WHITE PAPER

Immersive Experiences in Education

New Places and Spaces for Learning

Microsoft

About the author

Alice Bonasio is a technology journalist, author and consultant. She is currently Editor-in-Chief of techtrends.tech and contributor to publications including *Wired*, *Quartz*, *Ars Technica*, *Scientific American*, *Fast Company* and others. Bonasio has a particular interest in immersive technologies and is considered an influencer and expert in that field, having covered the space for several years while also consulting on digital transformation strategy and adoption of Mixed Reality solutions for a wide range of companies.

Immersive Experiences in Education

Abstract

Immersive technologies are becoming more popular and accessible to consumers, and this means that we are starting to see their use in a wider variety of settings, including the classroom. This is a positive development for teachers and students alike. When immersive technologies and game-based learning are deployed correctly and in a pedagogically consistent manner, they have the potential to support and expand curriculum, enhancing learning outcomes in ways which haven't been previously possible, affordable, or scalable.

As with the introduction of any innovation, however, there are obstacles and challenges as teachers attempt to balance technical logistics with content that correctly supports and augments learning styles and objectives, all without losing sight of individual student needs. In 2018, Microsoft collaborated with McKinsey & Company to publish the Preparing the Class of 2030 research study. This mixed-methodology research identified three key technologies as showing greatest promise in supporting personalized learning and social and emotional skills; mixed reality tools, collaborative platforms, and AI-enabled analytics. These findings were validated in 2019 when Microsoft commissioned further research with the Economist Intelligence Unit to examine the Emotion and Cognition in the Age of AI where, again, mixed reality and immersive experiences were highlighted as playing increasingly critical roles in modern education.

This paper examines the case for incorporating immersive technology and game-based learning in educational settings. This is done through cross-referencing pedagogical theory with case studies obtained through personalized email interviews with teachers, students, researchers, and technologists who have successfully deployed such technology within various learning environments and contexts.

Terminology

While there is a growing consensus among experts that immersive technologies offer extraordinary opportunities for enhancing motivation and learning across a range of subject areas, student developmental levels, and educational settings, there isn't yet a widely accepted common lexicon to which we can reliably refer, as experts continue to refine their definitions of terms in this field.

Virtual Reality (VR) is often used to refer to enclosed experiences that fully immerse the user in a computer-generated environment and shut out their physical surroundings to a large degree. *Augmented Reality* (AR) experiences, in contrast, superimpose digital elements onto real-world objects and backdrops.

As immersive technologies evolve, a more complex and granular picture emerges. There is an entire spectrum where the digital and real worlds mix together, giving rise to the term *Mixed Reality*, which is increasingly gaining traction. Since this paper mostly refers to evolving immersive technologies and experiences in a broader context, we predominantly adopt the term *Mixed Reality* (MR) to describe these.

Introduction

In the field of EdTech, technology often tends to take precedence over education, meaning that solutions are implemented without appropriate consideration and scrutiny of the pedagogical context within which they will be applied. This leads to the failure of many initiatives, because regardless of the transformative power of any one technology, its effectiveness inherently depends on coherent deployment as part of a broader strategy. This is evident in the education sphere in particular, where success is invariably linked to effective engagement with educators, and to building responsive feedback loops that prioritize learning outcomes.

Research has shown that the most effective educational experiences are those designed around social constructivist learning approaches, which involve mastering authentic tasks in the context of personally relevant, realistic situations.[1] This is something that immersive technologies are particularly well-suited to provide. Simulations allow learners to not only recreate and practice routine situations, but also to access experiences which would be out of reach—due to difficulty, expense, danger, or sheer impossibility—in real life. Their effectiveness, however, hinges on the ability to create conditions where the learner feels truly immersed in an environment and narrative, replicating the impact of a real-world experience.

This paper explores various ways immersive technologies, such as MR, can impact learning outcomes—for example, reducing the cognitive load on the brain by allowing direct, first-person visualization of complex ideas and structures. This not only dramatically increases student engagement, but also enables learners to assimilate complex information more efficiently and retain it for longer. Perhaps most important, this is achieved within a holistic context that significantly increases the rate of transfer (i.e., the ability to successfully adapt and apply what is learned in a variety of real-life scenarios). This transfer takes place because technologies such as MR can leverage immersion to successfully simulate a variety of realistic scenarios within specific pedagogical contexts.

Immersion

Immersion refers to the mental state of being completely absorbed or engaged with an activity. It is a powerful vehicle for identity and knowledge transfer, both of which are crucial factors affecting learning outcomes. This is a principle that has long been demonstrated with game-based learning,[2] which involves taking on and playing with identities in a way that the learner has real choices (in developing the virtual identity) and ample opportunity to meditate on the relationship between new identities and old ones. Learners are also given the opportunity to practice, and are supported in, transferring what they have learned to later problems, including problems that require adapting and transforming earlier learning.

1 Ertmer & Newby, 2013
2 Gee, 2003

A major criticism of instruction today is the low rate of transfer which sees even students who excel in schooling or training settings unable to apply what they have learned outside a theoretical context. Situated learning in well-designed digital environments, however, can lead to the replication in the real world of behaviors that have been successful in simulated environments.[3]

Within the Plan, Act, Reflect (PAR) cycle, students first prepare for an experience by doing something they want to master, then attempt that performance, and finally assess what went well, what did not, why, and what they need to learn in order to execute a more successful repetition of the cycle. Immersion is intrinsically helpful for some aspects of motivation and situated learning—which involves constructing an ecosystem within which students build their own learning experience.[4] Immersion is crucial to designing effective situated learning experiences, and it can take several forms, such as:

- ***Psychological immersion.*** Although it may seem counter-intuitive, basic ideas and skills are best learned in the context of attempting relatively complicated tasks that have relevance to the real world.[5] This occurs because both the configuration and the coordinated team activities within this environment provide a wealth of embedded knowledge. A medical student or surgical resident, for example, will gain and retain much more knowledge by performing tasks within the realistic setting of an operating room than by reading a book.

  Although this is a well-recognized fact, it has traditionally proved difficult to create such unstructured learning experiences embedded in real-world settings. Immersive experiences bypass practical limitations such as expense, logistics, capacity, and risk. They tap into the power of psychological immersion and provide experiences driven by social and collaborative interactions, where the setting itself contributes to fostering tacit skills.

- ***Sensory immersion*** occurs when students can effectively "feel" themselves being part of a virtual world, and has been used extensively for vehicle training and other procedural learning applications.[6]

  Leticia Ahumada, a primary education teacher who uses Minecraft: Education Edition to empower teachers to deploy game-based learning in their classrooms, observed how this use of technology increased student engagement by fostering a sense of immersion. She recalls that when she asked one of her students why they enjoyed studying history with Minecraft, they answered that, with Minecraft, they weren't studying history, but *living* it.

> *"I believe this is the real power of Minecraft and other immersive technologies. For younger students that are used to playing on their tablets and watching videos on their devices, such games are their reality, so the learning is more real for them in this environment than reading a book, for example."*
>
> **Leticia Ahumada**
> **Primary Education teacher,**
> **Microsoft Innovative Educator Expert,**
> **and Minecraft Global Mentor**

- ***Narrative and symbolic immersion.*** Narrative is an important motivational and intellectual component of all forms of learning, and an immersive experience can trigger powerful semantic associations. In a mediated, simulated experience, immersion requires the willing suspension of disbelief which is prompted by emotional investment in a compelling narrative. Inducing powerful immersion for learning therefore depends on designs that utilize actional, social, and symbolic/narrative factors, as well as sensory stimuli[7] in order to create game-based learning experiences that are believable from a psychological and cognitive—as well as physical—perspective.

3 Fraser et al., 2012; Mayer, Dale, Fraccastoro, & Moss, 2011; Norman, Dore, & Grierson, 2012
4 Wenger, 1998
5 Dede, 2009
6 Jacobson, 2013
7 Dede, 2009

"Students report a greater understanding and appreciation for the development of VR content after engaging in 3D animation and/or game design projects. In particular, students are able to see the connection between the engineering of a virtual world, and the virtual world's role as an element of digital storytelling."

Paul Turnbull
President Mid-Pacific Institute

"I think the main advantage is the motivation that students get. With game-based learning models they learn to learn by themselves, work in groups, solve problems.... In other words, they acquire skills they are going to need in the future to face the challenges in their lives. The feedback I receive from teachers is that students are not only motivated to learn at school but also learning on their own, starting to do activities while the teacher is not yet in the classroom, and researching subjects at home to perform better in class."

Leticia Ahumada
Primary Education teacher,
Microsoft Innovative Educator Expert,
and Minecraft Global Mentor

Part of this narrative-building aspect of immersion is the facilitation of social interactions. Learning to evolve group and organizational identity through identity "play" is a crucial skill in enabling innovation and in adapting to shifting contexts. This learning also provides a means for different sides of a person or team to find common ground and the opportunity for synthesis and evolution.[8] Exploring virtual identity—unfettered by physical attributes such as gender, race, and disabilities—can become an important part of a student's development.

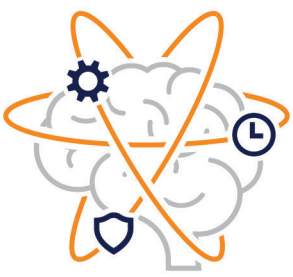
- ***Actional immersion*** involves initiating a process for the participant that leads them to take actions which have novel and intriguing consequences in the context of their own prior experience, such as a child learning to walk for the first time, giving that endeavor their undivided attention.

Cognitive processes

The jobs that will be available in the next few decades will require high levels of collaboration, negotiation, and emotional intelligence—while putting a premium on skills such as deeper cognitive abilities, creativity, and critical thinking. These cognitive skills are currently where the vast majority of the evidence base for MR in education shows significant promise. There are certain cognitive factors triggered by immersive technologies which are particularly relevant in a learning content.

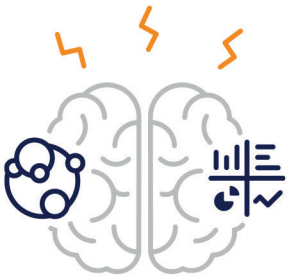
Cognitive Processes

Figure 1



Embodied cognition
Digitally immersive experience enable students to practice and perfect skills in a safe and accurate learning environment.

Mastery-focused learning
Evidence shows that test scores among students using Immersive Technology improved by as much as 22%.



Cognitive load
Mixed Reality reduces information bottlenecks and increases performance on skills-based tasks, resulting in gains in knowledge, abstract reasoning, and critical thinking.

8 Laurel, 1993; Murray, 1998

Embodied cognition

Immersive technologies let you practice and perfect skills in a safe and accurate environment, and the implicit learning through embodiment within those immersive environments results in the illusion of presence. This involves not only the feeling that one is in a certain place, but also that the events unfolding in that place are in fact occurring, and even extend to a sense of "body ownership" with one's avatar. This embodied cognition involves creating a mental perceptual simulation which, when facilitated by curricular and instructional support, can be quite productive within a teaching environment.[9]

Real-world embodied cognition experiences are limited by a variety of practical factors. Inner city students don't often have the chance to visit a farm, and it is impossible for anyone to travel back in time to experience life in a different century, or witness relativistic effects when moving close to the speed of light. With the aid of MR, however, digitally immersive experiences can be delivered to students, bridging the gap between theory and practice, and enabling new and powerful modes of learning.

Mastery-focused learning

MR provides a constant stimulus-response-positive reinforcement paradigm that results in efficient, mastery-focused learning.[10] Evidence shows that test scores among students using immersive technologies improved by as much as 22%, with the effect maintained over a period of weeks, including increased performance on skills-based tasks and gains in knowledge, abstract reasoning, and critical thinking.[11] This in turn affects psychological factors that result in better learning outcomes, such as problem-solving skills, increased attention and sense of flow, general motivation to learn, interest, confidence, emotional connection to the subject, and increased collaboration, among others.[12] Studies have also demonstrated that subjects using immersive technologies better retain information from short- to long-term memory.[13]

Cognitive load

When the brain is tasked with interpreting a 3D object, such as an atom as a 2D picture with abstract properties, it can become overwhelmed by the significant cognitive load required to generate, retain, retrieve, and transform this three-dimensional visualization. Excessive information can trigger a bottleneck in the limited working memory of the brain, causing lag in attention and interest—which in turn reduces student comprehension and retention.

MR can reduce this cognitive load by allowing learners to directly visualize, manipulate, and interact with complex structures, enabling the learner to assimilate more crucial information in a shorter period of time. In a study where learners' brain activity was monitored through electroencephalography (EEG) as they attempted to understand origami, there was a significant decrease in objective cognitive load when the subject was dealing with 3D interactive images.[14]

Social emotional learning and empathy

> *"Knowledge is one of the keys for empathy and giving kids experiences in someone else's shoes that is believable, real—almost tangible—has much more of an effect on their empathy."*
>
> **Brian Grantham**
> **Director of Educational Technology at Mid-Pacific Institute**

9 Barsalou, 2008
10 Liu et al 2017
11 Santos et al. 2016
12 Sommerauer & Muller 2014
13 e2013
14 Dan & Reiner 2017

Social and emotional learning (SEL) can be defined as, "The process through which children and adults acquire and effectively apply the knowledge, attitudes, and skills necessary to understand and manage emotions, set and achieve positive goals, feel and show empathy for others, establish and maintain positive relationships, and make responsible decisions."[15] Self-awareness, self-management, social awareness, relationship skills, and responsible decision-making have all been identified as significant contributors to SEL. Mixed Reality, in turn, has been shown to support collaborative learning modalities in adaptive, creative environments.[16]

Without a strong foundation of social and emotional skills, many argue that knowledge will be unusable for higher education and the 21st century global learning environment.[17] The Preparing the Class of 2030 study showed that effective social and emotional learning increased achievements scores up to 11%, and that the development of these skills increased motivation and perseverance, while decreasing anxiety, depression, and stress.

"Underpinning knowledge—and even more important than just the facts—is helping students acquire the skills they need to gain confidence and the ability to work with others, understanding and respecting differences, and developing empathy. We can all now access information very easily, but helping learners 'feel' in order to support their emotional development has always been challenging, particularly with the cynical and disengaged. I see immersive technology as an additional tool in enabling the development of these skills. The possibilities for enriching learning and developing these skills—often so difficult to both teach and learn—are endless."

Helena Williams
Retired teacher and former schools inspector

Fostering Social and Emotional Learning

Figure 2

Inclusivity
As costs decrease, Immersive Technologies can become a democratizing force in education by allowing students to access previously out-of-reach experiences.

Collaboration
Mixed Reality provides settings in which students can work collaboratively and has the potential to enable broader and more egalitarian access to knowledge which can be more personalized.

Diversity
Immersive Technologies are uniquely placed to break through emotional barriers and allow learners to experience life from the perspective of others, building crucial empathy-related skills.

15 Aidman and Price 201
16 Nebel et al. 2016
17 Armstrong 2006

Evidence seems to suggest that immersive technologies are particularly effective at breaking through emotional barriers and eliciting empathy where other approaches have failed. Even subjects who had previously demonstrated low levels of empathy were positively affected, and there was an increase in understanding people from other cultures.[18]

At the Mid-Pacific Institute in Hawaii, 8th grade students who experienced a few minutes in VR from the perspective of a person who becomes homeless remarked how they realized just how easily they could find themselves in that same position. "Becoming Homeless" was a project developed by Stanford University's Virtual Human Interaction Lab (VHIL) that measured levels of empathy regarding homelessness, and in spite of the sense of discomfort and unease engendered by the experience itself, students and teachers generally reported its effects as "positive." This is supported by a recently published study by Stanford University researchers which found that this experience effectively caused subjects to become more compassionate.[19]

Another VHIL project, which showed the effects of ocean acidification on coral reefs, had similarly engaging results, as reported by Robyn Vierra, Associate Director of the Punahou's Wo International Center.

Vierra shared testimonials from students which demonstrate how the game-based interactivity of the experience—simple mechanisms like buzzing hand controls as users passed their hands through bubbles emerging from the coral reefs—helped to create an emotional connection between students and the environmental issue represented in the experience. One of Vierra's students remarked how disappointed they felt at what human interaction can do to such beautiful and untouched ecosystems: "It's crazy to think how a beautiful and sustainable clearing such as the one shown in the VR could change and eliminate all the plants and other organisms."

Behavior

Figure 3

Powerful simulations

Simulations allow learners to recreate and practice routine situations as well as access experiences which would normally be out of reach in real life.

Emotional identification

Students working with immersive content report a higher level of engagement with issues such as environmental protection and homelessness, often leading to concrete behavioral change.

Situated learning

Use of Immersive Technologies can increase rates of skills transfer, enabling students to apply theoretical concepts learned to real-world scenarios.

18 Hew and Cheung 2010

19 Herrera et al., 2018

Inclusive learning

Although the cost of hardware and implementation might currently present a barrier to some educators looking to adopt immersive technologies in their classrooms, as such costs inevitably decrease this technology has the potential to become a hugely democratizing force in education, allowing students from all backgrounds to gain access to experiences which might have been previously outside their reach. One way this can be achieved is in providing students with virtual field trips.

> *"VR is a way to open up the world to students without many barriers such as cost and access."*
>
> **Robyn Vierra**
> **Associate Director of Punahou's Wo International Center**

Another of Vierra's students recounts his experience: "That was one of the cooler things I've ever done, well, virtually done. There was a part where I was on a boat off the coast of Italy, and I didn't have to fly 11 hours!"

Experiential education—learning experiences which tie a place to a topic—have long proved beneficial in bringing students to places relevant to the subject of study. Yet as Cody Karutz, Founder of Blue Trot Consultancy points out, traditional field trips require money, time, and permission slips, and not all schools can meet those costs. Immersive technologies, however, have the power to bridge that gap.

Blue Trot conducted a series of pilots with at-risk youth communities, one of which involved working with a last chance school in Edmonds, Washington, where students often come from backgrounds of trauma or gang violence.

> *"We led a lesson with an English class, where students designed a safe and scary space, then were able to experience them both in Virtual Reality. The lesson brought technology in the context of an English lesson by creating a spark for students to translate into their writing exercises."*
>
> **Cody Karutz**
> **Founder and CEO of Blue Trot**

In addition to helping improve conditions such as dyslexia, autism, and ADHD, immersive technologies have been shown to assist low-achievement students in improving learning outcomes and helping them increase efficiency, retention, and spatial cognition. When low-achieving primary school students were given MR instruction, they were able to improve their scores such that there was no longer any statistical difference between them and high achieving students.[20]

This mirrors experiences reported by educators like Leticia Ahumada, who deploy immersive technologies and game-based learning in a variety of contexts and observe how it helps different kinds of students overcome challenges.

> *"Each student benefits from game-based learning in their own way, but I noticed that there are some groups that get more benefits. For example, girls are usually quieter in the classroom than boys, so sometimes they don't get the credit they deserve. The same is true for special needs students. The game-based learning model gets them the opportunity to shine in what they are good at."*
>
> **Leticia Ahumada**
> **Primary Education teacher,**
> **Microsoft Innovative Educator Expert,**
> **and Minecraft Global Mentor**

20 Lu & Liu 2014

Benefits of Mixed Reality

Reduce cognitive load

Enable learners to assimilate complex information in a shorter period of time.

Increase retention

Information presented in Mixed Reality is retained more efficiently, which is reflected in improved learning outcomes.

Elicit empathy

Learners who experience 'being in someone else's shoes' through Immersive Technology increase their understanding and engagement with the subject.

Figure 4

Research has shown that Mixed Reality can...

Personalization and autonomy

Immersive technologies can provide settings in which students can work collaboratively and have the potential to enable broader and more egalitarian access to knowledge. Learning experiences can also be more personalized to suit students whose previous attitude toward learning had been negative.

According to the Preparing the Class of 2030 study, 67% of teachers agree that content should be personalized, but most (69% of those surveyed) feel unable to do so under current time and resource constraints. Technology can therefore play an important role in bridging that gap.

> *"As kids turn to more individualized education, identifying their strengths, weaknesses, and fears is important and immersive tech can help achieve this."*
>
> **Brian Grantham, Director of Educational Technology at Mid-Pacific Institute**

In fact, subjects and teachers report that using MR in the classroom enabled an increased sense of personalized and self-directed learning. In performing tasks, they had a sense that the devices afforded a more inquiry-based environment and maximized learning opportunities, effectively promoting a student's knowledge of concepts and phenomena.

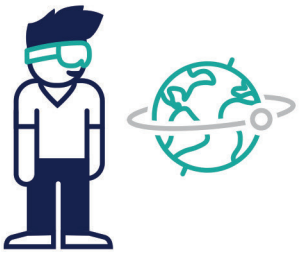
Mixed Reality can provide access for learners at their convenience and lends itself to autonomous work.[21] This is significant because 98% of students with highly personalized education modalities outperformed one-size-fits-all approaches.[22] The use of MR technology in both the classroom and other learning spaces instilled a sense of autonomy and incited inquiry-based exploration above and beyond what was given as the pedagogical task.[23]

The Mixed Reality Opportunity

Figure 5

Social emotional learning

Mixed Reality supports collaborative learning modalities in adaptive and creative environments.



Inclusive technology

Immersive technology such as MR have been shown to assist low-achieving students in improving learning outcomes.

Supercharged cognition

MR reduces the cognitive load on the brain by allowing learners to directly visualize, manipulate, and interact with complex structures.

Barriers to implementation

Most researchers remain optimistic about the use of immersive technologies in education, yet there is still a severe lack of data and peer-reviewed literature supporting its use.

> *"The challenge in research is to collect longitudinal feedback over time to see if the novelty wears off for students, and how immersive tech can have staying power in the classroom."*
>
> **Cody Karutz**
> **Founder and CEO of Blue Trot**

Those looking to incorporate immersive tech into their own teaching practices are often overwhelmed by the cost of procurement and maintenance as well as the prospect of being responsible for content development and possible long-term safety and ethical considerations of these rapidly developing technologies.[24] Currently, it would seem our innovation is significantly outpacing our safety and ethical research in this area.

> *"For us it's not only the consumption and the creation of this information, but also how to validate the information we put out."*
>
> **Brian Grantham, Director of Educational Technology at Mid-Pacific Institute**

Indeed, using immersive media requires logistics and technology infrastructure which include availability of hardware and reliable internet connections. The larger and more complex challenge, however, remains the integration of these new technologies with existing classroom systems and both current and emerging pedagogical practice.[25]

21 Ferrer-Torregrosa et al. 2016
22 Anderson and Sosniak 1994
23 Loup-Escande et al. 2016
24 Hoorn, Konjin, & Gerrit, 2003
25 Burns and Richards 2012

Although there may be safety and ethical concerns about VR, there's nothing to suggest that we stop developing, testing, and researching this extremely powerful tool. This needs to be accomplished in partnership with educators and students—building trust, transparency, and scientific robustness as well as equipping young people with the critical skills needed to approach the medium in an informed and proactive way.

> *"I believe it is essential to teaching media literacy to prepare young minds to be critical viewers and producers of new media content that is ethical and purposeful."*
>
> **Jennifer Goya, Digital Media Arts Teacher at Mid-Pacific Institute**

Educators show widespread enthusiasm for the possibilities that immersive technologies afford, but remain somewhat daunted by the practicalities of implementation, as well as the perceived need for extensive resources in order to utilize it appropriately in a pedagogical context.

> *"Things change so rapidly. It's usually every six months that I'm reassessing my curriculum. Having a support system or network that teachers are able to rely on to ask questions or bounce ideas off of would be helpful."*
>
> **Marcie Moura**
> **Animation and game designer educator at Mid-Pacific Institute**

To counter such concerns, educators would like to see examples clearly connecting science standards to lesson plans. According to Jakki Bailey, Assistant Professor at the University of Texas at Austin, having learning content that effectively leverages the unique affordances of the technology, while taking into account child development and practical tips on ways to incorporate the technology into the classroom, would be key to achieving this. "It will be important to understand how child development and the science of learning relate to how content is experienced and interpreted by children. Educating society will help identify the positive uses and provide warnings on when and how to incorporate the technology," Bailey notes.

> *"Having a great source that lists different immersive technology resources would be key. It can still take a while to find good content for different subjects. I hope that as the years progress we will also see the production quality of the experiences for education go up."*
>
> **Tony Johansen, School technology specialist at Mid-Pacific Institute**

The importance of high-quality content

> *"Curating good educational content is quite a task. Quality, accessible, and searchable content is the top priority, and lesson plans that incorporate VR stories into a wider theme would be fantastic. It is definitely engaging for kids and we know through the neuroscience that novelty usually leads to longer lasting learning. At the same time, the novelty will wear off, so it has to be more than that."*
>
> **Robyn Vierra**
> **Associate Director of Punahou's Wo International Center**

Emotionally and motivationally appealing design features for MR experiences can help increase cognitive engagement and retain information over traditional teaching models. Constructionist learning theory is based on the assumption that developing knowledge occurs best through building artifacts (physical or digital) that can be experienced and shared.[26]

> *"In youth media, immersive or otherwise, it's important to teach critical thinking around its consumption. When children learn about how media works and who creates it, they can have more informed agency around choosing the media they will consume. In my experience and research, the best way to do this is through teaching students to create. Once they go through the creation process, they're much more informed about how others create it for them."*
>
> **Cody Karutz, Founder and CEO of Blue Trot**

26 Papert, 1991

In the type of learning to which Karutz refers, participants are given tools to build their own immersive environments, or are provided an immersive environment and told to build something within it. This is important in building long-term engagement, as it has been observed that students tend to quickly internalize such experiences, which initially proved high-impact but may quickly become jaded and routine. Co-created content, on the other hand, fosters a more meaningful connection by generating something in which the student has a personal emotional investment.

> *"When we first brought VR, 360, and 3D scanning onto campus there was a fascination with this new technology. A good example of this is virtual tours. The first time our middle school student used this, it was like, 'Wow!' But the second time we came in with the same students, they were not as excited about a 360 picture with canned curriculum. This is when we really realized how important it is to find quality content and to begin making our own."*
>
> **Brian Grantham, Director of Educational Technology at Mid-Pacific Institute**

Conclusion

Immersive technologies offer a broad range of tangible benefits for educators, not only in terms of student engagement, but also in the efficiency of delivery and retention of materials. These technologies' capabilities to engage and foster empathetic connections in students offer unique possibilities for teachers, who should be fully supported in exploring the pedagogical opportunities they afford, as the ability to anchor abstract knowledge within personalized experiences that elicit empathy towards others is an extremely valuable tool in preparing students for future challenges they are likely to face. By encouraging and enabling students to not only view, but actively experience a variety of simulations and scenarios from different perspectives, teachers can help them build better social emotional skills, creating much more inclusive learning environments in the process.

In order to maximize the positive long-term impact of immersive learning experiences, however, we should not use such virtual environments to present isolated moments that provide short-term engagement or fragmentary insight. Instead, extended experiences that immerse students in rich contexts with strong narratives, authentic practices, and links to real-world outcomes are what truly unleash the transformational power of immersive and game-based learning experiences.

The consensus that emerges among those interviewed for this study is that immersive technologies—like all technologies adopted within a pedagogical classroom setting—should remain supplementary to in-person academic programming, allowing for human relations and interactions to ultimately guide the social-emotional learning experience. Quality teaching from consistent and well-resourced teachers is still the best tool in education, yet these technologies offer exciting possibilities in extending and democratizing the reach and impact of passionate, knowledgeable, and creative educators.

Interviewee profiles

Helena Williams, retired teacher and schools inspector taught English, French, and Drama to 11–18 year olds for over 20 years. Throughout her career, she also worked with practicing and student teachers on their development and served as an official schools inspector, monitoring teaching standards and outcomes in more than 500 schools across Devon County in the UK.

Cody Karutz, Founder and CEO of Blue Trot, a research and design studio, is a cognitive scientist with a background in educational media, youth research, and program evaluation. He managed Stanford University's Virtual Human Interaction Lab for six years and watched VR transform from academic to consumer technology. His work at Stanford involved studying how best to design and evaluate Virtual Reality for environmental field trips. After graduating, he founded Blue Trot, a research and design studio, to evaluate experiential content and programs for brands and organizations.

Jakki Bailey, Assistant Professor at University of Texas at Austin researches children's experience of immersive technology. Bailey is currently investigating children's social and psychological experiences of VR.

Paul Turnbull, President, Mid-Pacific Institute has been in education for 22 years as a teacher, high school principal, school district superintendent, and now President of Mid-Pacific Institute, where an Immersive Tech program was introduced three years ago and currently allows 500+ students per year access to VR for creation or consumption in academic settings.

Jennifer Goya, digital media arts teacher at Mid-Pacific Institute has been working with youth media arts education for past 11 years, and currently teaches grades 8-12. She first began integrating VR into classes in 2016 and was part of the first cohort of Mid-Pacific teachers who were trained to use laser scanning and photogrammetry.

Brian Grantham, Director of Educational Technology at Mid-Pacific Institute. After 10 years of working in experiential and environmental education, Grantham served as Middle School Tech Coordinator and eventually Director of Educational Technology for his school. Through his evolution, Grantham has become interested in video, animation, VR, 360, AI, machine learning, and big data as well as the ethics of technology use and digital citizenship.

Marcie Moura, animation and game designer educator at Mid-Pacific Institute began teaching in 2015 after 14 years in the animation feature film industry working for companies such as Dreamworks. Her principal interest and expertise is in 3D modeling and animation.

Tony Johansen, school technology specialist at Mid-Pacific Institute has been working in the technical side of education since 2005. After moving to Hawaii, he was hired by Mid-Pacific Institute as an education technologist and now assists faculty in using equipment such as their LiDAR scanner, 360 camera rig, and structured light scanners.

Robyn Vierra, associate director of *Punahou's* Wo International Center has been in education for 14 years. She first became aware of immersive technologies through Elise Ogle's work at the Virtual Human Interaction Lab at Stanford University. This in turn inspired her to apply for a grant through her school to research is further in an educational setting.

Leticia Ahumada is a primary education teacher, with expertise in music and art, learning and knowledge technology, and robotics. She's also a Microsoft Innovative Educator Expert and Minecraft Global Mentor.

Illustration references

Figure 1—Cognitive Processes

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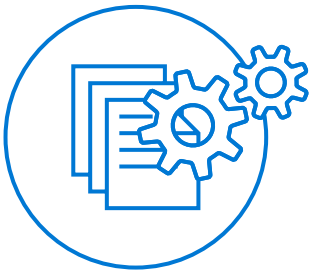


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