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Teaching Virtual Reality Interactive Digital Narratives: A Curriculum and Case Study

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Abstract

Programs of study for Immersive Media are being developed and enacted at many higher education institutions. This article presents a course on Interactive Digital Narratives (IDN) in Virtual Reality (VR) that can familiarize undergraduate students of diverse backgrounds with immersive storytelling's foundational technical, design, and development tenets. The course curriculum balances IDN design and immersive storytelling strategies with VR project management, user experience and interface design, spatial audio, digital scenography, introductory programming, and rudimentary artificial intelligence. The course connects technical and media affordances to theories of IDN to provide an introductory understanding of IDN in VR. The course ran in a remote synchronous modality in the spring of 2021 at a small liberal arts college in Chicago, Illinois. The paper presents the course's 15-week curriculum, student insights, examples of projects, a rubric for a final project, and a Github Repo with instructor resources.

Keywords: Virtual Reality, Interactive Digital Narratives, Curriculum Design

1. Teaching an Emerging Practice

Teaching an emerging practice such as Interactive Digital Narratives (IDN) is challenging [1–3]. These challenges are further amplified when designing and developing IDN for Virtual Reality (VR), compounding the difficulty of accomplishing defined pedagogical objectives. In the domain of IDN, theories and taxonomies seek standardization, and tools for composition are constantly changing along with design strategies [3–6]. In Immersive Media, the technologies and production tools are ever- evolving [7]. Complicating matters further, VR, as a medium of attraction, relies on the convergence of diverse interdisciplinary practices to generate experiences [8]. This flux, inherent experimental nature, and the diversity of media traditions pose significant hurdles in establishing a robust pedagogical foundation to nurture future immersive storytellers. Nevertheless, as noted by the Association for Research in Digital Interactive Narratives (ARDIN) committee, there is a need for effective curricula [9]. Through the integration of theory and hands-on skill building, the main objective for the curriculum and course discussed in this article was for students to develop IDN VR experiences.

The academic community has repeatedly highlighted the need to standardize IDN language, design strategies, and theories [1, 2, 4, 10, 11]. The authors of a recent presentation by the Immersive Research Learning Network (IRLN), “The State of XR and Immersive Learning Outlook 2021,” expressed a desire for more immersive storytelling in XR curricula as a credible pathway toward standardization [12]. Yet, as of this writing, in the archived proceedings of the IRLN, there is no single article proposing a curriculum for a course that teaches IDN for VR [13].

This paper delves into a 15-week curriculum designed for an introductory course on creating IDNs in VR, aiming to equip undergraduate students with the necessary skills to meet this demand. It’s important to clarify that by ‘introductory’, we do not suggest this course as suitable for first-year students; rather, we envisage it as an introduction to crafting IDNs within the VR framework. For instance, the course under discussion catered to students in their third and fourth years of study. Instructors facing temporal restrictions, such as an 8-week course structure, could adapt this curriculum into two sequenced courses.

We collated feedback from the students and performed an informal evaluation. The results, while preliminary due to the small sample size, should not be considered definitive but viewed as reflecting the students’ perceptions of the course and its material.

This article is an expanded version of the initial work published in the 2021 International Conference of Interactive Digital Storytelling conference proceedings, which took place in Tallinn, Estonia[14]. It incorporates additional information on the interconnectedness of different course modules designed to achieve specific learning outcomes. The essay has been broadened to provide supplementary structure and context for educators, culminating in a renewed call for educators and practitioners to contribute to the open GitHub repo. This repository currently houses a course syllabus, worksheets, source code, templates, and exercises for crafting VR IDNs [15]. The article concludes with lessons learned,

outcomes achieved, and insights generated for future research and curriculum development.

2. The Course

In 2019, the first author joined Columbia College Chicago with a mandate to develop an Immersive Media BA and minor program. This process resulted in a series of intensive courses superseding two survey courses[1] that primarily introduced students to an overarching concept of immersive media, spanning augmented reality, mixed reality, projection mapping, and immersive theater without covering technical training or theoretical grounding. As part of the degree program, these revamped courses were designed to shape and define the discipline of immersive media for students. In spring 2021, a pilot version of this course was launched, driven by student interest and administrative direction. Initially offered as an elective, the course is intended to form a cornerstone of Columbia College Chicago's upper-level Immersive Media BA degree. Conducted remotely via Microsoft Teams in a synchronous modality amidst the pandemic, the course met only once in person at the end of the semester in May, following public health guidelines.

Consistent with previous discussions on IDN pedagogy, creating IDNs requires a "practice-based education" [1]. Accordingly, the course was scheduled to meet once a week for three hours to accommodate both direct instruction (lectures) and practice-based learning. This schedule was intended to meet the course's goals :

1. Develop an understanding of the design and development techniques for VR experiences (Virtual Environment Design, Unity programming, Spatial Audio, VR UI, VR UX, and Interaction Design
2. Construct a VR experience with best practice and artist-led techniques
3. Understand IDN story structures and implement them in a VR experience
4. Articulate and receive precise feedback through usability

Given the breadth of content, effective time management is crucial. Instructional hours are carefully partitioned to meet these objectives. The course time is divided into three one-hour sections. Two hours were dedicated to lectures on IDNs in VR for the initial five weeks, with the remaining hour marked for design, coding, or development activities. The next five weeks see an equal split between lectures and studio activities. The final five weeks are primarily devoted to students' independent work on their VR IDNs, with iterative refinements based on usability studies to create a final product.

The course covers C# programming in Unity, locomotion, spatial audio, virtual environment and digital scenography, interaction design, VR UI and UX, usability tests and feedback, IDN story structures, and writing strategies. Critically, these topics needed to scaffold effectively over 15 weeks to enable students to produce a compelling portfolio piece [16].

2.1 Scaffolding the Modules and Learning

Effective scaffolding in curricular design and instruction is critical to student development, knowledge retention, and its practical application in the production of prototypes. Within the context of teaching an emerging medium, there are two concepts worth considering. First, simply enabling students to replicate design concepts in written or practical form does not necessarily cultivate their capacity to autonomously navigate the affordances of their medium, utilize available resources, or devise solutions to unforeseen developmental hurdles. Regurgitation, in short, fails to nurture the creative and critical engagement indispensable for generating compelling work. Lev Vygotsky's Zone of Proximal Development (ZPD) provides a framework for understanding this perspective.

Vygotsky defines the ZPD as "the distance between the actual level of development as determined by independent problem solving and the level of potential development as determined through problem-solving under adult guidance, or in collaboration with more capable peers"[17]. Given the wide range of initial skill levels among students in a course, it is necessary to regularly assess the gap between what was possible for students to achieve and what they could feasibly accomplish. The instructor has the responsibility to foster active problem-solving skills among students. This involves teaching them to read documentation, encouraging them to seek assistance when encountering difficulties, and promoting engagement with communities like Stack Overflow.

Importantly, in an emerging field problems stem from various domains such as narrative and visual design, mechanic development, programming, interface design, usability, and user experience design. These problems constantly evolve with new technologies and changes in the industry, presenting challenges for developers at all levels. For some students, these problems are well beyond their capacity to solve. The distance between the students' "level of development" and "potential development" has to be closed through careful scaffolding.

Scaffolding should be considered "a special type of support given by a teacher to a student when performing a task that the latter might otherwise not be able to accomplish." [18] Scaffolding mechanisms are embedded in curriculum content, module interrelationships, and through instruction. Originated by Jerome Bruner, scaffolds aid students in enhancing their problem-solving abilities. The scaffolding is executed through several steps:

1. Recruitment: The nature of VR as an exciting medium is central to recruitment efforts. Getting students signed up for this kind of challenging course involves employing materials that encourage their creative and critical curiosity to address the problems of designing and developing for an emerging medium. [20]
2. Reduction in Degrees of Freedom: Instead of beginning with the most complex version of the task, a simplified version is presented. This process enables the students to understand foundational concepts before moving on to more complex problems. Educators teaching an emerging medium should reduce their degrees of freedom. Such a reduction helps to scope the ideal results for student projects. Further, the scoping helps to reduce complexity overall and can lead to more achievable outcomes.

3. Maintenance of Direction: Keeping students on track and focused on solving the problem. In the course, this is achieved through the weekly group and one-on-one meetings with students as they encountered Students need access to tutors that can assist them as well. Regarding the case study, Columbia College Chicago employed exceptional undergraduate assistants to help their peers with programming and design challenges. These tutors were available via Microsoft Teams.
4. Marking Critical Features: Involves marking where students might improve on the work and providing guided feedback to help students achieve their ideal potential development. Marking critical features enable the instructor to motivate students to reach further and design more The instructor can point out what they are doing and how they might go farther. In the course, this occurred through graded evaluations and in one-on-one sessions between the students and the instructor. Depending on the module, more time can be given to technical challenges. For example, in the early modules, discussing design challenges and where students might improve can occur in an hour. Toward the end of a semester, this might take longer when more time is given to production and implementation.
5. Control of Frustration Levels: As expected, students will get frustrated with the issues that arise when developing an immersive experience on an emerging. As educators, it is critical to help them build a capacity to manage that frustration and stand with them in it. The students need to feel like the instructor is a capable collaborator who can help them turn their frustrations into constructive efforts. That transmutation of frustration into tangible progress is critical. Further, it helps students understand the nature of obstacles and how to approach them meaningfully.
6. Demonstration and Modeling: This is not showing students the perfect implementation or a ready-to-use model. Instead, it is about modeling for the students how to solve the problem meaningfully. Again, this approach is about building the capacity for creative problem-solving and imaginative storytelling. Accordingly, all instructions, worksheets, and other materials presented flexible and loose Students were encouraged to seek out additional implementations the instructor did not provide. This process helps the student realize their agency.

The application of scaffolding played an indispensable role in the structure and progression of the course. It allows for a tailored learning experience that considers the varied skill levels of the students and their capacity for development. Inherent in the scaffolding approach is the critical recognition that students require more than mere reproduction of theories, concepts, and technical materials. Instead, they need to cultivate a set of problem-solving skills and a creative mindset that enable them to navigate and make innovative contributions to an emerging and ever-evolving form like IDN in VR.

2.2 The Course Structure

Students iterate on their VR IDN over the semester. From day one, the expectation that they produce a complete and comprehensive IDN for VR is established. A rubric for this final project can be found in Appendix A. During the first seven weeks of the semester,

students focus on building their concept, diegetic material, and a usable late-stage alpha or early-beta version of their IDN. Students must turn in this rudimentary build for usability testing and feedback for the midterm, due at the end of the first seven weeks. Over the final eight weeks, students iterate two more times before turning in their final experience with a cinematic trailer for their portfolio. The entire course structure is in Table 1 below. Longer explanations of course content and scaffolding follow.

Table 1. IDN in VR Course Schedule. Classes were broken up into lectures, instructor-led activities, and studio time. Subjects and practices would often meld from one class to the next.

Weeks	Material Covered
1-2	IDN Overview
3	IDN Writing Strategies, Narrative and Character Development
4-6	Basic Interaction Design and Locomotion
6-7	Virtual Environment and Digital Scenography
8-9	Rudimentary AI and Custom Narrative Game Mechanics [19]
9-12	User Interface and User Experience Design
12-15	Dedicated Studio Time and Usability Studies

Interactive Digital Narrative Overview. Early lectures on IDN survey the field's history [20], what differentiates IDN from traditional narrative[21], dramatic agency[22], and canonical IDN works suggested by Hartmut Koenitz and Mirjam Palosaari Eladhari [4]: namely *Façade* [23], *afternoon, a story*[24], and *Save the Date* [25]. Further, VR IDNs from SideQuest are assigned. Marie-Laure Ryan's work on textual architectures is also presented in Week 3 [26]. These architectures are then used in the following weeks to scaffold the production of the IDNs. With only 15 weeks, the goal was to get students building as quickly as possible. This rush to development left little time to build literacy in the young conventions of VR IDNs. This rush had consequences on concept development and implementation of more advanced interactions. To ensure practical training, each student is equipped with a VR headset, accessible throughout the course. In the case study, Oculus Quests were used for this purpose.

This rigorous schedule aims to swiftly transition students from theoretical learning to hands-on construction within the 15-week course duration. However, this accelerated pace of content creation offers limited time to foster a nuanced understanding of the emerging conventions of VR IDNs. This constraint can impact the students' capacity to conceptualize and implement advanced interactive elements. To counterbalance the impediments of the rigorous schedule, students had to be motivated to tackle complex problems while at the same time being given a foundation to do this work.

To those ends, scaffolding in this module involves Recruitment and Reduction in Degrees of Freedom. Recruitment entails stimulating student interest and assessing their aptitude for the forthcoming coursework. Implementing a pre-course survey can be beneficial for

this purpose, allowing instructors to evaluate student interest, availability, and foundational skill levels. Such insights can inform the differentiated instruction strategies essential for effective learning within the course [27].

The Reduction in Degrees of Freedom is achieved by commencing with basic examples, helping students grasp foundational concepts. By studying established IDNs on platforms like Twine or within archives such as those run by the Electronic Literature Organization, students establish a foundation for considering more complex narrative designs in VR.

Interactive Digital Narrative Writing Strategies. In the context of writing strategies, Ryan's story structures [28] are taught as fundamental frameworks to structure IDNs. In particular, the 'Vector with Side Branches' structure is introduced as a basis for designing a Spatial Storyworld Architecture [28, 29]. This approach encourages students to visualize each branch of the vector as a distinct VR environment. As Asim Hameed and Andrew Perkis discuss, from each space come moments for dramatic agency and storytelling [30].

In alignment with Colette Daiute and Hartmut Koenitz's recommendations, students participate in character development exercises [3], which encourage them to create Non-Player Characters (NPCs) that serve as branching points for dialogue and narrative in their VR spaces. Concepts of worldbuilding are introduced along with immersion [21, 29] and Sense of Presence (SoP) [31–33]. Subsequently, students design their narrative world, curate spaces within it, and construct narrative beats aimed at enhancing and sustaining immersion and SoP.

In this context, Reduction in Degrees of Freedom manifests as the presentation of key IDN writing strategies and examples prior to students integrating their created content into a branching narrative system in Unity, the chosen game development engine for the course. Concurrently, scaffolding for Maintaining Direction during content creation is applied to ensure that students stay focused and on track, primarily through peer review. Following this creation process, students' story worlds and characters undergo an in-class peer review before being revised. These critiques happen in Week 3 during a 3-hour class period and as a homework assignment. This session invites detailed feedback on the storyworld, narrative structure, and characters. Each of these components is allocated an hour for a comprehensive review. For example, to aid students with character development, they can be given a worksheet (available in the Github Repo) that covers 38 character traits. It also includes four prompts to help them to develop their characters. Using this worksheet, students engage in multiple conversations with peers about how they could add more depth, life, and detail to the characters for their story. This process can be followed with additional worksheets for the storyworld and structure.

Additionally, During the case study, further support measures were necessitated by the disruptive effects of the COVID pandemic on student progress. These included structures to facilitate teacher check-ins during the peer review process over Microsoft Teams.

Basic Interaction and Locomotion Design. VR IDNs that achieve immersion support a SoP for interactors that enforces an emotional experience [34] and provides the dramatic

agency required for consistent, transparent, and meaningful interactions [21, 26, 35, 36]. As part of the course curriculum, students are introduced to the fundamentals of interaction design and programming. This includes both diegetic and non-diegetic interactions, developed and implemented via Unity tutorials. Although advanced narrative game mechanics are explored in later modules, students begin to understand the significance of interaction design at this stage, both as an element integral to the narrative [22] and a source for joy and play [37] supporting immersion. Comprehensive video tutorials for designing foundational grabbing and pointing interactions, complemented by Unity packages of assets and code, should be provided. The introduction of a third-party interaction framework can expedite the development and design process for the students.

Locomotion Design is critical for creating immersion and exploring an IDN with a Spatial Storyworld Architecture [37–40]. As locomotion in VR is also an accessibility concern, it's imperative to consider an interactor's natural mode of locomotion [41]. The course, therefore, teaches students to implement multiple forms of locomotion, including (1) impossible space architectures [42], (2) joystick, (3) teleportation, (4) flight, (5) climbing, (6) and vehicle or platform based [43].

At this point in the course, Vanishing Grace [44] is introduced as a relevant case study. It is a narrative puzzle game that uses spatial exploration, two modes of locomotion, good voice acting, and ludic and narratological interactions. It is also a case study in limiting the scope, standardizing interactions in the world, and designing meaningful spaces. Another example is the Last Labyrinth [70], a true VR IDN with multiple endings that utilizes puzzles and social presence to achieve immersion. Interactors communicate with Katia, who is unintelligible, to escape a labyrinth of horrific traps. The bond created with Katia is used to raise the emotional stakes and is instructive for students in producing SoP. Further, limited interactions—nodding and shaking the head, using a laser pointer—demonstrate to students that they do not need complex interaction designs to create an active and rich IDN in VR.

Scaffolding methods in this module include Marking Critical Features and Maintenance of Direction. The former entails highlighting areas of potential improvement for students, such as suggesting cleaner coding or design practices. For instance, if a student implements a basic inventory system found online that doesn't effectively utilize Unity's input system, an instructor or tutor can guide them towards more appropriate implementation. Maintenance of Direction is facilitated through the support of three peer tutors accessible via Microsoft Teams or Zoom. Having these additional resources proved critical to the success of the course, given that addressing every concern promptly would have been challenging for a single instructor.

Virtual Environment Design and Digital Scenography. The prescribed story architecture of the course necessitates a comprehensive understanding of Virtual Environment (VE) Design and Digital Scenography. The goal is to foster spatial immersion by focusing on narrative game spaces [37]. The course material for level design draws inspiration from the works of professionals such as Miriam Bellard from Rockstar North [45] and other established creators [46–48]. As there exists a significant semantic overlap

between narrative, experience, and level design in games, students are encouraged to consolidate these concepts into a form of digital scenography. This approach leverages the design and spatial composition to narrate stories and support immersion [30, 49]. These practices include how to use light [50], compose spatial sound [51], and use color to direct user attention [52, 53]. Both in-class and homework activities are centered around creating these immersive environments, covering both technical processes and conceptual work.

The Book of Isabel [54] is a proposed experience for this module. This exploratory walking simulator guides the interactor through a traumatized girl's mind. Interactors walk through memories and hear Isabel discuss the event and her recovery. With limited interactions but an emotional story, the experience is a good template for students with limited programming experience. Given that it was created by an undergraduate from the Academy of Art and Design, St. Joost, it presents a relatable and motivational example for students. A Fisherman's Tale [68] is another proposed case study. This VR experience is a puzzle game that plays with perception. It uses recursion and chains of interactions to create a world wherein the interactor is controlling an avatar, that is controlling another avatar, and so on. It is a case study of using non-Euclidean space in VR to create compelling interaction spaces. For students, it helps to inspire creative ideas outside of their familiar game worlds and their natural reactions.

In terms of scaffolding, this module integrates several steps: Maintenance of Direction, Marking Critical Features, Control of Frustration Levels, and Demonstration and Modelling. Maintenance of Direction becomes vital as students start to understand the significant time and focus required to build virtual environments. As students progress, Control of Frustration Levels also becomes crucial, especially when they grapple with project scopes, encounter obstacles, and balance their outside commitments.

Aiding students in controlling frustration sometimes necessitates Reducing Degrees of Freedom, slowly scaffolding towards increased complexity. For instance, if a student is struggling with implementing a VR grabbing mechanic but understands ray casting for object selection, the instructor can first help them implement the latter, enabling a sense of progress before moving onto the more complex task. Preparing students for complexity is also addressed through Marking Critical Features; for example, this is when an instructor might guide a student who has developed repetitive bird animations to Craig Reynold's Boids, a flocking and swarming algorithm that yields natural behaviors, thereby elevating the authenticity of their virtual environment. These methods of Demonstration and Modelling instruct students in problem-solving strategies for their design and development challenges.

Rudimentary Artificial Intelligence and Narrative Game Mechanics. In VR, worlds enforce immersion and a sense of social presence when NPCs exist [55]. The behaviors of NPCs, as well as animals, machines, objects, and more, within this world not only enhance narrative immersion and social presence but also lend an embodied scale [56] and scenographic energy [57] and help direct their attention [58]. Impressing upon interactors that there is emergent behavior in the space enforces narrative immersion [29, 59].

Narrative game mechanics are introduced. As defined by Teun Dubbelman, “Narrative game mechanics invite agents, including the player, to perform actions that support the construction of engaging stories and fictional worlds in the embodied mind of the player.” [19] These mechanics go beyond the foundational interactions discussed earlier in the semester. Initial mechanics focused on user interface interactions or non-diegetic interactions. Narrative game mechanics scaffold from those fundamental interactions and may support feelings of embodiment in interactors. Helping students conceptualize and implement these mechanics was a crucial challenge.

Considering the distinctiveness of each IDN, materials, and resources for these mechanics are created through personalized instruction and peer collaboration that were intentionally designed into a process for scaffolding student capacity and motivation for storytelling in VR. In one-on-one instruction, students discuss the narrative game mechanics they are planning or have implemented. The instructor can then Mark Critical Features when reviewing these mechanics or, through Demonstration and Modeling, provide additional resources to facilitate implementation. For instance, the instructor facilitates the transition between this and the previous module, i.e., from Virtual Environment Design and Digital Scenography to Rudimentary Artificial Intelligence and Narrative Game Mechanics, by demonstrating how simple wandering NPCs bring more life to the environments they designed. As an example of Marking Critical Features, the module introduces Finite State Machines (FSM) to control various AI agent behaviors—a more complex concept than a simple wandering algorithm.

Simultaneously, student groups are encouraged to review and support each other in overcoming challenges. The peer group discussions and reviews help Maintenance of Direction. This approach, though labor-intensive for the instructor and tutors, allows for patterns to emerge, leading to the development of templates for common mechanistic implementations. For instance, if multiple students require a dialog option resulting in an item addition to the inventory that will eventually allow them to pass into a forbidden area, the instructor can construct this as a template. By carrying over these templates of narrative game mechanics across different course iterations, students can focus their efforts more effectively and save instructional time.

One excellent example to show during this module is Moss [60], a third-person VR adventure experience that upsets expectations for VR narratives. The interactor plays a god-like character who directs Quill, a young mouse. The spaces are lush, but more importantly, Moss is a case study on building a social sense of presence for the interactor with a character. When the interactor is inactive, Quill will look at them and respond to their inactivity. This interaction helps to teach the importance of character development and social presence and their impacts on immersion. Another excellent example of this module is Shadow Point [69], a VR puzzle experience wherein diegetic content helps interactors solve puzzles to find a missing woman. Each world provides a new kind of interaction to script the interactor for future scenarios appropriately. It is a good case study connecting ludic elements and creating narrative game mechanics.

VR User Interface and User Experience Considerations. The curriculum encourages

students to understand and adopt best practices for UI and UX. These aspects are taught simultaneously with students learning from Oculus Quest [35] and LiminalVR [61]. LiminalVR's collected research on the psychological impacts of immersive design choices is valuable for IDN work. As in previous work on IDN curricula, engagement with the psychological impacts of interactions is required [3]. The research spans topics like the effects of motion, color, lighting, music, sound, interactivity, ludic interactions, flow, and cognitive load. Familiarity with these concepts can enable students to achieve immersion and a sense of presence (SoP).

Students are encouraged to develop as many interactive narrative game mechanics as possible, as an effective UX is necessary for an IDN [11, 62]. For example, one student created a teleportation interaction that looked like a rope that was, in some way, connected to the character's story and the world. This expectation is meant to encourage UI and UX to achieve Jay Bolter's transparency in service of immersion [63–65]. In another instance, one student's story involved a bully being turned into a gecko who then must converse with bugs. To begin the game, the interactor must open a box. After opening the box, insects scurry around inside, their movement encouraging the user to lean in. When the user leans in, an interaction triggers a scene change that starts the narrative.

The course also instructs students on how to conduct the 'Think Aloud' method [66] for their usability studies. During the pandemic, students designed their VR experiences in isolation, which posed challenges for usability studies. Consequently, they were not introduced to quantitative methods due to time and scope limitations despite their considerable value. Regardless of whether the course is conducted remotely or in-person, students are advised to record their playthroughs while verbally sharing their thoughts and interactions. Their peers would then convert these insights into actionable steps for subsequent iterations. Students engaged in this peer review process three times over the course's final three weeks, allowing them to receive feedback from the entire class while progressively refining their narrative.

Under ideal circumstances (non-pandemic), students would apply this method with multiple peers both during and outside class time, thereby ensuring a robust use of Maintenance of Direction scaffolding. In a classroom setting, it's easier for the instructor to observe the process and provide immediate constructive feedback. Moreover, students should be introduced to different usability tests, such as the user study prototype pair protocol discussed by Koenitz and colleagues [1]. This method could have significantly amplified the amount of feedback received and facilitated earlier testing if all students were in a single location.

2.1 Financial, Logistical, and Technical Challenges in Teaching

There are several challenges associated with executing the proposed curriculum, arising from the rapidly evolving IDN and Immersive Media fields and varying student literacy levels in these domains. To build this effective learning environment, educators must strike a balance of technological, pedagogical, content, and contextual knowledge. This blend,

often referred to as TPACK (Technological Pedagogical Content Knowledge) in learning theory[67, 68], must account for the unique institutional and circumstantial contexts, such as a pandemic, university, state, or federal policies governing student technology use, financial challenges, and socio-techno-cultural contexts.

Some students may not have had prior exposure to VR, necessitating a steep learning curve to comprehend storytelling within this medium. The previous section suggested several immersive experiences, which, if required for purchase, would cost students $115 (as of writing in 2022). Solutions to alleviate this financial burden and increase accessibility could include renting or sharing VR experiences, reintroducing free demos, or establishing educational licenses for experiences that allow multiple students to engage concurrently. Collaborative efforts between university libraries or departments and the industry could facilitate such solutions.

Determining incoming students' technical capabilities, visual or digital design skills, and prior knowledge in IDN, VR, or game design[69, 70] presents a significant challenge, especially in an emerging field. Self-reporting through pre-course surveys can be misleading [71], and students may come from different traditions entirely if the course is an elective. Balancing the educational material's rigor for advanced students while ensuring accessibility for beginners, particularly in areas like programming and development engines like Unity, is complex. However, having teaching assistants or tutors can help come up with diverse learning materials that meet learners where they are at.

Access to hardware and experiences is an issue. The Oculus Quest was used in the case study and may be an affordable option. However, the recent announcement that ads would become part of VR experiences may not make the Quest acceptable [72]. Further, students may, and did, resist being forced into the Facebook ecosystem when the course ran. Despite the ability to create independent Meta accounts, students have expressed hesitation about contributing data to a corporation perceived as problematic. This sentiment from students raises significant institutional questions about which headsets and ecosystems a university adopts. One workaround might be creating general accounts unlinked from students' identification information. However, students may then lose access to the work or experiences they purchase. Alternatively, institutional accounts managed by university libraries could be a more comfortable option for students and allow for renting VR experiences. Policies need to be developed for the borrowing, return, and maintenance of VR headsets for the students to use. This may mean wiping them off data between uses to avoid privacy issues.

Physical space can also pose a challenge. While some students can create VR experiences in large apartments, others may only have access to a small bedroom or dorm. To ensure equity, a common space on campus should be made available for students to experiment, supplemented with a VR emulator accessible to all [73]. The emulator will speed development for all students regardless of the size of their physical space. The case study was conducted during COVID-19, adding its own constraints. In a non-pandemic scenario, VR headsets should be provided for students to use in a common open space that enables multiple students to work concurrently.

The course modality also presents challenges. While a remote synchronous modality, as used in the case study, allows for lectures, discussions, and individual check-ins, it makes immediate feedback and project management difficult. For the case study, this was all done over Microsoft Teams. Teaching in a classroom allows students and instructors to use a VR headset in a shared space, which can enhance communication around embodiment and immersion concepts. In contrast, teleconference platforms flatten the spatial nature of VR and make it challenging to communicate these concepts effectively. Students miss valuable insights when they can only see a screen recording of a VR experience rather than the entirety of an interactor's body and the physical space they are occupying. Therefore, future iterations of this course should ideally be conducted in person.

3. The Case Study

This course ran at Columbia College Chicago in the spring of 2021 within the Department of Interactive Arts and Media. As mentioned, this was an experimental pilot course run during the pandemic. As a result, the class was able to run with a low number of students—only eight participated in the course. These eight were able to take the course as a degree-fulfilling elective. The students came from the following degree programs: one from Creative Writing, one from Programming, one from Interaction Design, one from Cinema and Television, and four from Game Design.

Each student was given an Oculus Quest that they could use for the entirety of the semester. While the class met synchronously and online, students also had access to lecture and tutorial videos hosted for asynchronous access on the college's learning management system, Canvas. Lastly, students had access to tutors and the instructor via Microsoft Teams. Tutors were available from 9h to 21h, and the instructor was available for one-on-one meetings from 9h to 17h.

Five of the eight students in the class produced complete IDN VR experiences that earned good marks, B or higher. The course was graded using the US 4.0 grading system with A+ through F letter grades. To earn the top grade, an A or A+, students had to present a bug-free experience, have a complete narrative arc with a beginning, middle, and end, achieve immersion and SoP as reported by peers, create at least five areas for the story, including interactions that provided dramatic agency, and had to have completed most of the action items from their think-aloud studies. Students were made aware of these expectations at the beginning of the semester when the course trajectory was discussed, and an official rubric that went into greater detail was presented after the midterm evaluation in response to student progress toward their final deliverable. This rubric is in Appendix A. It was made available online and was discussed in class. Students presented their final experiences through a trailer and in-class playthrough.

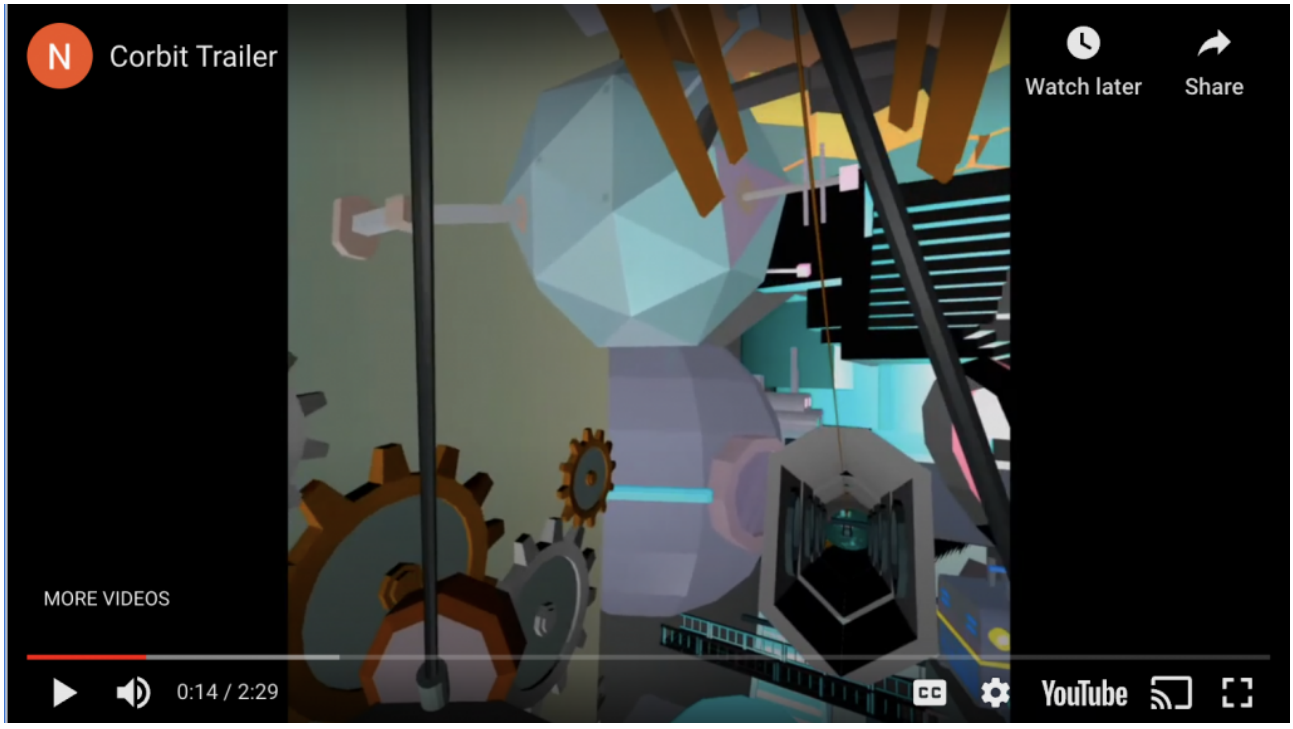
Of the seven students who completed the course, one student from the Creative Writing program and two from the Game Design program received the top grades in the A range. These students produced the most comprehensive and extensive experiences (20 or more minutes long). These experiences also had multiple branching dialogue options that

expanded the storyworld and, in one case, changed the story's outcome.

3.1 Select Student Work

The best student work is presented here with summaries of their narratives and video trailers.

Corbit. *Corbit*, in Figure 1, "takes place in a whimsical world in the center of the earth, where every cog has its purpose in the machine. *Corbit* aims to explore existential and environmental concepts in a fun, hopeful, and engaging way." The interactor embodies a Cog, part of a system of cogs and gears that help to keep the earth alive while humanity causes damage. Throughout five spaces, interactors learn who they are in this world, their role, how humans are destroying the earth, and how they can fix it. In conclusion, the interactor learns that their work is Sisyphean—that the machine is made for the earth, not humans, and will exist long after they are gone. *Corbit* uses digital scenography melded with UI elements to maintain immersion while supporting the user's SoP. The narrative is grounded within contemporary issues and anxieties, supporting SoP and engagement. *Corbit* effectively utilized the antechamber VR design method [74] to script the interactor before the experience began. Not only did the student capably weave diegetic information into the antechamber, but the interactions they scripted in the space modified the world. This project received the top grade.



The Spotted Journey. In this experience, shown in Figure 2, the interactor inhabits the role of a bully who is transformed into a gecko for their immoral acts. The student loosely based the narrative on a myth about the goddess Demeter's punishment for a man who mocked her as she ate and drank. The interactor must do good deeds while collecting crystals from rooms within their own house. Once the interactor is transformed into a

gecko, the bugs and small creatures within the space take the opportunity to scold them for their bad behavior (when large). *The Spotted Journey* relies strongly on scale and climbing locomotion to make the player feel small and feckless. As the interactor goes from room to room, the climbing challenges require more significant body movements. Such movements have a beneficial impact on SoP. NPCs quickly let the interactor know how rude they were when they were a fully-sized human inhabiting the space with them.

System Security. Presented in Figure 3. In this VR experience, the interactor is a character that is a program inside a larger system. Their role is to stop viruses from sneaking into the system and causing havoc. A mix between *Papers, Please*[75] and *Tron*[76], *System Security*, forces interactors to make difficult choices regarding who enters the system and who gets deleted. Throughout the experience, the interactor befriends a coworker. The interactor learns that this new friend may have a virus inside them. After plugging into their friend's head and discovering they are infected, the interactor must delete their friend. *System Security* effectively used worldbuilding and characters to create a sense of narrative immersion. The difficult choices interactors had to make increased the stakes of their dramatic agency. In the end, the interactor is not able to change the world in which they inhabit.

These three experiences present the range of IDNs developed. Each had its own unique world, story, and narrative game mechanics. Not presented in this article were the following projects:

- Interactors play as a worm in a community of migratory worms moving from one rotting food to The story was riotous, unique, and involved strong narrative game mechanics. The environment design needed to be improved, as were effective uses of dramatic agency. The experience was entirely linear.
- Interactors play as a piece of patchwork cloth in an oppressive tailor shop run by an oligarchy of pure fabrics. The world they built was expansive and beautiful. There were playful mechanics used as welll. However, implementing those mechanics was ineffective, and the IDN suffered. Further, at under 10 minutes, the experience was relatively short.
- The interactor is a discarded robot searching for its old human owners. The experience was short, lasting under 10 minutes, and did not utilize interactions that

changed any aspects of the story.
- The interactor is an overworked factory caterpillar looking to overthrow its oppressive spider bosses. This experience had numerous bugs, making it a challenge to experience.

4. Understanding Student Perspectives

To better understand students' responses to the course and curriculum, their answers to questions from a midterm and final course evaluation are provided. The evaluations were given with 5-point Likert-scale questions (one being the worst and five being the best). In both instances, students were encouraged to explain or reflect on their chosen values. Six of the seven students completed all the evaluation instruments.

The evaluation questions were divided into two sections—one on the course and another on the instructor. Only the questions about the course are discussed. They were: (Q1) I was intellectually challenged by the course; (Q2) I was encouraged to take learning seriously and to think critically in this course; (Q3) Class requirements and activities were useful learning tools to support the achievement of course goals, and (Q4) Overall, the course was well organized.

4.1 Student Perspectives at Midterm

Before discussing the results, it must be noted that they cannot be generalized due to the small sample size. They should instead be considered insights into how the students felt about the course material. During the midterm discussion, the average score for questions was 4.6 out of 5. The written responses (A1-6) to these questions (Q1,2,3, 4) are below.

- Q1 (4.8/5): (A1) I want more discussion of the VR experiences and best (A2) Some of the videos are less useful than others. I would prefer having a smaller core of videos that best demonstrate learning concepts and then having a list of extra videos we can choose to watch for more inspiration.
- Q2 (4.5/5): (A1) The lectures on immersion and presence felt (A2) If I had known this course was about storytelling and not games, I might not have taken it (A3). Too much focus on narrative and not VR. (A4) The lectures are a little heavy. However, the classes always provide interesting and useful content that I think will help me in the future. (A6) Group work highly depends on if team members collaborate or not, and sometimes they don't.
- Q3 (4.2/5): (A1) Slower tutorials please! (A2) There are not enough tutorials for my (A3) Class playthroughs for feedback are long and boring. (A4) The C# programming is very difficult. Provide more documentation. (A5) This course is incredibly challenging, and I feel way in over my head.
- Q4 (4.9/5): No student comments were

In response to this feedback, many course corrections were made as the course transitioned from the lecture-heavy first half to the production-based second half. In

response to Q1 A1, students were asked to come to the small synchronous class with video recordings of an experience playthrough they felt was effective. Reflecting on the problems, solutions, and recommendations discussed after each playthrough, students then discussed how to design similar aspects for their own experiences. This process was done as a class. However, the instructor offered mentorship, resources, and advice on implementations.

In response to Q2 A1 and A2, the ludology and narratology discussion was presented in the second half of the course, along with an activity that encouraged students to consider the connection between play and narrative. This discussion occurred in weeks 8 and 9 during the Rudimentary AI and Narrative Game Mechanics module. Students were encouraged to build ludic elements into their IDN. In response to Q1 A2 and Q3 A1, 2, and 4, templates were developed by the instructor on an ad-hoc basis for various interactions, dialogue, scene transitions, locomotion mechanics, and spatial audio. These templates and recourse are now in the GitHub Repo associated with this article. Walkthroughs were presented in class and as recorded videos. In parallel with studio time, one-on-one meetings with students were held to clarify processes and overcome obstacles. These one-on-one meetings were held online via Teams and lasted 20 to 30 minutes each. Occasionally, meetings would run over class time. Admittedly, the pandemic meant that students were still available when this happened.

In response to Q3 A3, class playthroughs for feedback were turned into asynchronous sessions for the students to complete independently during and outside of class time. Had capacity been built among department staff and tutors to review VR experiences from the students, the reviews would have been more effective, and feedback would have been provided faster.

4.2 Student Perspectives at the End of the Course

For the final evaluation, the average score for the questions improved to five out of five. The high score is not representative of a perfect course.

- Q1 (5/5): (A1) The class was tough, but it felt worth it to learn. (A2) This course certainly wasn’t for the faint of heart. It was incredibly challenging but also very fulfilling. (A3) In the future, I think it is very important to do some pre-evaluation of the skill level and knowledge of the students. This course was incredibly challenging, and I felt way over my (A4) Students need to know the level of work before signing up.
- Q2 (5/5): (A1) When I joined the course, I was told that as long as I followed tutorials, I would be able to have a finished project enough to do well. This was not the case for (A2) In studio collab, I feel that since the project would not be my own, I would not feel as motivated as I did in this class.
- Q3 (5/5): (A1) I had to put in probably 20 hours a week on this course. Students need to know and be prepared for the level of work they are signing up for. (A2) My experience in this course was probably different from other students in the course simply because I had no previous experience with game design or Unity, as well as

a very, very basic understanding of C#. (A3) I'm really, really proud of myself for sticking with it and producing the final product.

- Q4 (5/5): (A1) Teach the class about SideQuest earlier. (A2) Once we started to build our world, the guidance and tutorials didn't feel like (A3) Presenting the students with tools and things they can utilize to build their worlds would be beneficial before starting to get into the conception phase. If I knew how difficult some of the world & interaction building be, I would probably start with something a whole lot simpler for myself.

The responses to the questions during the final evaluation indicate several changes for the future course. As indicated by all respondents, the class was challenging and required a significant investment outside of course time. The college where the class runs expects students to spend 9 hours outside of class on the material. As discussed in Q3 by A1, some students did more than double that amount of work. Moreover, as in Q1, some students felt they needed more preparation for the scope of work required to complete an IDN in VR. In response to these challenges, future courses will provide a wide range of design and code templates to ease the production demands for students. Plug-and-play templates might be the most effective, even if they reduce the diversity of IDNs created. Options like Quill [77], the VR illustration and animation tool, might be more accessible and are frequently used for sequential narratives. Students might work well beyond an institution's expectations to realize their visions. It is vital to communicate to students that institutional policies are meant as safeguards and that putting in nine hours of work does not necessarily result in mastery. Mastery could take 20 or 30 hours.

Moreover, while mastery should be encouraged, instructors should be mindful of their students' work-life-school balance and the vast amount of material in the course. The course might present examples of final pieces that earned low, average, and high marks to address this in the future. These examples help students set proper expectations for their efforts. Further, students might be divided into small teams to work on projects. However, as stated in Q2 by A2, they worked with a group to produce an interactive experience and were less motivated because they did not have complete ownership.

In response to questions and responses about the production demands (Q2 A1, Q4 A2, and A3), an established third-party interaction framework will be implemented in the future course earlier in the semester. Several third-party frameworks can be implemented in Unity for the Oculus Quest (VR Easy [78], VRTK [79], and NewtonVR [80], to name a few). These templates provide a breadth of interactions with comprehensive documentation. The future course will utilize The VR Interaction Framework produced by Bearded Ninja Games [81]. The framework has documentation and tutorials for grabbing, grabbable events, climbing, teleportation, joystick locomotion, zip lines, platform movement, buttons, switches, levers, inventory management, tools, damageable items, drawing, UI elements, and more.

As discussed in Q1 by A1, in Q2 by A1 and A3 during the midterm evaluation, and in Q4 by A1-3 in the final evaluation, a stronger connection between technical practices in VR and IDN storytelling needs to be established earlier on in the semester. Not only will this

help with project scope (Q4 A3), but it may result in interactions that have more robust dramatic agency and connection to the narrative. For example, consider locomotion mechanics in VR, such as teleportation or joystick movement. Teleporting can be created with a hypermediated design mechanic. The interactor is aware of the medium because of the interface indicators, such as a white line arcing to a potential destination. However, the same mechanic can be designed to be transparent and immersive to fit logically and contextually within a storyworld. The teleport mechanic can be situated within a grappling hook or another appropriate tool. It operates in fundamentally the same way as a hypermediated teleportation mechanic but does not break immersion. Lastly, IDNs in VR should be presented as case studies that students can emulate using provided frameworks and templates. Providing these experiences at low or no cost to students will require university libraries to develop policies and capacity for distributing, sharing, and managing VR headsets and experiences [77].

4.3 Successes and Failures

The course demonstrated moderate success, but it fell short of its ideal implementation. The students' projects largely represented the success of the curriculum, but there were areas where execution could have been improved. Evaluating the learning outcomes in light of students' insights and final artifacts measures the course's strengths and weaknesses. To reiterate, the learning outcomes were: (1) Develop an understanding of the design and development techniques for VR experiences (Virtual Environment Design, Unity programming, Spatial Audio, VR UI, VR UX, and Interaction Design), (2) Construct a VR experience with best practice and artist-led techniques, (3) Understand IDN story structures and implement them in a VR experience (4) Articulate and receive clear feedback through usability studies.

Regarding the first two learning outcomes, students successfully designed and developed a VR experience, with one exception. They acquired a variety of technical skills and were able to implement these with the aid of templates. However, more templates were required for some novel use cases, and students put in more than double the university-expected out-of-class work time to master design and development skills. This challenge persisted even with two to three tutors available for meetings and office hours with the instructor. Students' over-exertion might be seen as a failure of the course, though it also illustrates student motivation. However, the scope and variety of work necessary to complete a comprehensive and engaging experience was overwhelming for all of the students. Yet, students were generally proud of what they produced. Future iterations of the course could involve student development teams or the inclusion of a lab hour with a teaching assistant or tutor on hand for assistance. The course might also be expanded to span two semesters, 30 weeks, so students have more time to realize a vision they can be proud of.

With regard to the third learning outcome, students were successfully introduced to IDNs in VR. However, the limited time spent on Sidequest's free IDN VR experiences delayed their familiarization with VR conventions and made it difficult to connect IDN design discussions to VR affordances early in the course. This resulted in a slower implementation of narrative game mechanics, and only one student managed to produce a

VR IDN experience in which dramatic agency altered the story's ending. Most students created branching narratives leading to a common ending. Thus, although students gained practical knowledge of IDN and VR design and development, the majority could not synthesize the two to create VR IDNs with multiple endings or kaleidoscopic stories [82].

As for the fourth outcome, students learned to provide feedback through remote think-aloud usability tests. While this was beneficial, additional qualitative and quantitative methods would have been advantageous. Teaching quantitative methods for evaluating effectiveness and efficiency could have improved VR interaction implementation. Furthermore, while remote feedback was useful for peer reviews during the pandemic, it offered limited information to students. Understanding the physicality of interactors in VR is vital for designing an accessible experience [85].

While a synchronous remote modality was appropriate for this class during the pandemic, it would be an obstacle to a successful implementation in the current environment. The remote synchronous modality made providing feedback, keeping student work on track, and encouraging participation and engagement challenging. Future courses should be taught in person in a space large enough for individual students to easily move between VR experiences. This shared presence would make peer reviews more effective and efficient and enhance the teaching impact as students could review the experience, code, and design in real time with the instructor.

5. Looking Ahead

The establishment of IDNs in VR as a recognized discipline necessitates the sustained participation of the community in the design and enhancement of curricula. Collaboration among multidisciplinary practitioners and scholars is crucial to solidifying a consistent set of practices, forming a strong foundation for this emerging field. Standardizing the discipline's language, history, and canon of experiences through the shared syllabi, curricula, and pedagogy is essential in this challenging yet thrilling endeavor to nurture the next generation of immersive storytellers.

The innovative use of VR for IDN implies a shift from established norms associated with traditional media. For example, the remediation of montage in VR promises a richer and more complex experience akin to a spatial journey through moments, as demonstrated by *The Changing Same* [83]. New storytelling mechanisms, such as spatial montages, provide valuable models for students of VR. As these examples evolve, instructors should continually integrate them into their course materials, thereby distilling the practical aspects of VR storytelling for their students. It is pivotal that the curriculum continually adapts to equip students with the skills to create and critically comprehend these works.

Based on the student feedback and subsequent course adjustments in the case study, it becomes clear that an essential aspect of future IDN courses that utilize emerging media is increased scaffolding of the learning experience by the instructor. This aligns closely with Vygotsky's Zone of Proximal Development theory and Bruner's theory of scaffolding. In the case study, without the instructor's swift creation of ad hoc scaffolds in response to

emerging student needs midway through the course, student frustration may have escalated, and learning outcomes might not have been met.

The continued development of such responsive pedagogical strategies will enable the cultivation of an immersive learning environment ideal for fostering the next generation of immersive storytellers. This approach applies established learning theories to the distinct context of IDN in VR, ensuring the evolving needs of students are met, and their learning experiences are enriched and empowered.

Since the article's publication, the interest in creating cohesive, compelling VR experiences enriched with storytelling and narrative has stayed consistent. For example, VR consumers have general anxiety when Mark Zuckerberg and Meta release seemingly flat or "soulless" experiences[84–86]. The mainstream offerings available in 2022 primarily focus on short, playful bursts rather than long-form experiences that engage in serious storytelling. By shifting industry focus away from rhythm, hack-and-slash, and first-person shooter games towards narrative-heavy experiences, we can redefine the potential of VR IDN.

Fostering close collaboration between educators and industry practitioners is vital in this endeavor. The realization of IDN in VR as a discipline is contingent upon our ability to develop the necessary competencies in upcoming designers and developers. Industry groups like the Real Time Society are working to establish immersive media production standards. Partnerships with academic groups like the Association for Research in Digital Interactive Narratives could help chart potential paths for higher education institutions to prepare students for VR storytelling.

As for this course, after the first author left Columbia College Chicago, he took modules and lessons from the material to Ball State University and New York University. Specifically, the material on IDN story structures, narrative game mechanics for VR, and UI and UX design for VR have been integrated into modules for both programs. The resources for these modules and other IDN VR templates, exercises, source code, and design tools are on the GitHub repo available here: https://github.com/jadlerfisher/IDN-in-VR-Resources. This repository is specifically for VR IDN materials that educators can use in their classrooms. As with all repositories, it is a living archive and is expected to grow and develop along with the VR industry and hardware. By consolidating these materials, we can better identify the principles that need to be taught and the best practices for doing so. Through our combined efforts, we can develop resources that will equip a new generation of educators to train future VR IDN creators.

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