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METASCAPES | ARCHITECTURAL QUESTS IN THE METAVERSE

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Abstract

The paper investigates the appropriateness of CAAD software and computational design tools for the creation of metaverse content along with the workflows and limitations involved. In parallel the research aims to assess the validity of architecture design studio research in the context of the metaverse, and its capability to produce results that justify further explorations in such direction.

Keywords

metaverse, education, architecture, computational design, optimisation

METASCAPES | ARCHITECTURAL QUESTS IN THE METAVERSE

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ABSTRACT

The paper investigates the appropriateness of CAAD software and computational design tools for the creation of metaverse content along with the workflows and limitations involved. In parallel the research aims to assess the validity of architecture design studio research in the context of the metaverse, and its capability to produce results that justify further explorations in such direction.

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ملخص

تبحث هذه الورقة البحثية مدى ملاءمة برامج التصميم المعماري باستخدام الحاسب الآلى لإنشاء محتوى للميتافرس، إلى جانب خطوات سير العمل والمحددات المعنية. ويهدف البحث بالتوازى إلى تقييم صحة نهج البحث فى استوديو التصميم المعمارى فى سياق الميتافرس وقدرته على إنتاج نتائج تبرر المزيد من الاستكشافات فى هذا الإطار.

الكلمات المفتاحية: الميتافرس، التعليم، العمارة، التصميم الحوسبى، التمثيل الأفضل

1. INTRODUCTION

Creating for the Metaverse, in its current development phase, appears to involve new opportunities for architects and novel or repurposed activities to be proposed, hosted, and supported in the virtual realm (Sun, 2021). However, while some core architectural skills and processes might be applicable to the field (Monfared, 2021), new skills and a shift in mindset, and methods is additionally required (Jensen, 2021). Along these lines, the authors of this paper investigate the appropriateness of CAAD tools and test the applicability of architectural design methodologies to produce metaverse content and environments.

To explore the above, an educational intensive 1-week workshop was realized at the University of Nicosia, offering the opportunity to undergraduate architecture students to engage with custom software workflows and metaverse platforms towards proposing and constructing interactive virtual environments.

The authors aimed to answer practical questions such as: could CAAD software be implemented for the creation of metaverse content and if so, what are the workflows and limitations involved? What is the potential role and possible applications of computational design tools in creating for the Metaverse? In parallel the research aimed to assess whether the architecture design studio research approach could be valid in a virtual context and capable of producing results justifying further study and exploration in such direction. In relation with the latter, the authors share David J. Chalmer's proposition that the questions that matter most are not about reality and unreality at all, but rather about the kinds of experience, agency and opportunities afforded by any environment we are responsible for: "if these are genuine realities, ones where you can have meaningful experiences, what kind of meaningful experiences are we going to have?" (Chatfield, 2022). Under such perspective, designing for physical or virtual spaces could be seen through a common lens and allowed the research team to investigate the capacity of architectural design process to produce new experiences, formulated through innovative uses and activities, for the metaverse.

The workshop brief was therefore structured to yield certain outcome, the analysis of which could provide answers to the above research questions. The participants worked in two parallel directions; A. developing a practical software skillset enabling building for the Metaverse, B. accumulating sufficient theoretical background knowledge, including fundamental concepts pertaining the Metaverse domain, to propose an innovative use/activity/experience for their proposals. They experimented with the creation of digital models using architectural 3D modelling design tools and actualized custom workflows involving paradigms from disciplines such us game developing and computational design to launch proposals for selected Metaverse platforms. The design development was forked in three pipelines implementing specific software workflows and file types, effectively identifying the required CAAD methodologies and classifying distinct Metaverse platforms. Five proposals were produced and discussed in the study, producing conclusive findings, and revealing a fertile ground for further architectural research in the Metaverse.

2. WORKSHOP

The workshop was hosted under the Architecture Catalysts Course at the Department of Architecture of the University of Nicosia in Cyprus. Architecture Catalysts are elective, intensive one-week courses, whose content vary every semester depending on the interests of faculty and visiting specialists. The courses are intended to add flexibility to the curriculum and provide a productive academic break during the semester. With the catalyst in place, the faculty can respond to newly developing research or design practices offering motivating and exciting opportunities to students and participants. The specific Catalyst Workshop ran during Spring Semester (14th– 18th March 2022) and was attended by thirteen, third-year students studying at the department of architecture divided in five teams. The workshop brief was structured so that the participants could work in two parallel directions: accumulating sufficient theoretical background knowledge and developing a practical software skillset enabling them building for the Metaverse.

Finally, the participants were voluntarily asked to submit their proposals to *The Next Top Metaverse Build*, a virtual buildathon, competition and accelerator program helping spotlight the next wave of Metaverse entrepreneurs and builders. The competition offered the opportunity to build, pitch and test ideas in front of industry leading Metaverses, protocols, organizations and investors.

2.1. Part A. Theoretical Framework

This part of the workshop aimed at formulating a foundation of peripheral knowledge from which proposals could be initiated. Like a design studio research assignment, the participants were initially tasked to analyze their virtual sites, corresponding to their assigned Metaverse platform. As such, they were requested to carry out research on the key characteristics of the platforms and register relevant metrics and data for the predominant activities and users. The students were requested to pose and answer questions such as: Who is the target audience, what are people using the platform for, how do users interact? Additionally, students were given key readings to consider, attended lectures from specialists in the field and were introduced to and discussed fundamental concepts relating to the domain.

The authors inherited an open-ended and purposely broad title for the workshop: *Metascapes*, deriving from the prefix meta- combined with the word –scape, was chosen to encompass a wide variety of interpretations while denoting a quest for a plausible Metaverse future. By discussing the title, the participants were encouraged to consider the role of the metaverse as a groundbreaking technology. Would it perform as an escape or a genuine connection to everyday life and activities? Is it emerging beyond our current reality, or alongside? Are we steering towards the idea of an augmenting layer or an immersive dystopian alternative to the physical world?

Additionally, participants were introduced to the fact that online virtual environments and gaming platforms present early versions of the Metaverse, exhibiting multiuser participation in a range of domains. Understanding the evolution and potential innovations promised by an emerging Metaverse involves some lessons on the precedent efforts in building virtual worlds (Sun, 2022). In this perspective, virtual societies, spaces, and identities present nothing new, nonetheless the adoption and integration of blockchain technology fuels new applications and a proliferation of the aforementioned virtual worlds and activities.

In parallel, the importance of virtual interactions and their hosting environments, during and after the pandemic lockdowns, was highlighted. Namely, the paradigms of museums and galleries which have virtually opened their gates to visitors and physical spaces which have acquired permanent extensions into the virtual world were discussed (Levin, 2021). Simultaneously, the NFT movement disrupting the institutions of the art world was introduced. Within this context, digital art works can now be unique, verifiable, and tradable driving the emergence of virtual exhibition platforms and spaces, the design of which is recently commissioned to architectural firms (Stouhi, 2021).

Lastly, architecture in the Metaverse era was approached and deliberated in relation to the mandate of the physical world. Crossing the doorstep of the Metaverse, one can experience spaces stripped of their structural or environmental constraints, tasked to support virtual or augmented happenings. Navigating, involves hyperlinking, teleporting, or flying, and gaming, albeit still the predominant use, is giving way to other human activities.

While some suggested that Digital twins will act as the "foundations of the Metaverse"(Frearson, 2021), the authors support that the place of architecture is yet to be established. Architecture is defined as the process of conceiving and facilitating the delivery of build environments to host human activities. By translating the above assumption, the research team aimed to investigate the capacity of the architectural design studio process to produce virtual environments for novel or re-imagined Metaverse activities. The outcome was therefore evaluated based on responding to the workshop brief in terms of sufficiently formulating and designing for a novel activity. For this study, the ability of the participants to propose and articulate a new activity (or a synergy of activities), was perceived as a key measure in the capacity of the design studio process and its applicability in the Metaverse domain. Succeeding in proposing new activities and designing virtual environments to support them would demonstrate competences already tested and verified in architectural education and therefore validate the applicability of the process as an effective framework for architectural contributions to the Metaverse.

2.2. Part B. Technical Framework

This part of the workshop aimed at developing and adapting technical knowledge and skills to aid participants building their proposals. The authors approached this part with the assumption that online 3D modelling tools (native platform builders) offered by various metaverse platforms are currently limited in creating, editing, and optimizing builds. From this standpoint, the research team posed the question of whether CAAD software, part of the curriculum, could be implemented for the creation of metaverse content.

Students at the department of Architecture of the University of Nicosia are formally exposed to several software packages but are specifically more experienced in Rhinoceros3D and its graphical programming editor Grasshopper (by Robert McNeel & Associates) It was therefore practical for the teams to choose the above packages as the tools to test the paper hypothesis.

To streamline the process, the research team prescribed three pipelines within which the participants could research and develop their projects (Table 1). Each pipeline was associated with specific file types identifying distinct paths to metaverse platforms. As such the participants operated in the “Voxel”, the “Polygon” and the “Game Engine” pipelines. The Voxel pipeline was handling *.vox file types, the Polygon Pipeline was corresponding to *.gltf files whereas the Game Engine Pipeline was addressing specific workflows from the 3D modelling software to gaming engines such as Unreal Engine or Unity associate with specific Metaverse platforms.

Table 1: Workshop pipelines.

Pipeline	Files Types	Metaverse Platform
Voxels	*.vox	Sandbox, Cryptovoxels, other
Polygons	*.gltf	Decentraland, other
Game Engines		Somnium Space, MONA, other

Subsequently, each team selected a pipeline and was requested to visit the corresponding Metaverse platforms and familiarize with their technical features, requirements, and limitations. Students were requested to identify and catalogue available plot sizes, permitted number of polygons, maximum file sizes, material and texture requirements and other relevant technical information.

In parallel, students were asked to experiment, research, and develop a consistent information workflow to transfer their designs from Rhinoceros3D to the corresponding Metaverse platforms. As such students needed to investigate the use of exporting and importing plugins or translate through various software to reach the destined Metaverse platform. Throughout the course the scale of the 3D model had to be constantly monitored and maintained, an often-ambiguous process. The research team understood that geometry size limitations imposed by various metaverse platforms in terms of numbers of polygons or voxels, or file sizes imposed a significant drawback in the workflow. Optimization strategies in regard to maintaining design intent emerged as a major task that drove the development of the proposals. Finally, the intrinsic characteristic of interactivity exhibited by virtual environments and supported by various metaverse platforms attracted special focus and was elevated to a central design element in several proposals.

3. PROPOSALS

During the workshop five proposals were developed along the pipelines explained earlier. The results include two proposals in the Polygon Pipeline (Decentraland), one proposal in the Voxel Pipeline (Sandbox) and two proposals in the Game Engine (Unity/MONA) pipeline. Each proposal and its characteristics are briefly described in the next paragraphs.

3.1. LUSH (DECENTALAND)

LUSH (Figure 1) is an awareness platform, designed to inform, donate and buy NFTs that benefit environmental development and the preservation of endangered flora; a garden space, which is used for gathering, education and play.

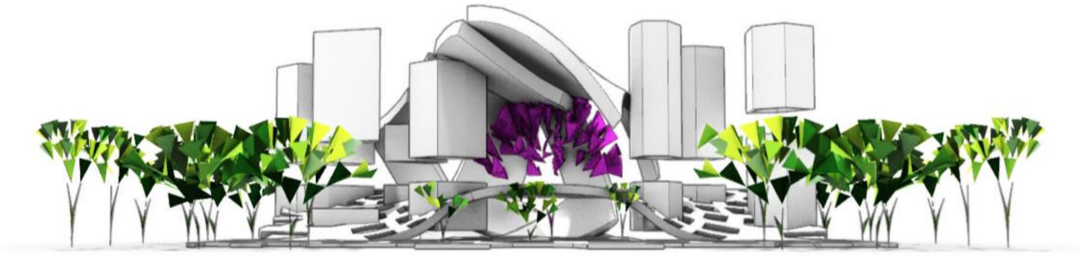

Fig.1: LUSH Proposal.

The project was designed, adapted, optimized and tested for Decentraland on 4 Parcels with 64 x 64 m in size. The main design element of the proposal are the trees that represent various species. These models (of trees) can be acquired by the virtual community and populated (planted) elsewhere in Decentraland or other Metaverse platforms, therefore contributing to the initial cause: educating the community and preventing further flora extinction. The trees were modelled in low-polygon resolution and were generated in Grasshopper, using an L-System algorithm. Unique models were produced by randomly changing the parameters of the tree model, such as number of branches, number of branching generations, number of leaves and color values. The geometry was exported from Rhinoceros3D via a plugin, including materials and texture. The file was uploaded as a series of assets into Decentraland´s Native Builder. Interactive elements, such as buttons, linked to donation sites and NFTs, were added via the builder.

3.2. CTRLshift (SANDBOX)

CTRLshift (Figure 2) is a customizable and gamified virtual Non-Fungible Token (NFT) gallery space that can foster interactions between visitors and engage the audience.

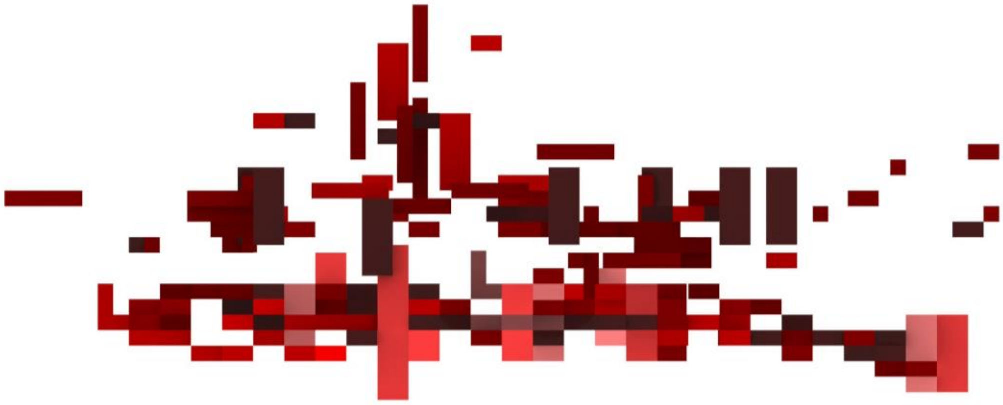

Fig.2: CTRLshift proposal.

The project was designed, adapted, optimized, and tested for the Sandbox metaverse platform on one Land Parcel of 96 x 96 m in size. The concept pertains the customization of virtual space. The environment represents a shifting gallery made of different types of block geometries. Some blocks are animated in space, some are portable, and some are fixed. The portable blocks allow for space customization by the user, to host other activities or implement specific scenarios, in a flexible game-like environment. The geometry was created in Rhinoceros and translated through Magicavoxel (a commercial/freeware software) before imported in Voxedit, Sandbox´s native Builder. Game mechanics, such as animations and interactions were prepared in Gamemaker, Sandbox´s custom game design tool. The software includes additional assets such as buttons, weapons, and avatar bots some of which were incorporated in the design.

3.3. Vortex (MONA)

Vortex (Figure 3) is generic exhibition space for built environment presentations. As such the virtual space can be used to exhibit models that perform as portals to experience real-scale versions of the structures on exhibition. The proposal can find applications in the Real Estate, Archaeology, Education, AEC, and other sectors producing building scale digital models. A fractal space that enables the visitor to teleport inside the exhibits to experience 1:1 scale buildings on display.

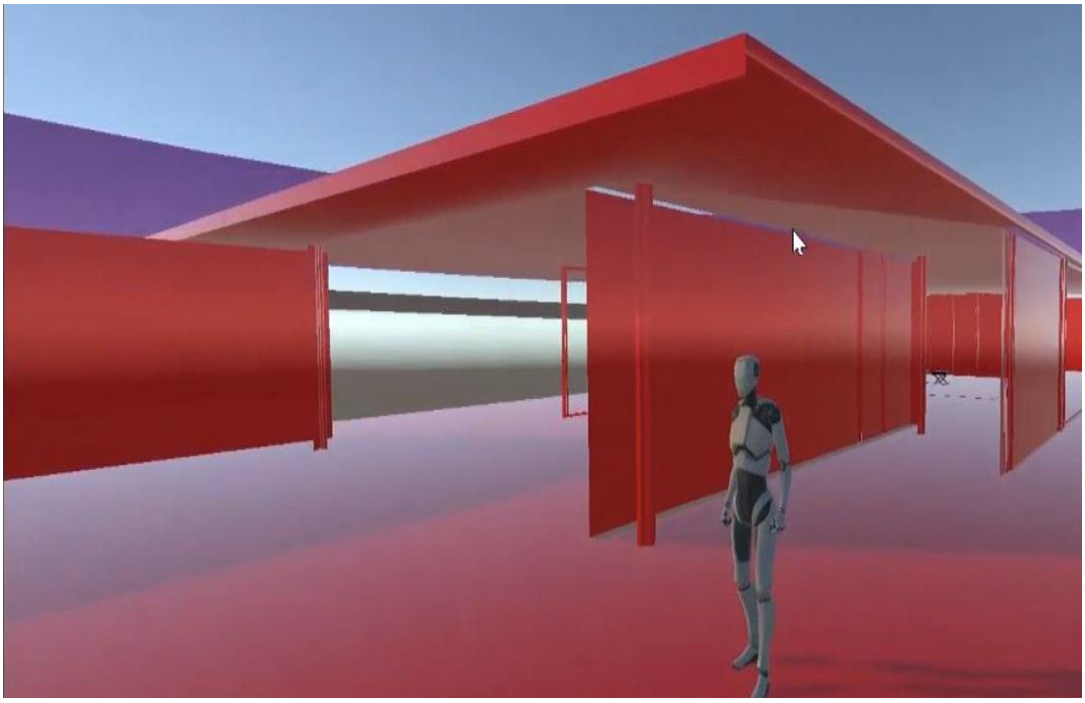

Fig.3: VORTEX proposal.

The project was designed, adapted, optimized, and tested for the MONA Metaverse platform and has a size of 180 mb. The geometry consists of a singular pathway gallery, shaped as a helix. Presentation panels and educational interactive media are placed on the exterior surface of the project. Scaled models are positioned along the central axis of the helix and are accessible through portal links, strategically located inside the gallery.

The geometry was modelled using Rhinoceros3D, including materials and textures and was exported to Unity. A Unity template, provided by MONA, was implemented to translate the model file into the virtual environment. Interactive elements such as portals for teleporting between the main exhibition space and the scaled models were also added in MONA.

3.4. META-mazed (DECENTRALAND)

META-mazed (Figure 4) is a gamified virtual space that aims to engage visitors through a maze type of environment. It presents an effort to implement interactive features of real-world escape rooms such as keys, riddles, and buttons into a metaverse environment. The project is organized in levels of increasing difficulty which the user needs to complete. The winners are rewarded with Access-NFTs, providing entry to specific social events.

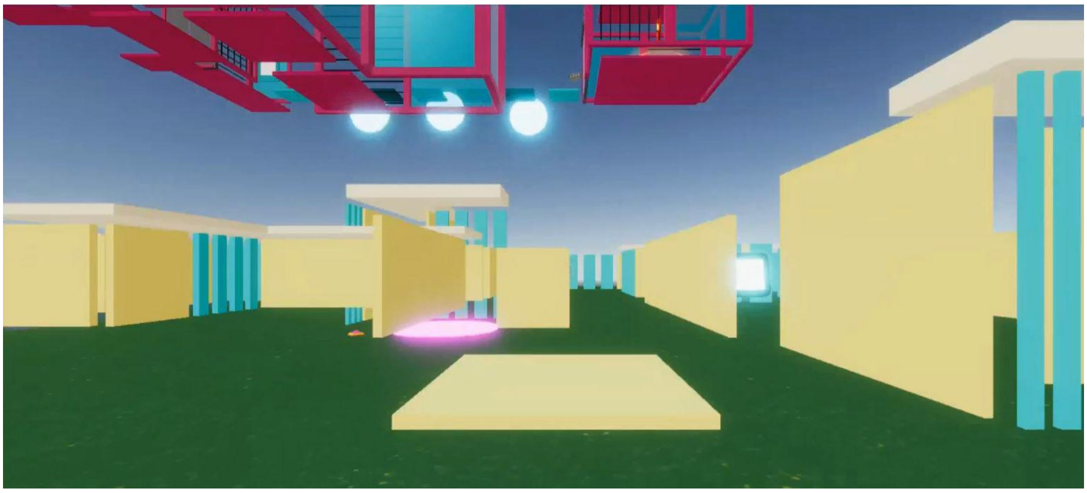

Fig.4: META-mazed proposal.

The project was designed for Decentraland on 2x3 Parcels with 32 x 48 m in size. It develops upon the platform's inherent spatial parameters such as the minimum height an avatar can jump, the maximum height it can walk over (bridge) and the maximum walkable slope (45°). It also implements materiality (transparency) to trigger the user´s perception into identifying which parts of the environment are walkable. The geometry was exported from Rhinoceros3D via a plugin, including materials and texture. The file was uploaded as a series of Assets into Decentraland´s native Builder. The various interactivity elements, offering the gaming experience, were added via the builder.

3.5. ODYSSEY (MONA)

The ODYSSEY (Figure 5) is an allegorical proposal that aims to engage the visitor in a journey of experiences and surprises. The project was designed, adapted, optimized, and tested for the MONA metaverse platform. Odyssey aims to cause extreme spatial stimulation to its users, by embracing the potentials of animation and lack of physics in a metaverse environment.

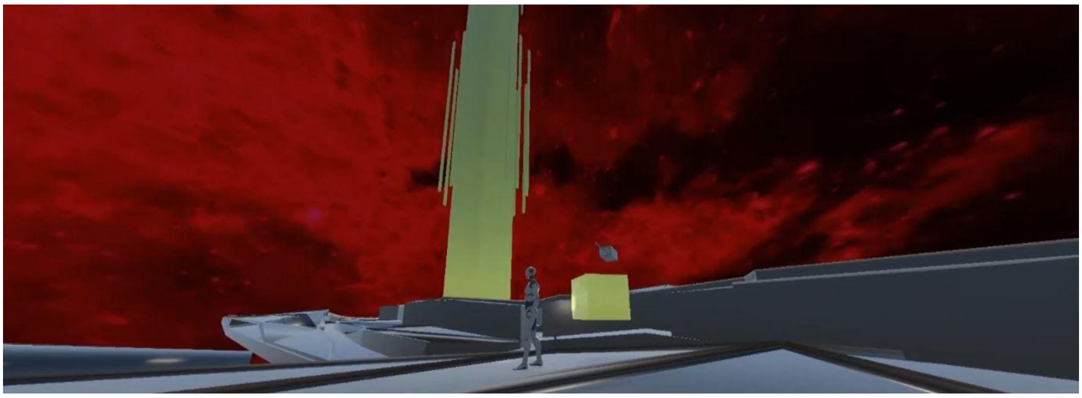

Fig.5: ODYSSEY proposal.

Upon entering the virtual environment, the user has a clearly visible goal to reach, an infinite tower. The journey takes the user from one extreme spatial experience to another through portals, shaped as parts of the tower. There are strong contrasts between these environments, from open to closed, bright to dark, monochrome to colorful and static to animated. Spatial experiences include a tunnel of rotating rings with hallucinogenic patters, or a sealed triangulated space with sharp edges. Additionally, one can experience an open-air platform with a striking sci-fi sky texture or a labyrinth with animated clashing walls, a reference to *the Symplegades*. No matter how persistent the navigation is, the user is unable to reach the infinite tower, denoting the importance of the journey over the goal.

The geometry was modelled using Rhinoceros3D, including materials and textures and was exported to Unity using the aforementioned template. All interactivity elements, animations and lighting features were added via Unity.

4. DISCUSSION

4.1. Theoretical Evaluation

In terms of proposing and articulating new activities, synergies, and experiences, all five teams were able to respond to the brief. While some of the projects are founded on existing uses or activities, like galleries or exhibition spaces, they manage to infuse or complement the proposals with innovative elements resulting in new ideas and pertinent results.

The LUSH project manages to link virtual to physical worlds through the means of sponsoring the planting of real trees and raising awareness on pressing environmental issues. The idea of generating virtual trees that are unique, sharable, and purchasable aligns with current activities recorded in major decentralized Metaverse platforms, has inherent 3-dimensonal and spatial qualities and has not been encountered beforehand by the research team.

The CTRLshift project manages to elevate the idea of an NFT gallery into a gamified public space of interactions, with certain levels of control by performing users or artists. As such, the elements of customizability and interactivity of space, beyond the obvious and commonly encountered updating of the exhibits, present unique characteristics that justify innovation in a metaverse context.

The META-mazed project focuses on providing novel experiences by proposing the idea of a virtual escape room. A popular form of entertainment in the physical world, with an inherent spatial structure, gets a virtual reinterpretation which offers innovative possibilities aligned with the lack of physical constraints encountered in virtual environments. The project explores the potential of virtual spatial configurations enhanced by elements of interactivity to offer new entertainment activities for the metaverse.

Vortex project can be categorized under virtual exhibition spaces but with a twist. The key element that differentiates the specific project is the fractal approach in the organization of the space itself. The proposal explores the navigating possibilities offered by virtual environments to hyperlink and teleport users between spaces and scales. As such the visitor could be observing a scaled model or a 2D representation but has the option to teleport to the interior to explore and experience it in real scale.

Finally, Odyssey attempts to use symbolism and narrative to structure a fictional cosmos. A journey of experiences and surprises with no definitive conclusion aims to create a virtual place that encompasses meaning and didactic value. The project hints that virtual environments could support collective and shared experiences revealing a virtual *genius loci* or the existence of Metaverse places.

4.2. Technical Evaluation

All five teams have managed to realize consistent workflows from a 3D modelling software to their chosen platform and to translate their projects from a familiar modelling environment to interactive metaverse scenes. The workflows support the argument of the research team for a classification of Metaverse platforms based on three pipelines and their corresponding requirements. As such the Voxel, Polygon and Gaming Engine Pipelines can be recognized as valid pathways that can lead from CAAD software to native metaverse builders and platforms. The Game Engine pipeline used in Vortex and Odyssey, was directly realized through an *obj file format, imported to Unity. The polygon pipeline, implemented in LUSH and META-mazed required exporting to a *gltf file that (performed via the glTF-BinExporter by Aske Doerge before moving to a Metaverse platform native builder. Realizing the Voxel pipeline presented challenges for the CTRLshift project team. Exporting the geometry from Rhinoceros3D and optimizing it for the Sandbox required exchanges between three software. The files were exported from Rhinoceros3D in *.obj file format before imported in Magicavoxel, to be converted into *.vox format. From there, the files were placed in Voxedit, Sandbox´s custom Builder. The transition caused inconsistencies (changes in scale), which the students had to overcome. Magicavoxel would only allow for objects of max. 5x5x5m to be imported consistently at a time from Rhinoceros3D, due to a max. 256 voxels importing limitation. To address this logistical workload, a simple algorithm was developed in Grasshopper, to split the entire design into blocks of 5x5x5m. Once all the blocks were imported in Magivoxel the entire model was exported in a *.vox file format before imported in Sandbox´s Voxedit for further editing.

Most metaverse platforms operate through browsers and are therefore very limited in handling large files or high numbers of polygons and voxels. All proposals identified the need for optimization, as a core design strategy that would enable delivery of the projects without sacrificing the design intent. The above task was handled by all teams, either through the use of modelling or computational techniques. In the case of META-mazed the team had to comply with the 60000 triangles limitation imposed by Decentraland which meant that meshes needed to be significantly simplified. A reduction came when all cylindrical elements (pipes) were translated into orthogonal cross sections. In the case of LUSH the design called for multiple tree models to support the concept. Initial trials only allowed for a single tree (commercial 3D model) to be uploaded on Decentraland before the platform's polygon allowance was reached. The use of computational design tools for generating the trees provided a practical solution while resulting in a unique polygonal-art character for the project.

Materials and Textures was another area explored as part of the above workflows. Along with geometries, all teams fared at consistently translating materials and textures from a 3D modelling software to the respective metaverse platforms. While the above task was accomplished at a basic color/texture level, in the case of META-mazed, the team has additionally managed to implement material properties such as transparency, reflectivity and light emissions from the Rhinoceros3D model into the Decentraland Builder. This was achieved by using only PBR-materials (Physically-Based-Render) and altering the Alpha Transparency.

5. CONCLUSION

The workshop and outcome presented in this paper verifies the appropriateness of CAAD software and computational design tools for creating Metaverse content. All results demonstrate a translation from a 3D modeling environment to a Metaverse platform through finite and repeatable steps. In addition, the results support the classification of three workflow pipelines proposed by the research team. The authors aim to continue exploring other software packages to identify further simplifications in the identified pipelines. Computational tools have been implemented to tackle optimization issues, logistical workload or as design tools to generate a multiplicity of solutions. Limitations were mainly imposed by the constraints of the metaverse platforms or the complexity of transitioning through various software packages while maintaining consistent models and materials. Finally, several breakthroughs were recorded in material processing and texture transitions with the implementation of PBR materials.

In terms of assessing the validity of architecture design studio research in the context of the Metaverse, the authors support that the resulting proposals present an indicative sample of the suitability of the process. While the authors understand that empirical analysis is difficult to be developed, the fact that all teams have responded to the brief, by assimilating and addressing the multi-parameter nature of the problem, presents a considerable finding. As such, all teams have proposed pertinent uses, activities and experiences realized as occupiable virtual architectural solutions.

The results justify further explorations with possible benefits for the architectural education. The research enabled key realizations that could turn advantageous for architectural curricula. Fundamentally, Metaverse spaces are inherently exposed to the user. This attribute enables real time testing and feedback on architectural scenarios by specific users or the public, adding new dimensions to the design process. Additionally, designing for the Metaverse can be selectively disconnected from the multi-parameter complexity of the physical world and intentionally focused only on specific spatial qualities. This property appears to fit the early years of architectural education aiming to explore and experience essential spatial concepts such as scale, perspective, colour, light etc. Finally, building for the Metaverse involves technical discipline, self-auditing, and optimization strategies that only digital fabrication currently imposes during the architectural education. Building for the Metaverse is therefore entailing the enhancement of CAAD skills and methodologies.

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