School Vs. Fortnite:

The Emergence of 3D Learning

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***Abstract*—3D-Based Learning is an effort to make learning more effective, relevant, and engaging to today's videogame-saturated kids. The potential of 3D-Based Learning in education is vast, and literally opens up new realms in education, where the abstract becomes real and students walk through magnetic fields, fly over countries, and explore subatomic particles. There is clearly a great unfulfilled promise in the learning potential of these powerful technologies.**

A trial effort, the largest ever use of 3D learning, occurred from 2017-2020, and involved 1.7 million users in 27 countries, across 150 programs in 6 subject areas. The goal was to test 3D learning technology and ideas with users on Chrome/Android platforms with the goal of informing and initiating the era of 3D-Based Learning in schools.

Keywords—3D Learning, Virtual reality, technology, innovation)

INTRODUCTION

A core concern of teachers today is student engagement. In today's digital world finding new ways to engage tech-savvy students is ever more difficult. When cell phones and game consoles are highly advanced and hugely popular, engagement with technology in the classroom can be difficult. We can all agree that the technology deployed in schools is less engaging than the technology kids use at home.

3D-Based Learning is an effort to make learning more effective, relevant, and engaging to today's 3D videogame-saturated kids. A trial effort, the largest ever use of 3D learning, occurred from 2017-2020, and involved 1.7 million users in 27 countries, across 150 programs in 6 subject areas. The goal was to test 3D learning technology and ideas with users on Chrome/Android platforms with the goal of informing and initiating the era of school-based learning in 3D.

The potential of 3D-Based Learning in education is limitless. It literally opens up new realms in education, where the abstract becomes real and students walk through magnetic fields, fly over countries, and cross underground magma chambers to understand plate tectonics. 3D and Virtual Reality (VR) learning have been typically confined to expensive VR headsets and clinical operating environments. These limitations have made it prohibitive to implement in an average classroom. How do educators now take advantage of students' newfound abilities to explore the inside of a human cell or fly through the human brain?

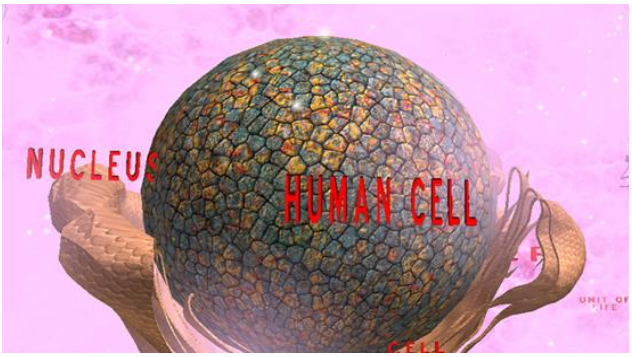

Figure 1. Inside a virtual recreation of a human cell

I. LEARNING IN 3D

The New World of 3D Learning

3D and VR technologies make it possible for students to experience any idea, location, time, or person in a simulated environment. It allows students to step into 3D interactive environments, putting them "inside" of their subjects. The goal is to complement existing learning materials with a 3D experience to truly engage students.

These technologies are creating powerful learning opportunities to understand physical structures, abstract ideas, and geographic locations. Through 3D-Based Learning, the abstract becomes real. Researchers have studied 3D and VR learning over the past decades and have concluded that "VR can lead to increased student engagement; provide active, constructivist learning; increase frequency of authentic learning experiences; allow for empathetic experiences; enable students

to exercise creativity; and provide an arena for visualizing abstract concepts concretely." (Hu-Au, Lee Columbia University, 2017).

Most explorations of 3D and VR learning have concluded that student learning is accelerated, and that students retain more information and can better apply what they had learned (Krokos, Plaisant, & Varshney, 2019). This is made possible through active participation and learning by doing, which facilitates knowledge construction and retention. The drawbacks and fatal flaws of 3D and VR learning technologies have historically been high cost, technical limitations, complexity of equipment, and unfamiliarity with hardware.

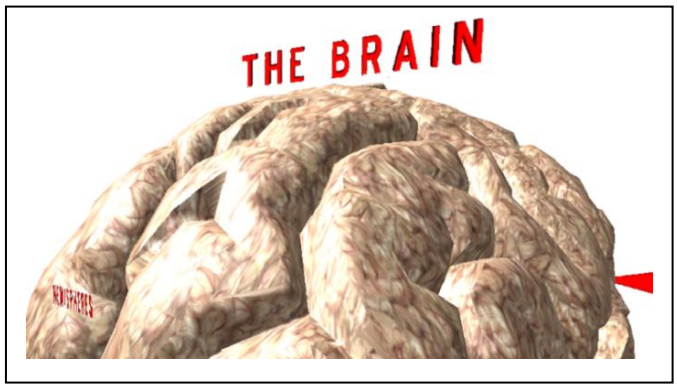

Figure 2. The virtual recreation of a human brain

II. GOOGE PLAY RESULTS

To challenge the significant cost, structural, financial, and technical limitations of using 3D and VR in schools, a framework was developed to port VR learning into 3D programs delivered via the Google Play store for use on Chrome/Android platforms. The deployment was a "proof of concept" model to deploy 3D visualization programs outside of expensive, complicated, and highly structured environments.

This largest ever use of 3D learning occurred from 2017-2020, and involved 1.7 million users in 27 countries, across 150 programs in 6 subject areas. The project aim was to test 3D learning performance on Chrome/Android platforms with the objective of informing the coming era of 3D learning in school, and its accompanying potential learning enhancements. As the Google Play store provides a global platform with universal access, it provided an ideal environment to test the initial use of 3D learning programs across an extremely ride range of users in highly varied technological environments.

How it Worked

The project used existing equipment, Chromebooks and Android devices. To overcome the traditional barriers of VR use in education, no special equipment was needed; users simply use the touchscreen to navigate through the virtual environment. The goal was to access 3D learning programs with one click with existing equipment. Programs were accessed through the Google Play Store, just like any other app. The familiar Google Play Store, with its structure and supports, allowed for the first widespread 3D learning that didn't need expensive equipment or specialized technical staff to support.

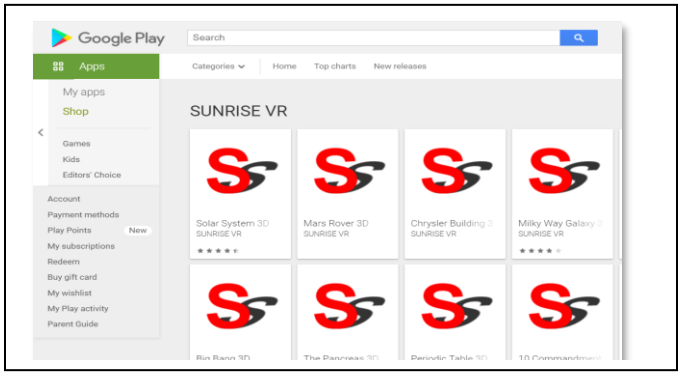

Figure 3. The Google Play Store download

Results

The majority of users rated the 3D education experiences highly, with an average Rating of 4.6 out of 5. The high rating was primary a function of the graphical interface, ease of use, information presented, and the installation process provided by the store.

STEM and Astronomy programs received the highest feedback and most encouraging comments. The theory is that 3D learning afforded views and experiences of phenomena that would otherwise be impossible to obtain,

TABLE I. PROJECT STATISTICS

Ratings	165,000 Ratings Average Rating was 4.6 out of 5
Subjects	Anatomy, Arts and Culture, Astronomy, Geography, History, Landmarks, Natural Features, Religion, Science, Technology,
Estimated Ages	17% 7-10 23% 11-13 33% 14-17 37% 18+
Estimated Location	56% North America 23% Asia/Pacific 11% Europe 6% South America 4% Africa
Example Comments	"As a teaching tool, this app is a wonderful device..." "It helps to see it all in 3-D." "Cool!" "Confusing navigation." "I love the graphics!!!" "I didn't understand where to go."
Usability	96% access success No technical staff needed to support Intuitive Interface Navigation issues with "non-gamer" users Reading text was difficult for some

The Future

The aim of the project was to inform the coming era of 3D learning in school. Most researchers believe that widespread educational adoption is inevitable. VR has been described as "the learning aid of the 21st century" (Rogers, 2019). The project has informed several iterative changes, including new program development, extensive program upgrades, and delivering information via voice instead of text.

As the Android/Chrome infrastructure delivers a seamless experience for users, and with significant technical/access issues overcome, the next step in the wider adoption of 3D technology is curriculum mapping/integration, and iterative development with feedback from classrooms. This will be accomplished through larger classroom-based pilot programs, and will include teacher PD, teacher input, curriculum requirements, and school/district technology infrastructure integration.

III. STUDENT ENGAGEMENT WITH 3D TECHNOLOGY

It is a common refrain that new technologies bring new societal advances, but there is an important caveat; only if leveraged correctly. Unfortunately, to date the promise and engagement of 3D technologies and visualization tools have been the exclusive domain of games and entertainment. Great movies are enjoyed and great games are played, but great minds are not stimulated. There is clearly an immense unfulfilled promise in the learning potential of these powerful technologies.

In today's digital world, finding new ways to engage tech-savvy students is difficult. Educators face major challenges in keeping students engaged and interested. Many classrooms often still rely on passive transmissionist methods such as lectures, with can lead to disengaged students (Capps and Crawford, 2013). 3D-Based Learning is an effort to make learning more relevant and engaging to today's 3D videogame-saturated kids. It allows students to be fully involved in learning, instead of merely passive observers.

Outside of school, kids have access to PCs, laptops, videogames, smartphones, texting, social networking, and video. Because of the disconnect between school life and non-school life, quite simply, many kids are bored in school. The George Lucas Foundation reports: "Teachers in every strata of education are increasingly dealing with a student population that is not only more wired than they are but also grew up in a techno-drenched atmosphere that has trained them to absorb and process information in fundamentally different ways."

Student Engagement: 87% of Kids Prefer 3D

Because it mirrors their preferred method of interacting with information and ideas, 87% of students preferred 3D-Based Learning to traditional learning (Bamford, 2011). A child can learn anything when they have full control over exploration in information-rich 3D environments. Research has found that students performed better when they were in control of their navigation through the virtual learning environment, just as in the videogames they love so much, Like their real-time 3D games, real-time 3D learning programs provide unlimited choices for students. They can fly, drive, swim, or walk anywhere, and the number of possible combinations of real-time interactive choices available are infinite.

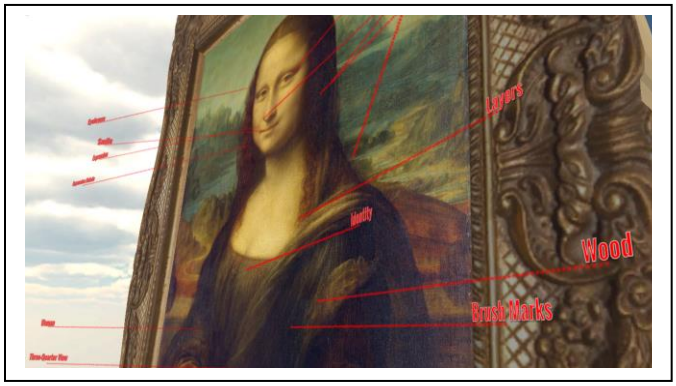

Figure 4. Through the Mona Lisa

Learning is much more effective when it is an active discovery process. 3D-Based Learning grabs and holds the attention of students. Students find it exciting and challenging to walk through an environment in 3D, interact with it, and create their own 3D worlds.

How Works In School

Teachers access programs through the Play Store, from emails, links, and PDFs. After one click, and a download from the Play Store, programs open seconds later into virtual environments to become a seamless part of the learning experience.

One click and students are in virtual worlds, 3D-Based Learning serves as a reference across the curriculum. When a program is selected it opens into a new screen, just like any other app for speed, familiarity, and simplicity. 3D-Based Learning programs are available on Android and Chrome devices, making 3D a viable new facet of the everyday learning experience.

3D learning programs serve as an experiential learning reference across the curriculum. They are intended to be a first stop, an engaging overview of a subject to create a cognitive map and initial understanding of ideas. They help students to see, experience, and understand abstract ideas by providing immediate context and understanding.

Platforms and In-school Use

The initial platform for 3D-Based Learning is grounded in Chrome/Android. The platform was chosen for ubiquity and ease of access. 30 million+ Chromebooks are now used in education around the world. Additionally, over 3 billion active Android devices can access learning. The ubiquity, stability, and ease of use of the Chrome/Android technology and open-

source framework provide a natural and inexpensive platform to deliver 3D learning.

IV. LEARNING IN 3D AND STUENT ENGAGEMENT

Cognitive Learning Overview

With 3D-Based Learning, ideas become easily understood, no matter how abstract. It transforms ideas and theory into understanding. A consistent acknowledged flaw of learning is reliance on theory accompanied by a lack of concrete experiences. 3D-Based Learning bridges the gap between the abstract world of ideas and the "tangible" world of the student by bringing ideas to life through advanced visualization. Abstract concepts like gravity and the Big Bang Theory become experiences to be explored as 3D helps students build mental models and understand ideas. For the first time they see how light enters the human eye or how sound enters the human ear in real time.

Foundations of 3D-Based Learning

3D-Based Learning draws its power from three core learning principles: visual, experiential, and self-directed learning, among the most effective ways to teach students.

- Visual Learning

Most of the information we receive come from visual images because it is simply the most effective and natural way for human beings to process information. That is the way we are designed.

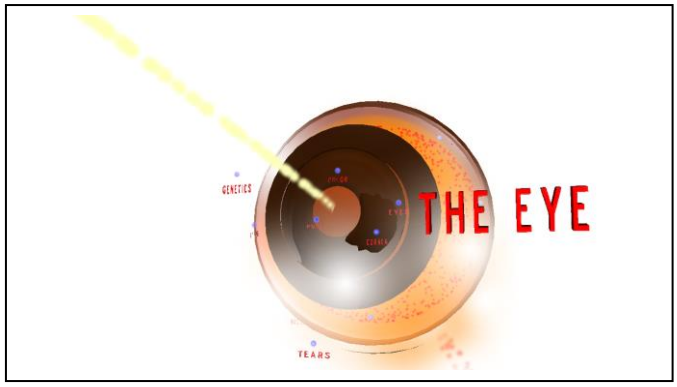

Figure 5. Visualizing light entering the human eye

3D learning programs provide an alternate method for presentation of material. They illustrate ideas and processes more effectively than other means of learning. With real-time control, they offer unpreceded visual insights and perspectives. For example, students can look at an object from an extreme close-up, from great distance, or even from within. They can view the whole or view a part. They gain great perspective through this type of examination that is unavailable by other means.

- Experiential Learning

"I hear and I forget. I see and I understand. I do and I remember."
–Confucius

One of the basic ways we learn is though experience. Active rather than passive processes better encourage learning. This idea is not new. 3D-Based Learning changes the way a student experiences subject matter. By nature, the programs require interaction and encourage active participation rather than passivity. If a student does not explore the program, nothing happens. They are encouraged to continue interacting by seeing results immediately, positive stimulus, and prompts to discover the unknown.

- Self-Directed Learning

Optimal learning takes place when the student works at her own pace, is actively involved in performing specific learning tasks, and experiences success in learning. 3D-Based Learning programs allow the learner to proceed through an experience at their own pace. As students control all facets of learning, they are able to spend more time clarifying concepts they do not understand, and gather additional information for comprehension. 3D-Based Learning allows the learner to proceed through an experience at their own pace, with total control.

3D-Based Learning in STEM

3D-Based Learning is particularly effective in STEM areas, and opens up new possibilities for STEM education. Students walk through machines, fly through the Hubble Space Telescope with ancient light, and hover over the Periodic Table, providing a foundation for conceptual and higher-order learning.

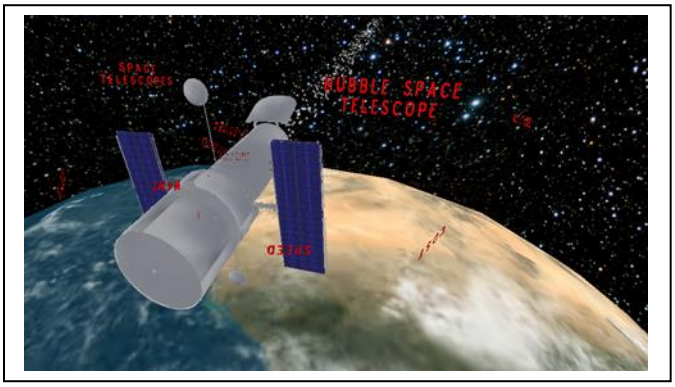

Figure 6. Visualizing light from one billion years ago entering the Hubble Space Telescope

A consistent acknowledged flaw of STEM learning is reliance on theory and lack of concrete experiences. 3D-Based Learning is the STEM conduit, the mediator that bridges the gap between the powerful abstract world of STEM ideas and the "tangible" world of the student. It gives students context to build mental models and better understand STEM ideas.

3D technologies are ideal STEM learning tools because they help students formulate authentic mental models of complex phenomena. Mental models begin the process of providing "meaning and form" (Riggins & Slaughter, 2006) to ideas. They create a foundation to integrate "ideas, assumptions, relationships, insights, facts, and misconceptions that together shape the way an individual views and interacts with reality" (Steiger & Steiger, 2007). Mental models are internal representations of concepts and ideas that we use to build deeper comprehension of a conceptual domain. " In STEM instructors want students to understand the underlying principles of scientific theories, to reason logically about those principles, and to be able to apply them in novel settings with new problem sets. "(Rapp, 2005)

Visualization and exploration-based engaged learning software is a powerful learning tool for STEM learning. As a supplement to traditional schoolwork it helps students to see, experience, and understand abstract ideas. At its core, these visualization and experiential tools are about creating new models of understanding by taking the best of existing educational pedagogy and pairing it with the world's most powerful visualization tools to spur comprehension of complex phenomena.

A consistent acknowledged flaw of learning is reliance on theory and lack of concrete experiences. Winn et al. (1997) have also seen the advantages of VR in making abstract concepts into concrete objects in science curricula. They posit that virtual environments 'can represent in directly visible and manipulable forms concepts and procedures that are intangible and invisible in the real world. 3D Learning transforms ideas and theory into understanding, bringing ideas to life; abstract concepts like gravity and Atomic Theory become experiences to be explored.

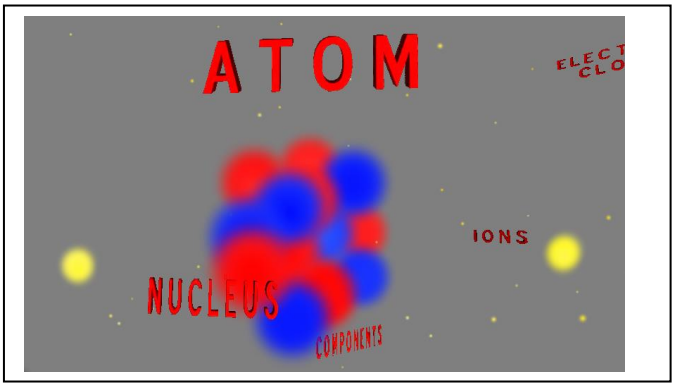

Figure 7. Into the Atom

New Models of Delivery

All advances in digital technology are accompanied by new models of delivery, whether it be newspapers (online), music (Spotify), or movies (Netflix). 3D-Based Learning delivered via the Play Store enables an ultramodern classroom where learning is delivered directly to teachers every week in their email inbox, hours after it was completed. Subscribers receive a program and lesson plan via email providing the classroom with the latest, most timely learning possible. This "Just in Time" education engages students through topically-relevant issues and the latest news, research, and discoveries to reinforce learning. From flying through a cell phone when a new phone is released, to visualizing the antibodies in a Coronavirus Vaccine, 3D-Based Learning flips the model from static education software to a highly-responsive medium of relevant current events. The ultimate goal is to capture student attention and ensure learning is always relevant.

V. Conclusion

3D-Based Learning is the learning the videogame generation wants. It is here today, proven, and has the potential to greatly enrich educational environments with interactive simulations that immerse students in engaging and highly relevant learning experiences. It is pushing the boundaries of the traditional classroom into places only dreamed of.

3D learning is no silver bullet, and is especially subject to traditional implementation pitfalls. The danger of any new techonology is the projection of unrealistic expectations; this is especially true in education, where software developers are completely disconnected from classrooms. Additional pilot work, research, and iterative development with educators are necessary to realize the full potential of 3D-Based Learning in educational settings.

TABLE II. ANTICIPATED CHALLENGES

Pedagogical Challenges

- *Poor Curriculum Integration*
- *Teacher technology comfort and professional development*
- *Technical rather than pedagogical focus*
- *Not relevant to teaching context*

Technological Challenges

- *Cost*
- *Wi-Fi Access*
- *Chromebook Versioning*

Developmental Challenges

- *Iteration of 3D programs to school use*
- *Development of new 3D programs to meet curriculum needs*
- *Align 3D curriculum to district or school goals*

The technology is here, but important classroom questions are still to be answered. In what circumstances do teachers realize the most success? Is it fully integrated into the curriculum, or is it just "technology?" In what context does it best enhance student understanding of subjects? Can a Just in Time model of education fit into a teacher's schedule as easily as a

YouTube video, or does it just create more work? The challenges are many.

With careful application and sound pedagogy, 3D-Based Learning can be a gateway into the "experience" age of learning. As technology continues its unrelenting march and educators seek to solve old problems with new tools, the dawn of the 3D learning era is unfolding before us.

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Educator downloads to allow participants to experience 3D learning:

Android Apps by SUNRISE VR on Google Play