagement is at a minimum visual and auditory, it and can also include touch (eg. haptics, wind, moisture) and smells. The base visual sense is from the display in VR moving according to the learner's head movement. The base auditory sense is spatial audio in VR where sounds appear to be coming from sources and those sounds change respectively when the learner moves their head or moves within the environment. VR hand controllers provide rudimentary haptics through vibration, and custom hand controllers are available that interact with the real world through peripheral equipment. Accessories are available to attached to VR headsets with small fans and emitters that create odors.

The sense of control begins with 'degrees of freedom', which describes the range in which the VR headset and its hand controllers can sense changes in location and rotation – both in respect to each other and in respect to the real world. Mobile VR (GearVR, OculusGO, Daydream View) typically has '3 degrees of freedom', which means that the headset and the single hand controller can sense rotation in respect to each other and to the real world, but neither can sense changes in location. Desktop VR (Oculus Touch, HTC Vive) have '6 degrees of freedom' because the headset and dual hand controllers can sense both changes in rotation and in location in respect to each other and to the real world.

The sense of control is significantly impacted by the quality of the user interface and by the level of control, responsiveness, and naturalness of interactions and locomotion.

Presence is an emergent element in the ILXD model, where the result is greater than just the sum of the four contributing factors. When the experience is free of distractions, high in fidelity, rich in sensory engagement, and deep in control affordances it provides for heightened immersion supporting flow and embodiment. Designing with presence in mind is a high priority in immersive learning experience design because it is critical to 'selling' the learning experience.

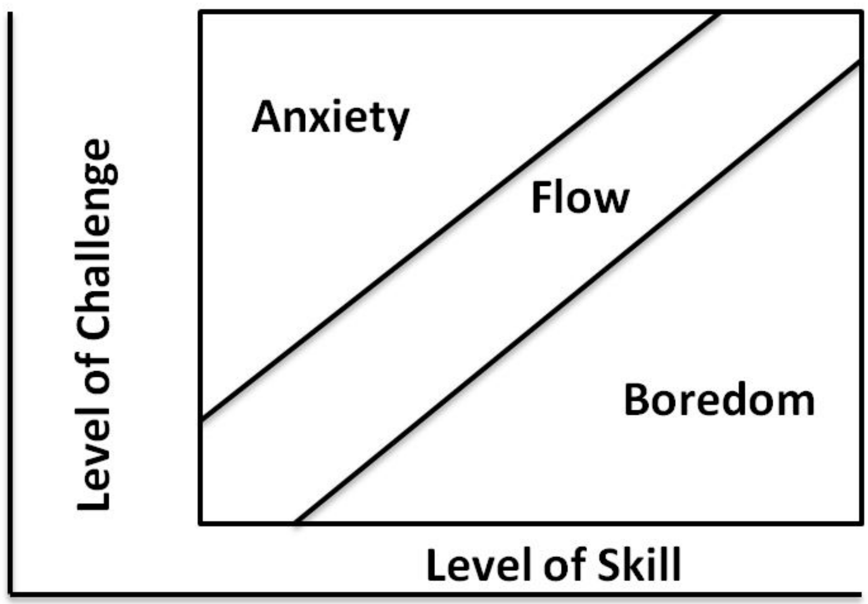
Flow

Flow is a term that was coined by a leading researcher in optimal experience psychology, Mihalyi Csikszentmihalyi, who began his career studying the motivations of (board) game players, rock climbers, and painters (Csikszentmihalyi 1975a). In this research, Csikszentmihalyi described Flow as the heightened and improved state of mind experienced while subjects were most engaged in a task and performing at their best.

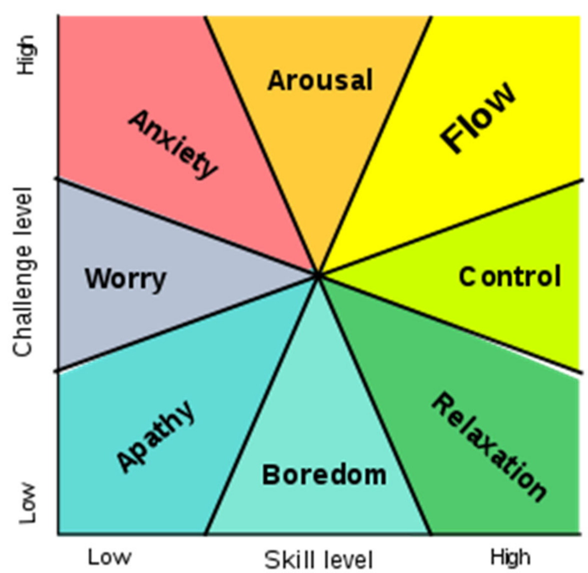
Csikszentmihalyi expanded his work to study people in their ordinary lives using the experience sampling method research tool (Csikszentmihalyi and Csikszentmihalyi 1990). On the basis of these empirical studies, Csikszentmihalyi specified eight major elements of the flow experience common to the majority of people during optimal experiences:

Flow Elements
A challenging but tractable task to be completed
One is fully immersed in the task, no other concerns intrude
One feels fully in control
One has complete freedom to concentrate on the task
The task has clear unambiguous goals
One receives immediate feedback on actions
One becomes less conscious of the passage of time
Sense of identity lessens, but is afterward reinforced

Csikszentmihalyi also formed the hypothesis that flow occurs as the balance between perceived skills and challenges [Csikszentmihalyi 1975a], thus what he calls the “flow channel” is a linear function on a plane with skills and challenges as axes.



Flow State is an experience description construct ubiquitous in game-based learning research. It is most commonly represented with a diagram that depicts eight conditions that are reached on the plane with skill and challenge as the axes.



This diagram explains the alternative states that occur when challenges or skills are initially too low or when a task must be repeated too often.

Csikszentmihalyi's theory states that it should be possible for any person to experience Flow in any activity, but that the participant and the activity must meet certain prerequisites before Flow can occur. Of these, perhaps the most important are that the person should have an *autotelic personality* (the ability to recognize and seize upon opportunities for flow) and that his or her skills match the activity's challenges in precisely the right ratio.

But, flow is isomorphic across all types of people—it is a universally uniform state of being, and all people recognize it when it is explained to them. Since universal cognitive states are inherent in the flow experience, there are certain types of universally accessible activities that preempt and enable these cognitive states. These include activities that facilitate flow far more easily than others for anybody, regardless of their skill in that activity. Games are one of these activities because the cognitive state necessary for the activity closely matches that achieved when in flow. An individual's propensity for happiness, brain chemistry, and capacity to concentrate will still impact their ability to experience flow, but the point is that the individual will start off that much closer to the cognitive state achieved in flow, by *simply pursuing activities of this class*. (Cowley, Charles, Black, Hickey, 2009)

Among the possible classes of activities, game-based learning in VR is the ideal for the activation of the flow state due to the heightened propensity provided by presence.

In the ILXD model, a critical objective is achieving and maintaining a flow state by balancing the challenge of learning activities in the experience with the learner's skills, interests, and motivation. It is expected that throughout the duration of the learning experience a flow state should naturally ebb and rise in response to the story arc of the experience, pacing, and scaffolding of challenges.

Flow is addictive. Flow state has been shown to release neurotransmitters including: seratonin, dopamine, norepinephrine and endorphins. Csikszentmihalyi's research showed a strong correlation between flow state and happiness. Every learner has their own unique set of factors and stimuli that puts them in a flow state. But, the end effect is similar in all learners.

A flow state becomes critical objective in the ILXD model because it promotes empathy and heightens engagement in all respects.

Embodiment

Effective learning experience design leads to embodiment, which is a critical component of ILXD. A sense of embodiment in VR is the subjective experience of using and 'having' a body. It is a sense that emerges when properties and behaviors in VR are processed as if they were the properties of the learner's own biological body.

The learner's whole body can be 'replaced' by a virtual body in VR so when they look down towards their own body, they would see the virtual body instead. Additionally, when they look towards a virtual mirror they would see this virtual body reflected back. This is already a very powerful cue to the brain to feel this virtual body as their own since throughout life whenever we look down towards our body, or in a mirror, of course we see our own body.

Cognitive neuroscientists have discovered that our body representation is surprisingly flexible, where the brain can easily be tricked into the illusion that a virtual hand is your hand or that a virtual character body is your body. These illusions work well in VR, and such embodiment induces perceptual, attitudinal, and behavioral changes that are concomitant with the displayed body type (Slater and Sancheze-Vives, 2014).

The idea of 'body semantics' is that when the brain generates an illusion of body ownership and agency over a virtual body then it also generates attitudes and behaviors that are concomitant with that type of body, independently of any other factors such as social expectation. This is an intrinsic property of brain functioning, and not necessarily a product of social expectation, whether actual or imagined.

This is often called the "Proteus Effect", which is a phenomenon in which the behavior of an individual in VR is changed by the characteristics of their avatar. This change is due to the individual's knowledge about the behaviors that other users typically associate with those characteristics. Like the adjective *protean* (meaning versatile or mutable), the concept's name alludes to the shape changing abilities of the Greek god Proteus. The Proteus effect was first introduced by researchers Nick Yee and Jeremy Bailenson at Stanford University in June 2007.

There are three primary representations of embodiment in VR:

Sense of Self-Location
The sense of self-location refers to one's spatial experience of being inside a body. Furthermore, this spatial representation is always self-attributed; that is, the body where one perceives one's self is one's own body. Finally, this body also obeys the intentions of one's self; for example, one is the author of one's body's actions.

Self-location is a determinate volume in space where one feels to be located. Normally self-location and body-space coincide in the sense that one feels self-located inside a physical body.

Self-location is highly determined by the visuospatial perspective given that this is normally egocentric. Indeed, it has been shown that where one feels located can be influenced by the origin of visuospatial perspective.

Other studies on the role of perspective (e.g., Slater, Sanchez-Vives, 2014), showed that physiological responses to a threat given to an artificial body were greater for first-person perspective than for third-person perspective.

Vestibular signals are also considered to play a significant role in one's self-localization. These signals contain information with respect to the translation and rotation of the body in addition to orientation with respect to gravity.

Sense of Agency

The sense of agency refers to the sense of having ''global motor control, including the subjective experience of action, control, intention, motor selection and the conscious experience of will'' (Blanke & Metzinger, 2009).

The sense of agency results from the comparison of the learner's expectation and the actual result in regards to movement. When the learner has taken an action to move in VR and the movement that occurs closely matches the intention, the learner feels that they are the agent of that action. The converse is also true, when there is a discrepancy between the action to move and the resulting movement in VR the sense of agency is negatively impacted.

Sense of Body Ownership

Body ownership refers to one's self-attribution of a body. It has a possessive character and it implies that the body is the source of the experienced sensations.

The sense of body ownership emerges from a combination of:

Afferent sensory information that arrives to our brain from our sensory organs; for example, visual, tactile, and proprioceptive input.

Cognitive processes that may modulate the processing of sensory stimuli; for example, the existence of sufficient human likeness to presume that an artificial body can be one's body.

In order to induce ownership toward an external object, a basic morphological similarity with the real body part is needed. Body ownership is not exclusive to artificial body parts but can also be felt for artificial whole bodies.

Embodied Cognition

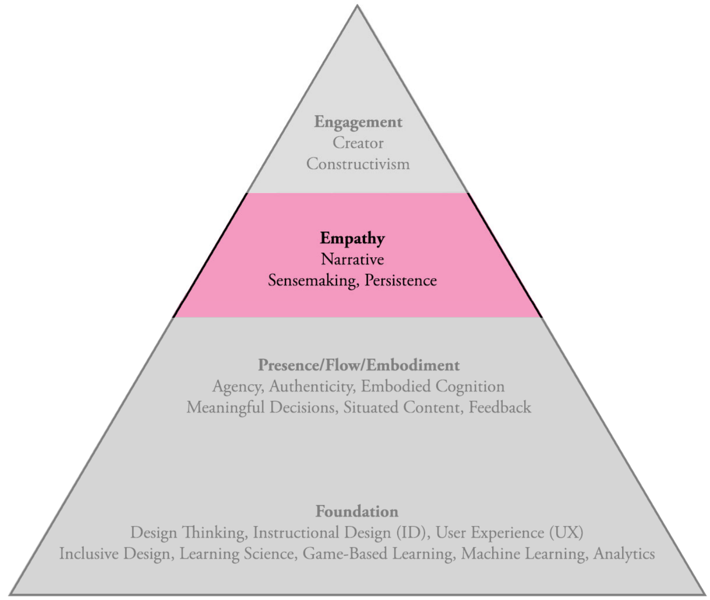
Embodied cognition acknowledges that the mind and body are agents working together to make meaning of VR experiences.

VR can convey experience or feelings to a learner. In VR environments, learners can strongly feel emotions or situations by being in the same space and close to another character.

Becoming absorbed in VR can stimulate empathy. Stimulated empathy in VR can make users perceive a virtual environment as a more realistic and generally empathic experience.

Through empathy, users can feel a sense of embodiment or embodied cognition. Learners in VR are able to embody experiences by viewing, playing, and feeling perceptual cues linked to those experiences. Embodied experiences create the sensation of personally having an experience in VR. Learners who embody their avatars tend to perceive avatar actions as their own. Embodiment has a positive effect on engagement.

The immerse layer of the ILXD model is the first level of learner engagement. The learner is present and experiences a flow state so they are fully able to embody the learning experience. Immersion supports the learner so they are able to transition into the feel layer of the learning experience and feel connected to the learning.



Feel

“I care about the story and my role in the experience.”

Empathy is the ability to understand and share the feelings of another. It is a critical element of learning and a fundamental aspect of our products. Empathy fosters insight into different perspectives and promotes genuine open-mindedness. It discourages hasty and superficial problem examination and stimulates critical thinking. Empathy discourages belief rigidity and encourages cognitive and personal flexibility.

We are built to understand the emotions and actions of others. Empathy is a major force in human behavior, so attaching empathy to learning in order to change behavior (apply learning) is essential. There is hard evidence that empathy and academic performance are correlated.

Our goal is to attach feeling to learning, to make the learner care about the story and their role in the experience. Gaming is the ideal environment to utilize empathy in learning. In order to capitalize on these benefits, we follow some guiding principles. We attach all learning to “self” by providing agency to the learner. We enable the learner to construct the learning for themselves and to use what they know to relate to the world around themselves.

Because we often understand ourselves through understanding the needs of others, we create an environment with a sense of community. In game play, we activate the learner's intrinsic motivation by building relationships with non-player characters (NPCs), the AI guide, and learner peers. This socio-constructivist approach enables learners to make connections and build a sense of community, increasing empathy and engagement.

Our methods of building empathy include using **Narrative** and **Sensemaking**. An outcome of a well-designed, empathetic gaming learning experience is **Persistence**.

Narrative

Narrative is the game story, including the situation, the learner role and goals, NPC character motivations, talents, and needs, the problems to be solved, and the skills to acquire or the goals of the game.

We use narrative to increase the learner's emotional proximity so that they identify with their role in the game. Story can cause feelings of pleasure, drama, and stress, to name a few, and strong emotions lead to memorable experiences.

With plot hooks, the learner experiences unanswered questions they are compelled to answer or they are called to action and are motivated to solve a problem. Narrative helps focus attention, aids in comprehension, and creates curiosity in the learner, all motivating factors. Performance and feedback fuel the learner's motivation and persistence.

Role play has long been proven as an effective learning experience. It is inherent in gaming, since learners are embodied in experiences. As they experience the game, learners engage in learning, critically reflect, and solve problems. They synthesize diverse information, analyze outcomes, and identify causal relationships between concepts.

Well-designed narrative does not allow for a passive learning experience. It is immersive and demands participation in the story and in the learning.

From a learning perspective, narrative is a cognitive framework that supports problem solving and enables the learner to assign meaning to their experiences. The schema provides a structure to foster skill development and content knowledge by requiring skill application and knowledge to complete the game. Narrative enables us to use multiple modes of information that enable the learner to solve problems, and provides opportunities for reflection, evaluation, exemplification, and inquiry. It is naturally scaffolded and provides opportunities for metacognition and reflection by asking key questions and guiding the learner to think about what they've accomplished (learned) and how that will lead to the story goals (learning outcomes).

Sensemaking

Sensemaking is the articulation of the unknown. It enables a learner to make sense of the world so they know how to act in it. In game, when the learner asks, "What's the story?", they are sensemaking. It's a method of making sense of an ambiguous situation and creating situational awareness in complex or uncertain situations in order to make decisions.

This natural strategy requires the learner to create a "map" of a changing world, then test the map through data collection, action, and conversation in order to refine the map. The continuous effort to develop a plausible understanding of the world, testing it, and refining their own understanding helps motivate the learner to make connections in order to act effectively.

In order to get the most out of this strategy, games must be designed with stimuli placed into a framework within the learner's zone of proximal development so learners can understand, explain, and then apply, analyze, synthesize, and evaluate information. These adaptive challenges require responses just outside of a learner's existing skill set, taking advantage of the gap between what they want to achieve and what they can achieve. By acting in game, they are able to understand their new reality and assign meaning to new concepts.

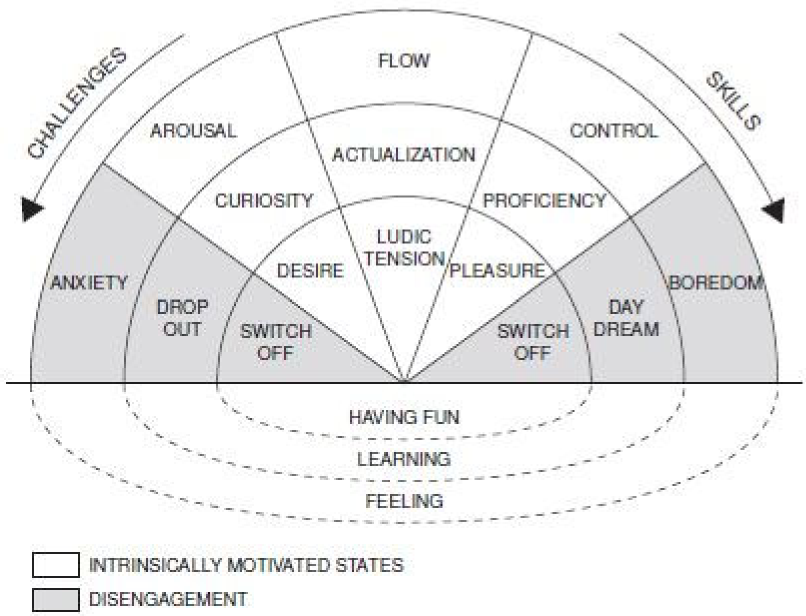
In gaming, we have a unique opportunity to create a virtual environment that immerses the learner in an environment that directly relates to their learning goals. Through sensemaking, learners can use their reasoning, intuition, logic, and emotional intelligence to navigate successfully through stories and simulations to move from "what is" to "what it can be" based on the learner's decisions. We can create meaningful, interactive, and challenging worlds involving the learner as the conductor of their own development.

Motive

An important aspect of sensemaking is motivation, or the reason that explains or justifies actions. In gaming, learners are motivated to make sense of their world, which is a key part of their success or failure.

Extrinsic motivation pulls a learner to complete an activity because it is important or because of a reward or a threat. Intrinsic motivation is what the learner finds interesting and can be linked to learning through fun. Sustained participation in any learning activity, or persistence, is closely related to intrinsic motivation.

In learning, motivation leads to the activation of efficient cognitive strategies. Fun, a key element in gaming, is a potent source of intrinsic motivation. Games engage learners emotionally, activating pleasure and desire, eliciting ludic tension through chance and strategy, rules and freedom, reality and fiction.



Intrinsic motivation is a balance between challenges and skills, curiosity and proficiency. Our goal in game design is to capitalize on motivation-based synergies in game in order to activate intrinsic motivation.

Motivation-based synergies: Values, Power, Usability, Openness, Candor, Humility, Hunger

Taking advantage of key factors of motivation ensures the game is as effective as possible. These essential elements of game design include best practices on what include and what to avoid in order to design an effective, motivating game.

Values: Building our games with embedded values expressed in the rules activates intrinsic motivation. We enable the learner to test the values of the game and compare and contrast them with their own. The learner can experiment with values in the game to learn what would happen with a different set of values.

Power: Enabling learners to confront and test the rules in game and experiencing meaningful feedback gives the learner control. This way, the learner may gain knowledge through interactions rather than static data. It enables risk-taking, a critical factor in learning.

Usability: Ensuring that all learners have access to the game, we must keep our audience in mind by designing for accessibility. We use AI to create individualism and avoid barriers that might lower the learner's urge to play the game (technical difficulty, gender bias, etc.).

Openness: Providing autonomy by designing gameplay with choice and space is a key motivating factor. We avoid predefined trajectories that hinder creativity and exploration (fun and learning).

Candor: Designing games to take advantage of all aspects of communication in order to create opportunities for collaborating (with AI or other students), negotiating, competing, etc., is an effective tool for sensemaking and activating empathy.

Humility: Pushing learners to honestly acknowledge the skills and talents they have and those they need to refine or improve is an important factor in motivating game design. We meet the learner where they are, and design the game so they are challenged just outside their comfort zone.

Hunger: Accessing a learner's primal need to succeed and their desire to work hard and do whatever it takes to win the game is a fundamental element of game design. Learners in game are already intrinsically motivated, so keeping them hungry through various levels of success and failure ensures persistence in game.

Persistence

Persistence is a highly valuable skill in most aspects of life, and has been shown to positively impact learning. Two aspects of persistence bolster our argument for gaming in education. First, learners persist in their learning due to their increased desire to continue playing a game. Second, educational gaming increases persistence of knowledge retention over time.

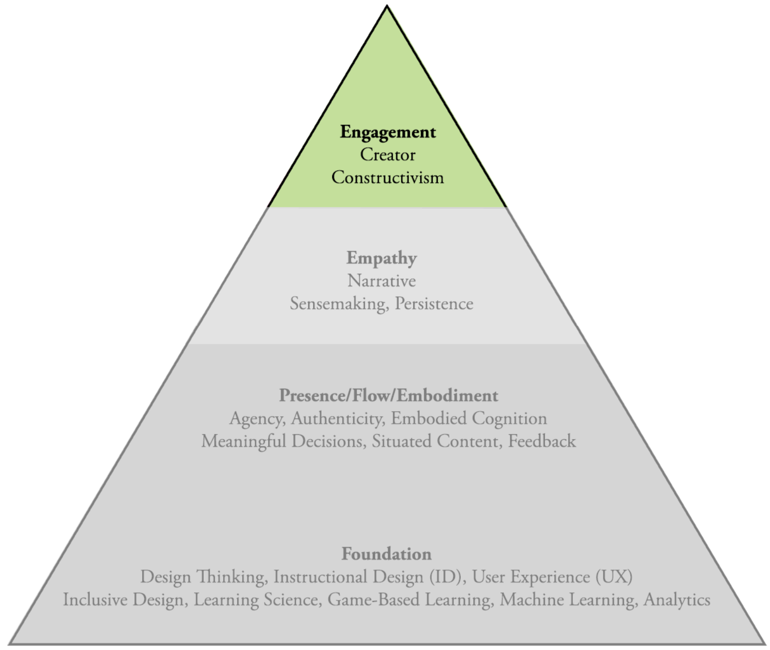
Persistence reflects the need to complete difficult tasks and the desire to perform well in the face of frustration. Learners are intrinsically motivated to persist through a game due to many factors already discussed. Thus, a well-designed game has an advantage over traditionally-delivered learning in the fact that learners are more likely to engage in and successfully complete the learning. Persistence is higher in games with the right level of difficulty for each learner, on the outer edges of the learner's abilities. The progressive difficulty and repeated exposure to challenge creates a willingness to work hard despite repeated failure.

Another advantage of gaming over traditionally-delivered content is the effects of persistence in learning. Persistence can positively impact learning for all students, especially for struggling students. Games, especially games with risk, improve long-term retention of information, enhance transfer of knowledge, improves recall, and can even increase knowledge over time. In addition, people remember information better through Virtual Reality than traditionally-delivered content. Games can be designed with spaced repetition to instill concept review, remediation, and skill building in frequent intervals over time.

One important reason persistence is so evident in gaming is because of the strong connection between gaming and empathy. Any learner about their favorite book or movie, and they will be able to tell you in great detail about the plot, characters, and story. They have emotionally imprinted on the media triggered by their natural empathetic nature, an element of learning that is ever-present in gaming.

Because learners are more likely to persist in their learning through games, and because that learning is more effective than traditionally-delivered learning, learners better retain information and their learning persists over time.

The learner has immersed themself into the learning experience. They have used their empathetic skills to feel and engage with the narrative and have employed their sensemaking strategies to effectively navigate the experience. Through their high level of connection to the learning, they will persist through the learning experience and retain the concepts they learned. The final level of the ILXD Pyramid describes the pinnacle of the learning experience; full engagement with the learning.



Learn

"I am a creator and share my experiences with others."

The sum of the ILXD elements realizes the potential of intelligent immersive learning with full engagement. When the optimized LXD has afforded immersion and leveraged empathy, and it is supported by AIEd and analytics, the optimal conditions are in place and the stage is set. The **learner** is fully empowered in every respect and **constructivism**, with heavy reliance on **collaborative** techniques, is the final element that enables the optimal learning experience to occur.

Constructivism
The constructivist philosophy holds that knowledge is constructed through an individual's interaction with the environment. The core ideas of this theory have existed for over a century, with Jean Piaget and John Dewey as among the first to develop a clear idea of it. As opposed to behaviorism that holds to knowledge reproduction, constructivism as a learning theory emphasizes the combination of inputs from the senses, existing knowledge, and new information to develop new meaning and understanding through active, authentic, cooperative and reflective learning activities.

Constructivist learning is not the passive acceptance of knowledge but requires a learner to manipulate something such as constructing a product, manipulating parameters, or making decisions. To engage the learner in meaningful learning, learning must be an active process in which the learner uses sensory input and constructs meaning out of it.

It is crucial to provide problems to the learners in constructivist learning as they learn through their attempt to solve the problems. Constructivism also holds to the principle that learning is contextual.

A constructivist learning environment needs to provide adequate description and/or depiction of the contextual factors that surround a problem so that the learner can understand it. Constructivism stresses the importance of presenting an authentic problem; a problem that is similar to the one that exists in the real world. It also highlights the necessity for presenting such an authentic problem in an appealing and interesting way. The understanding of the problem context, and the authenticity as well as the attractiveness of the problem, helps the learner to value its importance and relevancy, which leads to higher motivation and engagement in finding the solution for the problem.

VR provides a controlled environment in which learners can navigate and manipulate the virtual objects found within and more important, the effects of such interaction can be observed by the learner in real time. VR is ideal for providing exploratory learning environments which enable learners to learn through experimentation.

VR provides a three-dimensional representation of a problem in the form of visual, auditory, and tactile and/or kinesthetic. It can mimic the real-world and artificial environments that simulate aspects of the real world, providing access to places that are inaccessible through direct experience.

Agency in VR allows the learner to freely explore and manipulate the virtual objects within the environment. Unlike many other learning experiences, a VR experience is designed without a specified sequence. Its focus shifts from the design of prescribed interactions with the learning environment to the design of environments that permit the student to experience any kind of interaction the system is capable of. This complies with the learner-centered approach where the learner can keep control over what he or she wants to explore or manipulate.

In other words, the learner can choose to navigate through the simulated environment or interact with the objects of his or her interest for further observation. In doing so, the learner may make mistakes and wrong predictions. These experiences are the conditions for modifying existing knowledge and thus constructing new knowledge. Therefore, VR agency complies with another principle of constructivist learning that specifies the need to grant learners the responsibility for the learning process in order to create understanding.

Since constructivism holds that learners can learn better when they are actively involved in constructing knowledge in a learning-by-doing situation in which they are in complete control, the characteristics of VR and the axioms of constructivist learning theory are well aligned.

The Learner as Creator

In the ILXD model the learner is a creator of their own learning experience. The learner is empowered and responsible, leading to a high level of engagement.

They are free to pursue perspectives of choice and diverse ways of thinking. The learner chooses how, where, and when to focus on aspects of the given problem. They can choose to examine content and context in detail or experiment with abstractions. Ultimately, the learner discovers and evaluates cause and effect relationships and constructs their own understandings.

With this freedom comes a responsibility to experiment, explore, and analyze from multiple perspectives using multiple methods and to discriminate among myriad outcomes.

Collaboration

From the constructivist perspective, learning best occurs when a group of learners work together to solve problems in a social activity where teamwork and mutual exploration is important. This “community of practice” of learners working together develops a shared history, a shared identity, a repertoire of common practices, and a similar knowledge set.

In the constructivist model, social interaction creates new knowledge—a distinction between “knowing that” and “knowing how”. “Knowing how” is best accomplished through actual practice, social interaction with other learners, observation of practice, and brief apprenticeships in teaching and learning. Social interaction is essential in “knowing how” to perform because “learning how” is a social-dialogical process of negotiating tacit knowledge through dialogues and conversation. The wide variance often found in practice, the nuance found in exemplary performance, and the translation required between theory and practice are best mediated through social interaction.

Emergence is a function where the learner's experience varies depending upon group dynamics and it can prolong social participation. In this way, emergence adds to engagement and most often results in increased duration, replays, and persistence of the community of practice.

Social VR (multiplayer) amplifies the elements of the ILXD model. Presence, flow, embodiment, and empathy are dramatically increased when learners encounter other learners real-time in the learning experience.

The collaboration can be aided with AIEd. This can be internal to the experience through AI characters and/or external through group assignments that are optimized by AI selection and/or AI moderation of the group dynamics with AI driven changes to the experience, content, or context to best suit a desired dynamic for each learner.

Through constructivism with reliance on collaboration, the learner is empowered as the creator of their learning experience. This final level of the ILXD Pyramid enables the learner to be fully engaged in their learning, signifying an effective, personalized, powerful learning experience they created for themselves.

Conclusions

We intend for the ILXD model to provide a framework to design 'the optimal learning experience': exhilarating learning with a deep sense of enjoyment and satisfaction. The experience will encourage the learner to stretch to their limits as they are focused on applying new skills that are matched to challenges and opportunities.

Most importantly, we intend the IXLD model to serve a fundamental shift in focus, with the learner's experience as the core objective and the learner's personalized instructional needs as the guiding framework.

The depth and breadth of pedagogy and educational technology topics imbued in the the elements of the ILXD model can at first seem overwhelming. This effect can be amplified by the fact that they are drawn from across disparate disciplines and are prone to a dizzying rate of change. While each element is integral, they can be individually considered and understood. We have found this to be the recommended approach for implementing the model.

The elements of the ILXD model are not intended to be considered all-inclusive, nor is the model itself intended to be considered absolute. The entire model is not necessarily appropriate for all situations.

Instructors can enable learners to create their own 1:1 learning experience, and can utilize machine learning and deep learning to ensure that students do not design an ineffective learning experience for themselves.

Our goal for this paper is to introduce our experience with the ILXD model as a starting point for discussion and collaboration in a community of practice. We hope that you will find it useful and we look forward to learning about your work and discussing your comments, suggestions, and questions.

In the next paper (part two of three) in this series, we address taking the ILXD through production using our own products as case study examples for implementations in professional education and university courses.

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