

ISTANBUL TECHNICAL UNIVERSITY ★ GRADUATE SCHOOL

**OPTIMIZING ARTISTIC PROCESS:
EXPLORING EFFICIENT ENVIRONMENT CREATION WORKFLOWS
IN GAMING INDUSTRY**

M.Sc. THESIS

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Department of Game and Interaction Technologies

Game and Interaction Technologies Programme

JULY 2024

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**SANATSAL SÜRECİN OPTİMİZASYONU: OYUN ENDÜSTRİSİNDE
VERİMLİ ÇEVRE OLUŞTURMA SÜREÇLERİNİN İNCELENMESİ**

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Dedicated to my father and mother,



FOREWORD

I would like to thank each of my family members for their support throughout my entire life, for their love and respect they put in my life. I would like to thank my advisor, Prof. Leman Figen Gül, for her assistance, time, and endless motivation, and jury members, Prof. Levent Arıdağ, Prof. Sanem Saniel, for their time and contribution. I also would like to thank my oldest friend, İsa Şahbaz, for his fun spirit. Huge thanks to my coworkers Melih Gündüz, Yusuf Bekleviç, and Artur Aydogdyev for their support and time.

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Lead Environment Artist



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ABBREVIATIONS

2D	: Two Dimensional
3D	: Three Dimensional
AAA	: Informal Classification of games, games with higher development time and budget among other tiers of games
AI	: Artificial Intelligence
AR	: Augmented Reality
AO	: Ambient Occlusion
CGI	: Computer Generated Imagery
CPU	: Central Processing Unit
FBX	: Film box, a universal file format for 3D models
GENAI	: Generative Artificial Intelligence
GPU	: Graphic Processing Unit
LOD	: Level of Detail
NPC	: Non- Player Character
PA	: Procedural Approaches
PBR	: Physically Based Rendering
PC	: Personal Computer
PCG	: Procedural Content Generation
UDIM	: U and V tile texture array-U DIMension
UV	: U and V Axes or Coordinates in Modeling Space
VFX	: Visual Effects
VR	: Virtual Reality



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OPTIMIZING ARTISTIC PROCESS : EXPLORING EFFICIENT ENVIRONMENT CREATION WORKFLOWS IN THE GAMING INDUSTRY

SUMMARY

Although there is no specific data about when researchers demand to study video games, it is understandable to experience an industry which reach 200B in just two decades and making 400 million in just 24 hours with a single title. The technological innovations and hardware improvements in early twenty-first century bring huge productions which eventually made consoles, computers and games more affordable and increase number of players in all groups, ages and genders.

Game industry growing fast which pressure academicians and studios make more research about every aspect of developing, marketing, player and experience. Despite many research focusing why, only few of them describe how. This is most likely video game industry is relatively young and to develop certain tools, software and plugins for production; it is required to make research about why we need it, why we develop it. But asking why in many research raise another question which is how. Demand for comprehensive research becomes evident, not only to understand the underlay motivations of development but also explore practical methodologies and how to do. This need for practicality is mirrored to environment art realm where artist and designers are tasked to crating virtual worlds that all digital stories drive.

Game development is consisting of four main disciplines. The first discipline is programming where developers create codes and blueprints to drive gameplay and mechanics like elements. The second discipline is design where designers craft gameplay and create room for interactions and mechanics that fit player experience. The third discipline is technical art and design where first two disciplines connect in a way to make overall gameplay, mechanics, player experience and interactions flow as expected. The fourth discipline is art which is visual representation of all other disciplines on top of story and narrative that pull the player into game world. Art in video games involves of concept art, prop art, texture art, lighting art and more.

Environment art can be defined as combination of all art disciplines in a video game. Each environment is a synthesis of location, culture, history, theme, lifestyle and atmosphere like elements and has a purpose of answering questions like where gameplay located, who lives there and how they live, what is their culture and lifestyle or what happened there. Overall, an environment is all visual elements of digital world that game characters and player live and interact. Environment artist are specialized artists responsible to make environment scenes. These artist uses various techniques and methods to create desired looking that pull player into game world. In this creation process, they follow various environment art creation steps. These steps are initial planning and referencing, conceptualization, blackout and proxy meshing, modeling and sculpting, texturing, set dress, lighting and finalization. Environment artists use various methods, strategies and approaches as their workflow to create an environment.

Workflow as a term means a repeatable pattern or series of steps to produce an activity. Workflows in game context means the sequence of steps from initial planning and concepting to final game art creation process. The purpose of a workflow provides a repeatable process from beginning to end; therefore, the process can apply to multiple projects in multiple time frame. It is essential to note that while environment art creation involves steps to the medium or underlying technology, these steps are distinct to be considered as a workflow or a base. Conversely, a workflow in environment art means an optimized or refined variations of art creation steps. Therefore, the creation of an workflows mainly refers to a need, to refine one or more environment art creation stage to possibly reduce time, cost or increase art quality and efficiently.

The purpose of this thesis was to understand how game environment art workflows are being used, improved, and developed by artists with a focus on well-organized, optimized and high-quality work to create narratives that enhance player experience. By analyzing approaches and methods used by artists and literature, this study identifying efficient practices and strategies for the creation of video game environment arts. The final purpose of this thesis is presenting finding in a format that is accessible to artists, studios, and educators working in the video game industry whom aims to implement these practices and strategies into their environment art production pipeline.

In the introduction part of this research, we discussed the purpose of our work and significance of thesis following by our research questions and scope, we finished this part by defining research method.

The second section of this research paper started with literature overview. In literature section we discussed two main questions. These questions were what is environment art in video games and what workflows actually mean. We discussed these two main terminologies Following by detail clarification of workflows stages specialized to environment art, these were important because a workflow mainly refers to a need, to refine, optimize, shorten, increase one or more environment creation stage in terms of time, cost or quality. This section of research continued with background research, particularly previous works and history of environment art in video games from very first two-dimensional(2D) graphics to this moment. This part included examples of environment art and industry developments. We finished this section with current environment art workflows trends and previous studies made for this topic.

In the third part, we introduced core part of this work where we explain our methodology for this thesis. We adopted grounded research method for our research. This method has been used in many areas including sociology, psychology and business and become very effective for its ability to generate new insight and theories that based on real world data. This method is especially suitable for dynamic research fields that has fewer existing resources and has a need to construct ideas based on evidence itself, as research field has low literature references, it was essential to benefit from real world data and external contributors. Our methodology consists of three data set and study type; preliminary study, experimental study and main study. These studies created and used data sets, preliminary data, experimental data and semi-structured interview data which later on called as main data.

Environment art field evolve rapidly whereas due to dynamic nature of research topic, some of literature finding may already replace with new methods while some of them may completely obsolete over time. This created a problem, because investigating replaced or unused methods were be impractical for research goals. Therefore, a study

for ensuring literature being reviewed is relevant data was needed. This study was preliminary study which only examined recent literature. In this study, we further detail recent literature and observations to identify active literature while eliminate obsoleted part of it. This study only focuses each environment art creation stages because workflows mainly refer to a need, to refine one or more environment art creation stage. Therefore, only focusing environment art creation stages was a logical method for such purpose since any changes on environment art creation stages would dictate workflow and method itself. Also, this approach would be efficient and practical to ensure literature being reviewed was relevant and up to date.

This approach allowed us pinpoint areas where refinement, change or obsoleted happened. The study in general showed us; 2 dimensional, manual and time-consuming methods are greatly replaced while more automated, algorithm or AI based workflows has a trend. Furthermore, this study provided strategies and methods for efficient practices visible in literature for each environment art creation stages. The end result of this study created preliminary data.

The dynamic nature of research topic created yet another problem. As the research topic was extremely dynamic, some of preliminary study data may be too new and only have theoretical background without practical base. Experimental study was a practical study for this need. Therefore, we created an experimental project based on preliminary data. In this study, we created a dedicated environment art project named “Living in the Bubble of Love”. This study focused preliminary data and measured the practical base of it. Therefore, some of preliminary study findings like procedural workflows and modular workflows has a practical base while AI based workflows may need further definition, tool, learning resources and most importantly regulations for copyright. This study created our second data set which is experimental data.

Preliminary study and experiment project study created two data type, these were preliminary data and experimental data. These two data sets used as a base for preparing a semi structured interview. Therefore, based on previous studies we prepared a semi structured interview framework which included an extensive survey along with minimum 4 industry artists and compare their approach for each step of environment art creation pipelines. The end result of this interview created last data set which is main data. This data, preliminary data and experimental data used for final main study. The main study was final analyzing and writing of all data sets using grounded research method to generate theories for literature, research goals and environment art field.

The main study started with our goals and scope following a detailed explanation about our data collection and analysis methods. We used Grounded Theory as both analysis methods data collection method. This section of study started with semi structured interview framework, including participant selection criteria like relevant field and experience; recruitments methods like professional networks and referral methods. Semi structured framework setup continued with confidentiality procedures, data sets, final interview layout and interview questions.

The section ended with main study analysis and findings. The analyzing used open coding, axial coding, selective coding, theoretical sampling, theoretical saturation and memo writing to analyze all three data sets. This analysis and finding included discussion about methods and workflows we interviewed and experimented during this research. The final theoretical sampling and memo writing groups created various theories as follows. 1-Base workflows, 2-Tools and compatibility, 3- Prototyping, 4-

Feedback and collaboration, 5-Importance of planning stage, 6- Artist Role, 7- AI workflows and 8-Automated workflows.

In the last part, we concluded with contribution of this research and future prediction. The thesis specially focused artistic process of game environment and it presented in a format that is accessible to artists, studios and educators working in video game industry, this thesis filled an important gap in literature and proving a valuable insight for those looking to improve their environment art workflows. Furthermore, this research analyzed approaches and methods used by artists working in game industry, identified efficient practices and strategies for creation of game worlds and aid to advance in game environment art workflows. The presentation on this study could be used to inform best practices and aid new developments in industry. Meanwhile, this study brought a deeper understanding of game art in video game and highlight the importance of art in game development and the needs for a greater focus on creative side of game development. This could lead to a greater appreciation for the role of artists in game development and encourage researchers to study artistic perspectives in game development.

Research topic has bright feature in computer graphics. Finding can be used for related research or an upper education level like PhD project. These projects could be like Workflows Developments and managements various AI implementation projects and AI training projects for environment creation purposes.

SANATSAL SÜRECİN OPTİMİZASYONU: OYUN ENDÜSTRİSİNDE VERİMLİ ÇEVRE OLUŞTURMA İŞ AKIŞLARININ İNCELENMESİ

ÖZET

Araştırmacıların video oyunları özelinde ne zaman çalışmaya başladığı bilinmese de 20 yıllık bir süre içinde 200 milyar dolarlık toplam ekonomik değere ulaşan bir endüstrinin incelenmeye değer görülmesi olağandır. Özellikle 21.yüzyılın ilk yıllarından itibaren hızla gelişen teknoloji ile bilgisayar donanımları ve kapasitesi artmıştır, bu artış beraberinde büyük bütçeli oyun üretimleri getirmiştir. Yaşanan bu gelişmeler aynı zamanda donanım fiyatları üzerinde olumlu görülmüş ve oyun üretimin de oyuncu sayısında da büyük bir artış yaşanmıştır.

Oyun sektöründe yaşanan gelişmeler en nihayetinde akademisyenlerin ve araştırmacıların da ilgisini çekmiş ve konu ile alakalı araştırmalar farklı bakış açıları ile yoğunluk kazanmıştır. Bu araştırmalara bakıldığında zaman teknik konuların ağırlıklı olarak işlendiği ve temelde niye bir araca ihtiyaç duyulduğu üzerinde durulmuştur. Bu muhtemelen bilgisayar bilimlerinin ilk zamanlarda çok karmaşık algılanması ve teknoloji üretmenin onun nasıl çalıştığından daha önemli olduğu fikrine dayalı olarak gelişmiştir.

Oyuncuların gelişen teknoloji ve bütçelerin artması ile oyunlara dair beklentileri artmıştır. Bu beklentiler doğrultusunda yüksek bütçeli ve binlerce tasarımcının, sanatçının ve yazılımcıların çalıştığı oyunlar yapılmıştır. Bu tür oyunların yapımı çok uzun zaman ve yüksek maliyetlere neden olmakla beraber, çalışan insanlar iş akışlarını optimize etmekle bu maliyetleri optimum seviye çekip, yüksek kaliteli oyunlar yapmıştır.

İş akışlarının optimize edilmesi ve veriminin artırılması amacı özellikle oyunlarda ki çevre sanatı kısmına yoğunlaşmıştır. Oyunlar temelde dört farklı disiplinin harmonik çalışması ile oluşturulur. Bunlardan ilki oyun içi mekaniklerin ve kuralların belirlendiği yazılımsal disiplinlerdir. İkincisi oyun içi akışları ve interaktif parçaların tasarlanmasından sorumlu tasarım disiplindir. Üçüncü disiplin ise bu iki disiplin arasında ki koordinasyonu sağlayan ve beraber çalışmasını amaçlayan teknik disiplindir. Sonuncusu ise oyun dünyasında ki yaşamı, hikaye ve anlatımı, önceki üç disiplinin belirlediği sınırlar içerisinde oluşturulmasını sağlayan sanatsal disiplindir. Bu disiplinin iş yükü diğerlerine göre oldukça yüksek olmakla beraber en çok maliyet ve zaman gerektiren süreçtir. Çevre sanatları bu disiplinin en önemli kısmını oluşturur ve üretimi için gerekli iş akışlarının optimize edilmesi her zaman bir ihtiyaç olarak görülmektedir.

Oyunlarda çevre sanatı, hayali dünyanın dijital ortamda oluşturulmuş halini ifade etmektedir. Oyunlarda yaşayan varlıkların yaşadığı alanlar ve çevrenin, mekan ve konum özellikleri, mimari yapının; tarih, kültür ve inançsal değerlerin; iklimsel özelliklerin, zaman ve kavramın beraber işlendiği ve gerçek hayat özelliklerin belirlenen bu koşullar ile tekrar yaratılmasını ele alır. Bu yol ile oyununun, oyuncular

içine çekmesi ve oyuncunun oyunlarda yaşayan varlıklarlar, çevre ile bağ kurmasını amaçlamaktadır. İş akışları ise bir şeyi oluşturmak için kullanılacak, tekrarlanabilir ve yeniden üretilir süreçleri ve bu süreçteki her bir adımı ifade etmektedir. İş akışları, oyunlarda çevre sanatı öğelerinin üretimi için izlenen adımları belirli yöntemlerle optimize etmek, bazı adımları elemek yada yeni adımlar ekleme yöntemiyle, nihai ürünün kalitesini artırma veya üretim maliyetlerini düşürmeyi hedefler.

Bu çalışma oyun üretiminde ciddi iş yüküne sahip çevre sanatlarının oluşturulmasında kullanılan iş akışlarının incelenmesi ve nihayetinde planlanması, oluşturulması veya geliştirilmesi için izlenen metotların incelenmesini ele almaktadır. Bu iş akışlarının incelenmesi ile uygulanabilir etkili yöntemler bulma ve çeşitli stratejiler oluşturma vede bu bulguları sanatçıların, eğitimcilerin veya bu konuda kendisini geliştirmek isteyenlerin ulaşabileceği formatta sunulması amaçlanmıştır.

Çalışma kapsamında yöntem olarak güdümlü teori yöntemi kullanılmıştır. Bu yöntem, az sayıda literatür kaynağı bulunan araştırma konularında, edinilen gerçek zamanlı verilerden yola çıkarak yeni çıkarımlar oluşturmada oldukça etkili olmasından ötürü seçilmiştir. Bu kapsamda nihai literatür araştırmasından sonra 3 adet çalışma yapılmıştır, bunlar literatürün geçerliliğini kontrol eden birincil çalışma, bu kontrol sonucu oluşan verinin uygulanabilir yönünü inceleyen deneysel çalışma ve son olarak bu iki veriden yola çıkılarak oluşturulmuş olan yarı yapılandırılmış anket çalışması. Her bir çalışma birincil veri seti, deneysel veri seti, ve yarı yapılandırılmış röportajdan elde edilen ana veri olmak üzere 3 adet veri çıkartılmıştır, bu veriler nihai ana çalışmada kullanılmıştır.

Çevre sanatları konusu doğası gereği oldukça hızlı gelişen bir alandır. Bu alana ait veriler hızlı bir şekilde eskir. Alana ait bilgiler bazı durumlarda yeni metodlarla kısmen değiştirilir, bazı durumlarda ise tamamiyle kullanımdan kalkar. Kullanımdan kalkmış veya değiştirilmiş iş akışları veya metodlarının incelenmesi araştırma hedeflerimiz için uygun bulunmamıştır. Bu doğrultuda literatürün güncel kısmını belirleyebilecek ve eskimiş, değiştirilmiş yada kullanılmayan yöntemleri süzmek için birincil bir çalışma yapılması amaçlanmıştır. Bu çalışma yakın zamanlı literature odaklanmıştır. Bu çalışma kapsamında özellikle 2 boyutlu geleneksel çalışma yöntemleri, manuel çalışma yöntemleri, çok fazla zaman alan yöntemlerin ve bunlara ait metodların artık kullanılmadığı benzer şekilde algoritma, parametre tabanlı, yapay zeka merkezli yöntemlerin veya metodların bir trend kazandığı anlaşılmıştır. Bu çalışma sonucunda özellikle yapay zekanın alana entegrasyonu için yapılan ilk denemelere ulaşılmıştır. Bu denemeler özellikle planlama, dökümantasyon vede 2 boyutlu görseller oluşturulmasını kapsadığı görülmüştür.

Konunun dinamik olmasının getirdiği başka bir problem daha bulunmaktadır. Literatür çalışmasında bulunan ve birincil çalışma ile güncelliği onaylanmış bazı metodların teorik altyapısının bulunmasına rağmen uygulama ve pratik altyapısının bulunmama durumu mevcuttur. Bu sorunun kontrolü için bu çalışma kapsamın gerçek bir çevre sanatları projesi hazırlanmış, birincil çalışmada elde edilen bilgilerin; yöntem, araç ve uygulama açısından uygulanabilirliği anlaşılmak istenmiştir. Bu çalışma sonunda çeşitli veriler elde edilmiştir. Modüler, prosedürel veya parametrik iş akışlarının uygulanabilir bir yöntem, öğrenme kaynaklarına, araçlara ve kullanıma sahipken, özellikle yapay zeka ile ilişkili iş akışlarının bir takım kısıtlamalar içerdiği ve bu alanda daha fazla tanımlama, araç geliştirme, öğrenme materyalleri oluşturma vede en önemlisi telif hakları ile ilgili çalışmaların yapılması gerektiği görülmüştür. Bu çalışma aynı zamanda birincil çalışmada elde edilen bilgilerin uygulama alanları açısından bir örneklem oluşturmuş ve tartışılan yöntemleri etkinlikleri hakkında

fikir edinilmesini sağlamıştır. Benzer şekilde yapay zeka ile ilgili mevcut metodların veya görsel çıktılarının, oyunlarda çevre sanatları için kullanılmasının uygun olmadığı sonucuna varılmış fakat özellikle planlama, dökümantasyon aşamalarında etkili olduğu anlaşılmış, gelecekte alanın önemli bir parçası olacağı sonucuna varılmıştır.

Birincil çalışma ve deneysel çalışma sonucunda oluşturulan birincil ve deneysel veriler ana çalışmanın oluşturulması için kullanılmıştır. Bu doğrultuda, araştırma sorularını da göz önünde bulundurarak en az 4 alan uzmanı ile yarı yapılandırılmış anket yapılmıştır. Bu ankette kullanılan sorular, önceki iki araştırma baz alınarak hazırlanmıştır. Bu çalışma kapsamında orta çıkan nihai yarı yapılandırılmış veri, birincil veri ve deneysel veri ile ana çalışmada kullanılmıştır.

Tez kapsamında oluşturulan ana çalışma, çalışmanın hedeflerinin ve süreç ile ilgili çeşitli tanımlamalar ile başlamıştır. Bu tanımlamalar, katılımcı kriterleri, ve katılımcı bulma yöntemleri ile etik araştırmaya yöntemleri için yapılan çalışmaya ait bilgilere yer verilmiştir. Yarı yapılandırılmış anketin bir veri toplama aracı olarak kurulması ve üç aşamalı veri analiz yöntemleri hakkında bilgiler sağlanmıştır. Çalışmanın bu kısmı anket sorularının hazırlanması ile devam etmiştir.

Tezin ana omurgasında toplam 3 adet çalışma ve 3 adet veri seti kullanılmıştır. Bu veriler açık kodlama, çapraz kodlama, seçici kodlama ve teorik örnekleme gibi güdümlü teori analiz yöntemleri ile analiz edilmiştir. Bu analizde karşılaştırma, benzerlik ve farklılıklara göre gruplandırma, veya kategorize etme gibi yöntemlerle, benzer veya ana başlıklara toplama, bu grupları ve başlıkları çaprazlama ile farklılıklarını bulma gibi metotlar ile niha analiz tamamlanmıştır. Her üç veri setinden elde edilen bilgiler de güdümlü teori kullanılmış ve benzer analize tabi tutulmuştur. Bu analizler ve nihai teorik örneklendirme sonucunda çeşitli teoriler üretilmiş ve çalışmanın bu kısmı bulunan teorilerin sunulması ile sonlanmıştır. Bu analizler çerçevesinde elde edilen teori başlıkları şöyledir, 1- Temel iş akışı, 2-Araçlar ve bunlar arasındaki uyum, 3-Prototip yapmanın önemi 4-Geri dönüt sistemleri ve takım çalışmaları, 5-Planlama aşamasının önemi, 6-Sanatçının rolü, 7- Yapay zeka iş akışları, 8- Otomatik iş akışları.

Bu tez çalışmasının son aşamasında, çalışmanın literature, topluma katkıları hakkında tartışmalar ve tezin devamı olabilecek proje çalışmaları, alan hakkında geleceğe dair fikirler yürütülmüştür, konuya dair literature çalışması ve bu literaturin geçerliliğini araştıran birincil çalışma, literatürün güncel durumunu özetlemiştir. Uygulama çalışması hem alana ait bilgilerin pratiğe dökülmesi hemde bir örnek proje olmasından ötürü literature katkı sağlamıştır. Ana çalışma ile beraber, araştırılan ve uygulaması yapılan proje ile sanatçıların, stüdyoların ve eğitimcilerin takip edebileceği yol gösterici bir belge hazırlanmıştır. Eklerde çalışmada üretilen kapsamlı bir ders programı eğitimcilerin referans almaları için hazırlanmıştır. Bu tez çalışması video oyunları geliştirilmesinin önemli bir parçası olan çevre sanatlarında kullanılan iş akışlarının, anlaşılmasını ve bu iş akışlarının planlanması, kullanılması veya geliştirilmesi için izlenen yöntemlerin belirlenmesi, bu iş akışlarının geçmişten günümüze yaşadığı değişimleri, geleceğe dair muhtemel yönleri vede bu değişimde sanatçının rolünü araştırmıştır. Elde edilen nihai belgenin bu alanda çalışmalar yürüten sanatçıların, eğitimcilerin ve sanat stüdyolarının kullanabileceği bir formatta sunulması amaçlanmıştır. Bu çalışma sonucunda elde edilen bilgiler gelecekteki tartışmalar için bir referans oluşturmuş ve literatürdeki kaynak çeşitliliğine ekleme yapmıştır. Çalışma alanı hakkında teorik ve pratik bilgiler üretmiştir. Bu belge alana olan ilginin ve önemim anlaşılması ve bu alan için daha fazla çalışma ihtiyacı gibi sonuçlarla, araştırmacıların bu alanı ele almaları için cesaretlendirmeye çalışmaktadır.



1. INTRODUCTION

Video games are highly popular of entertainment, advancement of technology and hardware improvements enable more experience for players and now expectation for immersive experiences higher than ever. Developing such demanding video games is no easy task. The process involves of numerous discipline work together counting programming, technical, designing and art. Each of these processes are complex and time consuming which oblige efficient planning and well-organized workflows. This need for practicality is mirrored to environment art realm where artists and designers are tasked to creating virtual worlds that all digital stories drive. Game environment art, in particular, plays a crucial role in creation of video games, it encompasses all visual elements that make up the game world, from small props to large landscape elements and essential in conveying game story to create compelling experience for players. However, the creation of game environment art is a complex and time-consuming process that require a well-organized workflow to avoid costs and time while also reach desired quality.

Environment art workflows refer to process and steps involved to creation of art while maintaining a well-organized and optimal pipeline. Workflow's usage, improvement and development is essential for artist to create environment art and bring game world to life. To achieve this, artists, studios, educators constantly exploring and adopting various workflows, techniques and strategies to optimize their creation process, reduce production cost and achieve overall high quality that match player expectations. A well organized and optimized workflows can result high quality game environments in video games. Effective workflows in game development help to minimize inefficiency and reduce production cost which leading to an overall improvement in game quality. In addition, these workflows highlight the importance of streamlined methods in game development, as it helps to leading faster delivery of high-quality work in various steps. However, while significant body of studies on technical or programming side of workflows, there has been relatively fewer research on artistic perspective of game environment art workflows. In order to fill the gaps in the literature regarding game environment art workflows, this thesis aims to analyze the approach and methods used

by game environment artists and question underlying workflows in creating engaging game environments. The aim is to understanding the use, improvement and development of workflows and to identify efficient practices and strategies for creating game environments for video games while also explore the evolution of workflows from the past to the future.

1.1 Purpose of Thesis

The purpose of this thesis is to understand how game environment art workflows are being used, improved, and developed by artists with a focus on well-organized, optimized and high-quality work to create narratives that enhance player experience. By analyzing approaches and methods used by artists, this study identifying efficient practices and strategies for the creation of video game environment arts. The final purpose of this thesis is presenting finding in a format that is accessible to artists, studios, and educators working in the video game industry whom aims to implement these practices and strategies into their environment art production pipeline.

This study will involve a literature review to understand the history and evolution of workflows and environment art in current time, as well as previous studies made. While there are many examples in the literature emphasizes the technical and programming aspects of production, there are fewer studies that examine the artistic aspects of environment art workflows (Figure 1.1). Thus, this thesis aims to fill gaps in the literature by creating a survey with minimum of 4 artists to gain their workflows and techniques for environment art in video games.

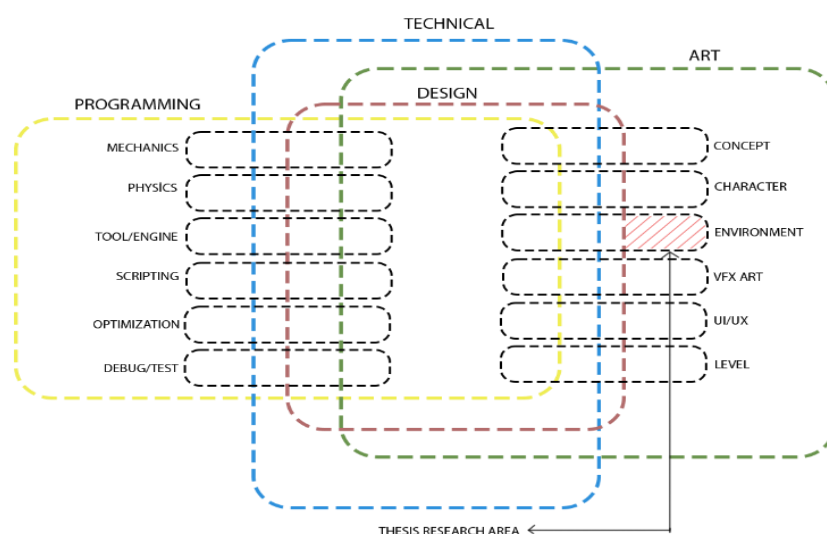


Figure 1.1 : Thesis research area.

Overall, the main purpose of this study has deeper understanding of game environment art workflows and how they can be used, created or developed. By questioning the approaches and methods used by artists and identifying strategies for creating immersive environments. This thesis aims to help artists, studios and educators to optimize their workflows to achieve desired results in any medium. Unlike many studies made for technical and programming side of environment art workflows, this study will address a gap in literature by focusing on artistic perspective of environment art production.

1.2 Significance of the Thesis

This thesis is significant for number of reasons. First, it is one of very few studies specially focused artistic side of game development and it presented in a format that is accessible to artists, studios and educators working in video game industry, this thesis filling an important gap in literature and proving valuable insights for those looking to improve their environment art workflows. Second, this research analyzing approaches and methods used by artists working in game industry, identify efficient practices and strategies for creation of game worlds, aid to advance in game environment art workflows and provide practices for how to use, how to create and how to improve a workflow for game environment art. The presentation on this study could be used to inform best practices and aid new developments in industry. The last reason, this study brings a deeper understanding of game art in video game and highlight the importance of art in game development and the needs for a greater focus on creative side of game development. This could lead to a greater appreciation for the role of artists in game development and encourage research to study artistic perspectives in game development.

1.3 Limitations and Scope of Study

While this study understands how game environment art workflows are being used, improved, and developed by artists, there were some limitations. The research only focuses artistic side of environment art and workflows whereas intentionally leave technical and programming side for future researches. The research mostly focuses three-dimensional(3D) video game environment and workflows and last 30 years of development, meaning 2D workflows and techniques from 1960s were not included.

Although we planned to make the survey with at least 4 industry artists, the sample size may be small to capture full range of approaches and workflows. A larger sample size may be needed to have a more comprehensive understating to the topic. Additionally, there might be a risk of bias in sample selections, as well as in information gathered through interview. Experts may only provide information aligns to their own perspective and experience which is a potential viewpoint limitation. Finally, game industry grows fast and evolving constantly, methods and approaches used by artist might impacted by new technologies and tools.

Therefore, gathered information's might be outdated for particularly new tools and techniques. The scope of this research applied only specific genre of games (3D games) and time frame for this study was last 30 years. 3D games represent a significant relevant of the video games and with heavy workflows and demanding requirements which require high level experience and skill expertise from environment art (Vaccaro, 2023). These genres suited our purpose to study deep understanding game environment art workflows. Additionally, the last 30 years of game development have seen significant technological advancements and have impactful improvements in game environment creation, which make this time frame relevant and important period to study.

1.4 Research Questions

In our focuses on understanding, improving, and developing art creation methods and workflow by studying current literature and interviewing artists in the industry. We want to understand efficient workflows, develop and apply new methods to improve the environment art creation pipeline in terms of cost, time, quality, and efficiency.

This thesis focuses on the following questions:

- **Research Question 1:** What are current workflows in the context of game environment art?
- **Research Question 2:** What are strategies for artists to plan, change, improve, or develop workflows for production needs?
- **Research Question 3:** How have workflows evolved and specialized for modern video game environments and what is the role of artist in this evolution?

1.5 Methodology

This thesis used Grounded Theory as its research methodology. This method has been used in many fields including sociology, psychology and business and has become very effective for its ability to generate new insight and theories that based on real world data. Grounded research or Grounded Theory is a qualitative research system created in the 1960s by Barney Glaser and Anselm Strauss (Glaser, B. G., & Strauss, A. L. , 1967).

The process involves of constructing ideas or conceptions based on the evidence itself, rather than pre-existing beliefs or assumptions (Strauss, Anselm, Juliet Corbin, 1998) Ground theory involves several steps including collecting data and organizing into categories, analyzing the data, coding and theoretical resampling (Charmaz, 2014). During data collection stage, research gathers as much as data for interested topic. Then this data is organized to make a reliable analyzing process. During analyze phase research goes through the data and identifies key concepts that emerge from the data. These concepts can be refined and revised any time in research period. Research needs to make detailed notes for each category and create memos for potential connection points. The last step of this technique is theoretical sampling the data and understand which sections need further explorations and additional data to fill any gaps or address and discrepancies. (Mill, Bonner&, Francis, 2006).

Environment art in video games is a mixture of different skillset and technical abilities (Gard, 2023). Artists in this field are responsible for creating visual elements of game world, including structures, vegetations, terrain systems and other environmental features which require both artistic and technical skillsets such as modeling, texturing, lighting and composition (Mehrafrooz, 2023). This process require a well-organized workflow that allow different artist work simultaneously. Therefore, making research about this field was highly complex which was our first reason to go with grounded method. The second reason was there were many examples in the literature of the technical and programming aspects of this field, but there were fewer studies that examine the artistic aspects of game environment art workflows. Thus, ground research method used since this method suitable for studies that has fewer existed resources.

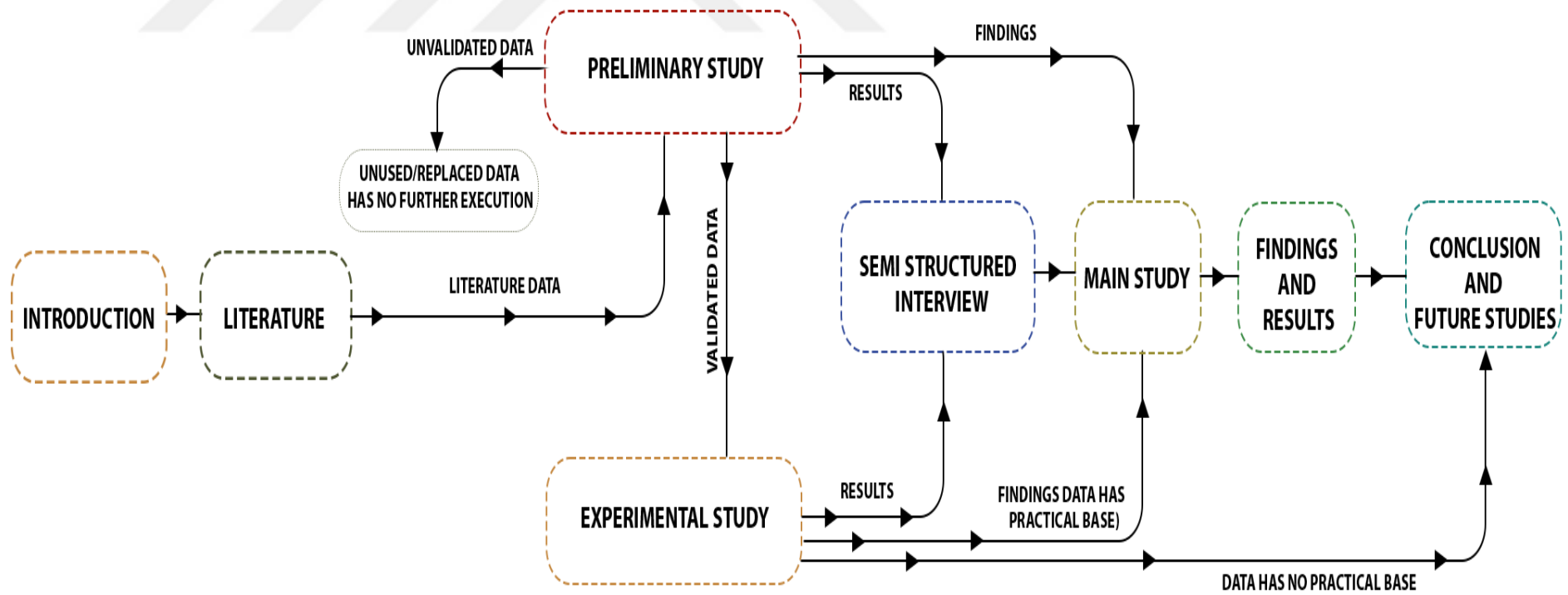
Based on research methodology total of three study type were prepared. Preliminary study, experimental study and main study. Preliminary study created to validate literature finding and observations by only focusing recent literature, as the research topic is extremely dynamic, there was a need to ensure which part of literature being replaced or obsoleted. Preliminary study focused to environment art creation stages since all workflows mainly refers a need, to refine, change, improve one or more environment art creation stage. Therefore, any changes or improvement on art creation stages will dictate workflow itself. This study further defined recent literature while also provided detailed explanation of each stage, methods and strategies available in literature. However, not all these methods or strategies has a practical base. Therefore, an additional experimental study was needed. Experimental study and preliminary study were made simultaneously. Meanwhile, after each preliminary study chapter a practical study prepared. Preliminary study created a base for current workflows while experimental study conducts practical base for each of this.

Data generated with these studies were used for semi structured interview framework, this interview included total 8 questions prepared from preliminary data and experimental data sets. The interview process took roughly 30-40 minutes each and were conducted with total 4 participants. Data collected with voice recording and interpolated into text. Semi structure interview created third and last data set. This data and was analyzed and organized into categories, grouped and theatrically resampling based on research questions.

Semi structured data set, preliminary and experimental study results were used in main study. The end result of research has obtained various transcription result like 1-Base workflows, 2-Tools and compatibility, 3-Prototyping, 4-Feedback and collaboration, 5-Importance of planning stage, 6- Artist role, 7- AI workflows, 8-Automated workflows,

Based on these end result finding research has been concluded while data that has unpractical usage from experimental study were added to main study findings and results, particularly for future predictions and studies. Figure 1.2 shows methodology frameworks (Figure 1.2).

METHODOLOGY FRAMEWORK



▲ EXECUTION DIRECTION

Figure 1.2 : Methodology Framework.



2. LITERATURE OVERVIEW

Over the past decades, video game industry has been gained considerable advancements which resulted in an increasing emphasis on visual aesthetic of video game (Battie, 2022). As a result of demanding high-quality visuals in game, workflows behind engaging game art become an integral part of game development (Chopine, A. 2011). The growth was not only meant to be in technical and programming but also in terms of creativity and artistry, this growth particularly applied to game environment arts. Game environments are referring to gameplay areas or game world that any action happened. It including all individual elements such as structures, vegetation, landscape or any other environmental features that contribute overall immersive experience for players. The creation of game worlds has been driven by the continuous improvement of workflows and approaches. These workflows have played critical role of growth of game environments, allowing more complex and detailed environments to be create with greater efficiency (Brathwaite & Schreiber, 2009).

This literature overview examines history and evolution of game environment art and workflows. Identify key developments and advancements that change the game. Through a comprehensive review of existing studies, we aimed to explore and identify current workflows and practices for optimizing game environment art workflows and creation of environment art.

The review has begun with definition of environment art and its importance in game development. Literature overview continued with environment art creation stages in games which refers to the series of steps involved into creation of visual elements and make up of game world. The overview continued with current workflows used for environment creation process in video games. Workflows are repetitive and reusable steps to create or manage a process. In the context of video game environment, workflows are reusable series of steps to create game environments.

This literature continued with early examples of environment art in games, providing insights about development and quality improvements throughout history. Following

with trends for environment art in game development, the literature overview ended with previous works made for the research topic, and limitations of this study.

2.1 Environment Art

Game creation is consisting of four main disciplines. The first discipline is programming where developers create codes and blueprints to drive gameplay and mechanics like elements. The second discipline is design where designers craft gameplay and create room for interactions and mechanics that fit expected player experience. The third discipline is technical art and design where first two disciplines connect in a way to make overall gameplay, mechanics, player experience and interactions flow as expected. The fourth discipline is art which is visual representation of all other disciplines on top of story and narrative that pull the player into game world. Art in video games involves of concept art, prop art, lighting art and more. Environment art can be defined as combination of these art disciplines. Environments are visual creation of digital world where player interact with game world

(Vaccaro, 2022). Each environment is a synthesis of location, culture, history, theme, lifestyle and atmosphere like elements' and can reveal questions like where gameplay located, who lives there and how they live, what is their culture and lifestyle or what happened there (Figure 2.1). Whether exploring the winding streets of medieval city, adorned Gothic cathedrals or busting markets travelling the arid expanse of a post-apocalyptic wasteland, where the remaining civilization are slowly being reclaimed by overgrown nature.



Figure 2.1 :Environment art in video games (url-1).

Architecture is essential part of environment art. It reflects the ingenuity and aesthetic sensibilities of each culture and people lived or lives there (Garth, 2021), from the ornate palaces of fantasy kingdoms to the wooded structures of imperial palaces (Figure 2.2). Futuristic skyscrapers of science fiction metropolises or a civilization of unknow time within a distant planet. Architecture offers insights about non-player characters (NPC) values, believes, their power and whensoever structure in game environment art tells a story and hinting values, traditions (Vaccaro, 2023).



Figure 2.2 : Assassin's Creed architecture and location (url-2&3).

Location is yet another aspect that artists need to consider while creating a game environment art. Location sets the stage for unfolding narrative, whether it is sprawling in a dense forest or an inhabitant alien planet where player has to use special suits and powerful ships. Each location offers unique narratives, interactions and story that shapes player journey within game environment. Assassin's Creed is one of the most famous video games strongly connected to architecture and location, player can explore iconic landmarks such as Colosseum in Roma, Hagia Sophia in Istanbul or Giza pyramids (Benjamin Hall , Thierry Dansereau, 2022).

Culture and lifestyle influence game environment visual and thematic elements such as costumes, traditions, believes, social dynamics of NPC' and artists have to consider these parts during creation. These elements strongly connected to architecture, history, time period and location (Macdonald, 2022). Whether drawing inspiration from a historical time period while diverse culture occurs and people with different identity live peacefully or a speculative futuristic period where player explore different creatures with unique lifestyle and culture. These two elements influence social dynamics and daily activities. Player may encounter NPCs life and daily routines such

as working, socializing or engaging religious activities. Culture and lifestyle allow player to understand how NPCs shape their world and life (Figure 2.3). Therefore, artists have to properly plan such elements in a game environment art (Andersen, 2022).



Figure 2.3 :Witcher Game, Culture, lifestyle, social dynamics (url-4).

History and time period are another question that have to be answered in environment art. From ancient civilizations to modern world, history provide a framework for narrative, story and help player understand social dynamics, conflicts and behaviors of NPCs. Time period, similar to history, is an element artist uses while creating a game environment. A game environment may set ancient time period or a far future time. Time greatly effects technological advancements. Therefore, it defines human made activities such as tools, architectural structures and overall game world conditions.

Theme in video game environment serve as underly concepts or message that give the depth to narrative and story. It can also refer to center idea in video games. Themes are crucial for game environment and artists have to plan this element carefully. Themes can encompass a wide range of topic from social issues to struggles or non-existential problems, opposite or similar ideas. Bioshock (2KGames, 2007) game has morality of free will theme while Last of Us (NaughtyDog, 2013) has survival and sacrifice theme (Figure 2.4). All environmental elements must match theme and main idea as they are very important for players to understand game world. Therefore, artists have to work based on planned theme.



Figure 2.4 :Theme in game environments (url-5&6).

Atmosphere in game environment refers to overall mood, tone and ambiance in game world. It is a collective feeling that evoked by various visual elements (Ribeiro, et al 2020). Environment artists use colors, light in artworks to convey different emotions. For instance, a dark and grayish color with dim light can evoke foreboding in a horror game while colors like orange or yellow evoke more cherish and calm emotions (Figure 2.5). Atmosphere is important for artist to transfer story emotions to player.

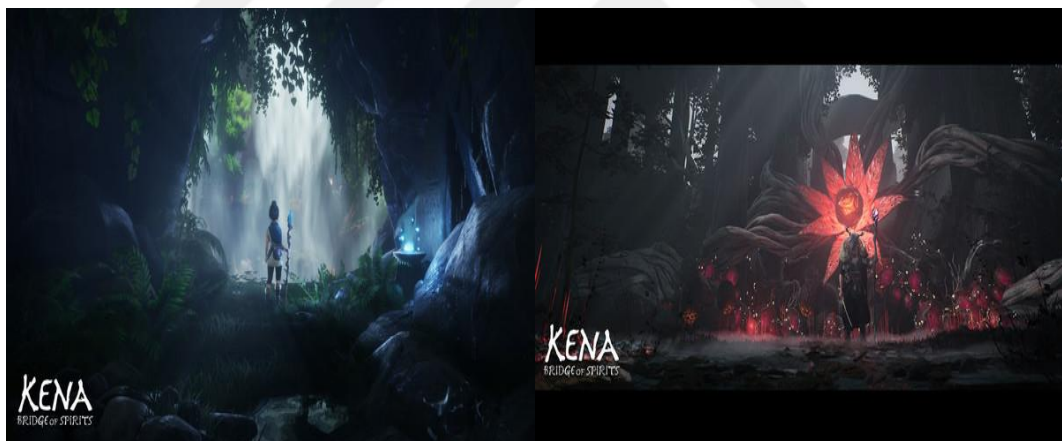


Figure 2.5 :Atmosphere reveal mood and overall tone (url-7).

Physical conditions like time of day, seasons and climate are elements of game environment art. Environment artists needs to carefully plan what kind of physical conditions environment has. These types of conditions effect environment flora and fauna which connect to gameplay and interactions. Environment may have desert conditions where plant life is limited (Zegal & Mateas, 2010). Therefore, player may experience a survival gameplay conditions where resources are limited. Time of day, seasons, climate dictate overall environment visual and player experience (Vaccaro, 2023).

Overall, environments are virtual worlds created for gameplay, interactions and story. Each environment is a synthesis of location, culture, history, theme, lifestyle and atmosphere like elements. These are elements push the player into game world and help them understand game world setting and conditions (Worch & Smith, 2010). A good example for elements of game environment are visible in Last of Us (Naughty dog, 2013) video game. Last of Us environment represent itself as a post- apocalyptic setting, telling game story through the remnants of civilization and nature reclaiming cities and all human creations. Throughout environmental exploring, player uncover backstory of game world and start to piecing together the events that led to downfall of human kind.

Ruined structures, overgrown streets, facades and makeshift settlements unfold the story and history of game world. The tone, colors and atmosphere evoking feeling of desperation and isolation (Figure 2.6). Elements of environment art are important for artists to evaluate even before starting any environment art creations. An environment artist creation workflow will be determined by these elements of environment art (Maxinow A, 2023).



Figure 2.6 :Last of us game environment, color and atmosphere evoking feeling of desperation and isolation (URL-8).

2.2 Environments Art Stages

Game environment art stages refer to the series of steps involved into creation of visual elements and make up of game world of a game. These stages may vary for each environment and project but generally include initial planning and referencing of

environment, concept art and Blackout, asset creation phase, texturing, lighting and final composition, below figure shows each environment art stages (Figure 2.7).

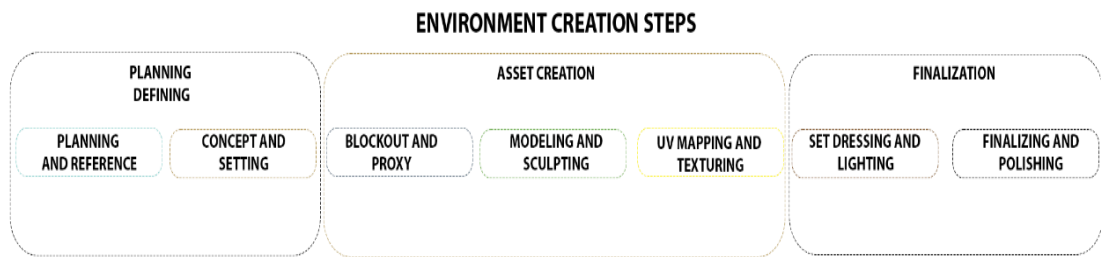


Figure 2.7 :Environment art stages.

A typical environment begins with planning and reference phase, in this stage, artist make necessary planning and art direction about environment. These initial plans range from deciding setting, time, culture in environment and follows reference planning. In reference gathering phase artist uses various resources such as books, websites and photographs for visual and text-based references. This stage generally finishes by making rough sketches and mood boards (Vaccaro, 2023).

After planning and reference phase, artist create concept arts which establish overall look and feel of environment art. Concept art typically created by concept artists and environment artists mainly cooperate closely with concept artist in this stage. This stage over with materials that inform deign of environment art which guide artist till to final production (Ghez, 2016)

Blackout stage is another stage of environment art workflow. In blackout stage artists uses basic objects to create a foundation of final artwork which has critical importance in terms of general size, silhouette and scale of environment. Environment artist typically collaborate with level artist to make sure environment supports narrative and gameplay mechanics. After this stage artist move to asset creation stage.

Asset creation stage is one of the most intense stages in environment art and even in whole game development. This stage is the critical stage where all environmental elements being created. These element including buildings, props, vehicles, foliage and more. Asset creation stage involves of specialized modeling tools and sculpting tools for further details. This stage can be time consuming and involve high degree of technical and artistic skills (Desamsetti, 2019).

Once 3D models are created, environment artist requires to make U and V Axes or Coordinates in Modeling Space (UV) maps which is an unfolded version of 3D model

surface. This stage is called texturing and materials phase in 3D art context. This step requires for texturing and other surface features for 3D models. In this stage of workflows environment artist may collaborate with other team such as character team and prop teams in order to ensure the final assets are consistent with overall visual direction of game. Asset creation stage continue with lighting stage where environment artist cooperates with art directors, level artist and lighting artist to ensure artwork has overall desired mood, atmosphere and visual style. After lighting stage, environment artist needs to pass next stage which is set dressing. This stage is very essential for narrative and environment story. In this stage artist finalize asset creations and place them in game world. This is stage is where artist tweaking assets, textures, lights and balancing for all environmental element to make the environment alive and immersive. Set dressing stage include various steps like placing assets, vegetation, architectural elements and story elements while also checking collisions and level flow. The end result of this stage creates an overall environment that looks cohesive and composited to support story, narrative, player movements and overall gameplay.

Optimization is also a stage of environment art workflows but this stage is active whole production time. For example, in asset creation stage artist needs to optimize triangle and vertex count in order to have desired frame rate in game (Ahearn L. , 2017). Likewise, in lighting stage, number of lights and their features such as being dynamic light effect performance, therefore artist needs to trade between performance and desired looking to ensure high quality environment without any performance issue in running.

In a typical environment art workflow after optimization artist may need to turn back specific stage to solve any optimization problem. In an effective workflow, minimizing the need for back and forth is important, as it can help save time and ensure project stays on schedule. This can be achieving by anticipating potential performance issue during planning stage and building whole environment with optimization in mind form.

2.3 Workflows

Workflow as a term means a repeatable pattern or series of steps to produce an activity. Workflows in game context means the sequence of steps from initial planning and concepting to final game creation process. The purpose of a workflow provides a

repeatable process from beginning to end; therefore, the process can apply to multiple projects in multiple time frame. It is essential to note that while environment art creation involves steps to the medium or underlying technology, these steps are distinct to be considered as a workflow or a base. Conversely, a workflow in environment art means an optimized or refined variations of art creation steps. Therefore, the creation of an workflows mainly refers to a need, to refine one or more steps to possibly reduce time, cost or increase art quality. Overall, a workflow mainly targets to one or more areas in environment art creation stage, and by changing, improving or implementing new methods to stage, each workflow aims to create expected results such as shorter creation time, higher quality or cost efficient. For example, traditional workflows are mainly targets to modeling-sculpting and texturing stage. By adding low poly-high poly methods to modeling and normal map detail transferring in texturing, this workflow expecting high quality results with performance unaffected. Each workflow in environment art follows similar target- result relationship.

- **Traditional workflow:** The fundamentals of traditional workflows was introduced by Levoy and Krishnamurthy in 1996 (Krishnamurthy & Levoy, 1996). The most known workflow is called traditional workflows where all environment art creation steps follow each other in order. This workflow mainly created for optimization and quality needs. The process in traditional workflow is tend to be manual and time consuming. The process is following with model creation and detail transformation. This workflow mainly focusses on modeling and texturing steps (Figure 2.8).

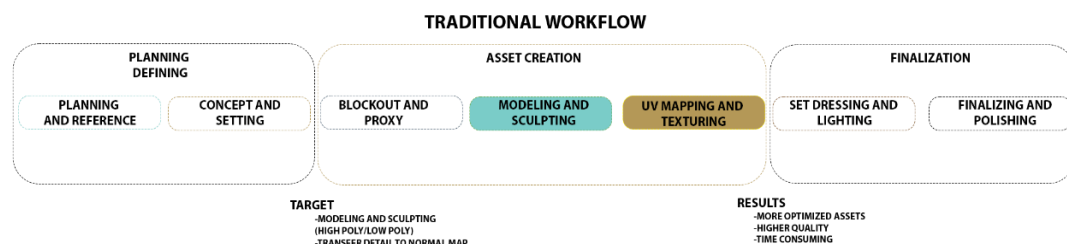


Figure 2.8 :Traditional Workflow.

- **Modular workflow:** Modular workflow is a logical workflow that refers to pre-designed, reusable modules or assets. The workflows bring a huge impact in performance and optimization because instance usage has less impact in GPU and memory stats (Ahearn L. , 2017).

This workflow target to final set dressing and final asset usage but it is required to be planned in planning stage. A typical example of this workflow can be found in architectural element-based environments. The modules consist of walls, floors and doors like architectural elements that can be combined or arranged into different combinations (Figure 2.9).

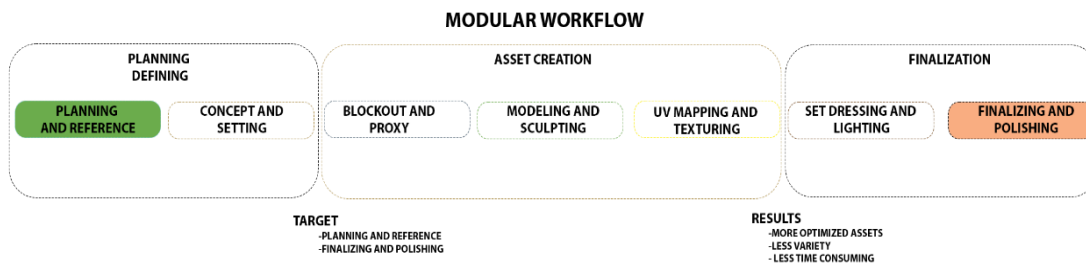


Figure 2.9 :Modular Workflow.

- **Procedural workflow:** Procedural workflows or Procedural Content Generation (PCG) refers to a creation logic that various assets are generated algorithmically rather than being created manually. In the workflows, artists define rules and parameters to control generation content (Shaker, 2016).

This workflow made important impacts to accelerate environment creation time and allow artists create multiple variations of levels, terrains, textures, characters and more. The system randomizes each parameter to generate content dynamically which allows artist to have potentially infinite number of content and reducing the need for manual content creation (Figure 2.10).

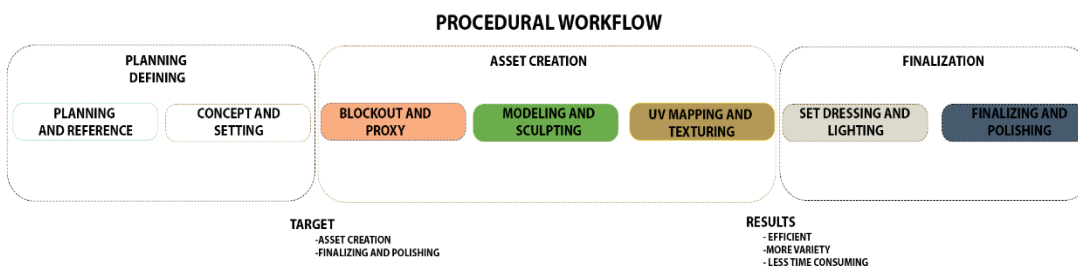


Figure 2.10 :Procedural Workflow.

- **PBR (Physically Based Rendering):** PBR workflow is another workflow mainly target to realistic lighting interactions (Kelly H. , 2021). The workflows use various textures such as surface roughness, metalness or refraction to define how light interact with surface. This workflow allow artist to simulate real-world light conditions in an accurate way. Therefore, the workflow creates more convincing visual representations in 3D rendering and game environment (Figure 2.11).

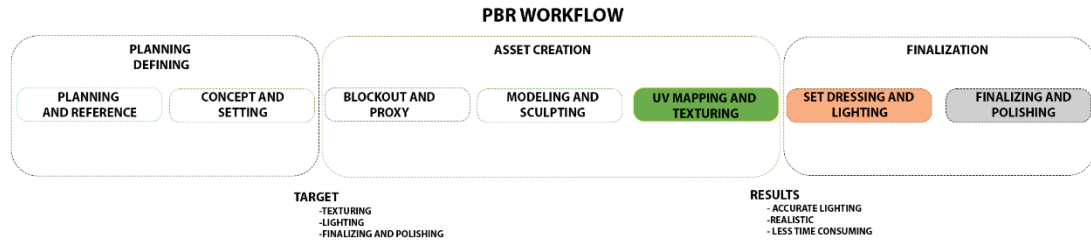


Figure 2.11 :PBR Workflow.

- Photogrammetry workflow:** Photogrammetry is a technique that eliminate entire asset creation stage with generating 3D assets and environmental elements from real world objects. This workflow resulting accurate 3D models or textures with high quality in less time and effort (Linder, 2009).The technique involves into several steps. The first step is taking photograph of real-world objects. These can be anything from a stone to large building. After taking enough photograph artists delve into color correction and exposure balancing. This is important for scan software's to match each image. After that artist creates cloud points and meshes, textures for game environment art. This workflow obligates additional equipment's and cleanup process but create accurate and realistic results in shorter amount of time. The workflow has been used in many realistic games including Battlefield video game (Figure 2.12).

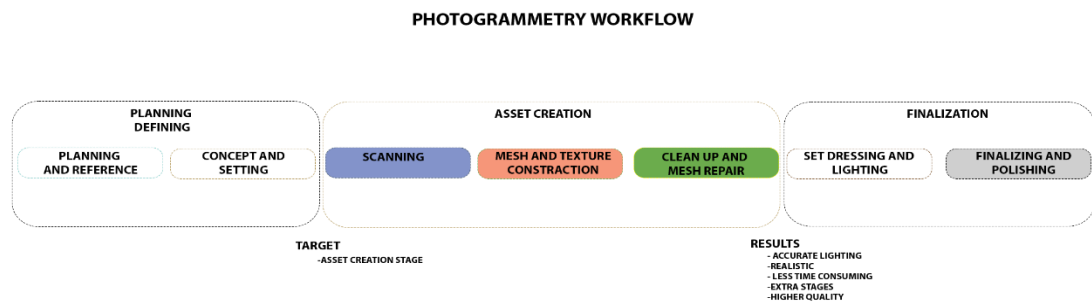


Figure 2.12 : Photogrammetry Workflow, eliminate some stages and add new ones.

- Asset library workflow:** The asset library workflow is a structured approach used in environment art workflows. The purpose of this workflows is managing and utilizing a repository of reusable assets. This is workflows followed by mainly studios rather than individual artists. In these workflows, artists or studio create a database for each asset they created and use them in other levels within same project. This way overall game looking match and allow artists to create a cohesive

looking for all levels of a game. This workflow may allow studios use same assets in different projects too.

Therefore, instead of remaking each similar assets artist can use premade assets and use remaining time for further creativity and polishing game world. It is important to note that this workflow does not include any new asset creation stage rather than document each asset to use in future (Figure 2.13). With this workflow artists and studios are able to eliminate entire asset creation process and quickly pass thought set dressing stage

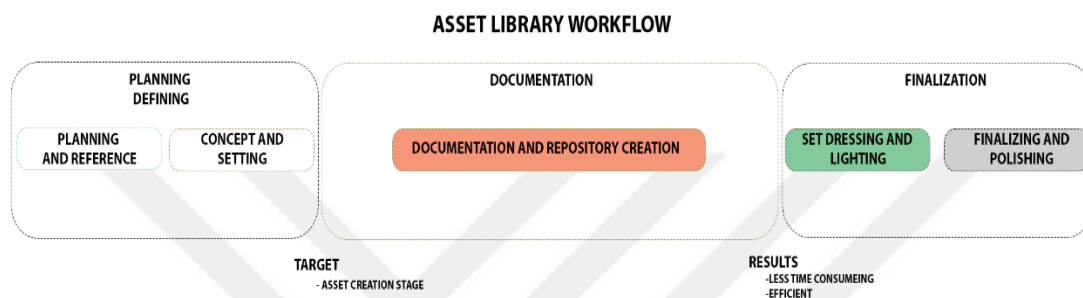


Figure 2.13 :Asset Library Workflow.

2.4 Milestone Examples of Environment Art

Game environment art has a rich history that has evolved alongside maturation of video game industry. However, within this rich history there are pivotal moments both shaped environments and workflows to create them. These pivotal moments are significant advancements, innovations and groundbreaking ideas altering industry to new directions. Introduction of two-dimensional games was one of these pivotal moments. Early 2D games characterized by simple, two-dimensional images that limited to processing and computing power of computers and consoles (Jesper Jull, 2010). The earliest examples are games like Space Invaders (1978) and Pacman (1980) has basic game environments (Figure 2.14) with two-dimensional wall, corridors and characters as visual part of environment (Moses, 2023). As graphic capacities and computing power increased, amount of interactivity and realism increased. Doom (Id Software, 1993) is of the most important example of better interactivity and realism. This development later on lead even more complex and realistic and projects such as Super Mario (Nintendo, 1996) and The Legend of Zelda (Nintendo, 1998). Open world games like Quake were very first projects for large gameplay areas, these projects led todays highly interactive and large open world games such as Battlefield 1 (2016) and Witcher (2018). These types of milestones are developments where game industry and

game environments made tremendous improvements in terms of interactivity, realism and complexity.



Figure 2.14 :Earliest game environment examples, Space Invaders and Pac-Man (url-9&10).

The second pivotal moment that greatly effect game environments is the translation from 2D to 3D graphics. As graphic capacities and computing power increased, game environment become more complex and realistic, the paradigm shift whole development process while also open up new avenues for game environment art. One of the most important examples was the release of Doom (Id Software, 1993). Doom was a milestone because it allows more realistic environments and better player interactivity in three-dimensional space (Figure 2.15). Development of Doom lead many other games including Super Mario (Nintendo, 1996) and The Legend of Zelda (Nintendo, 1998) which has even more detailed environments and greater interactivity.



Figure 2.15 :Doom video game made by Id Software (url-11).

After Doom and Quake like projects game environment art improved significantly which later on emergence open world games. Open world games allow player explore freely and interact with game world, while also require mass production in development side (Figure 2.16). These complex and heavy development requirements

emerge the specialization of artist to focus specific part of game. These artist focused game environment parts such as vegetation, terrain, material and more. This allows multiple artists to work within same environment while also focus different elements of environment.



Figure 2.16 : Open World game environments, GTA III left, Skyrim right (URL-12&13).

Grand Theft Auto III (Rockstar, 2001) was one of the most important example open world games, which again lead many other projects like todays open world games such as The Elder Scrolls V: Skyrim (Bethesda, 2011).

In recent years, game environment art has been pushing the limits more than ever. Advanced tools with the power of high-end hardware make possible more detailed and realistic game environments. In recent titles, photogrammetry like techniques and workflows used in Battlefield 1 (2016) and Witcher (2018) like huge projects bring high quality and historically accurate environments (Figure 2.17).

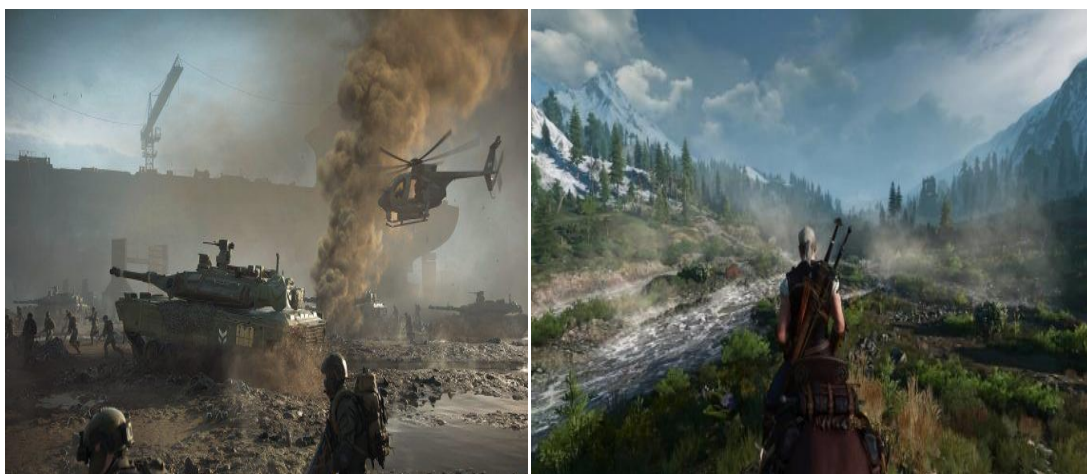


Figure 2. 17 :Modern games, Battlefield 1 left and Witcher 3 right (url-14&15).

2.5 Developments

Over the course of video game development history, there have been many significant achievements that have impacted creation of game environment art and workflows. From the introduction of basic graphics in early days to the photorealistic environments of today, plentiful advancements and artistic developments helped to shape the industry. These advancements include hardware and software developments to changes in artistic methods and styles. Each improvement opens new possibilities for artists and creators to build even more complex and detailed immersive game environments. By investigating these notable developments and impact while exploring how they transformed the process and workflows, we can have a better understanding of the growth of game environment and the changes in workflows.

- **Introduction of vector graphics (1950s/1960s):** This achievement allowed scalable shapes and easy manipulation by algorithms. Even this development mostly related to mathematical simulations and scientific calculations, it has significant impact in game environments and workflows by establishing the idea of editing with more precision and flexibility (Foley, James D. et al, 1994).
- **2D graphics and sprites (1970s/1980s):** These times also known as the era of 2D graphics, video games were composed of two-dimensional graphics and pixel art. Introduction of personal computers led to the emergence of the first video games like Space Invaders (1978) and Pac-Man (1980). These games utilized sprites which are 2D basic animations moved on screen. Using 2D graphics and sprites in games allowed for more creativity and designs which brought a realization for the video game industry. This development not only changed the way of video game creation but also forced developers and artists to create 2D assets with new styles like pixelated art style. (Newman, J., 2012).
- **3D graphics and rendering (late 1970s/early 1980s):** The introduction of 3D worlds was a major milestone for video games. This technology allowed the creation of three-dimensional game worlds, which greatly enhance game experience. One of the first examples in this era was 3D Monster Maze (1981). This achievement aided in creating specialized hardware and advanced algorithms to solve complex geometry and calculations (Chopine, A., 2011). 3D graphics and rendering marked a shift in game art in general, as artists could now create three-dimensional environments instead of 2D sprites and backgrounds.

- **Texture mapping (1980s):** The development of texture mapping allowed more realistic video games. Texture mapping involve applying 2D texture data onto 3D object which give the appearance of heaving detail and give certain information about what object made from. This technic become industry standard and is used extensively in creation of environment art. The development of texture mapping allow artist make realistic worlds and allow player to feel like they are truly inside video game (Foley, J. D.et al. 1990).
- **The use of physics engines (1990s):** Development of physics engines allowed game developers to make accurate simulations in their games. These engines were first impression of mathematical algorithms and behavior consternation in video game (M. Ihde, 2000). The revolutionizing of physics engine particularly effected field of environment art. Artist and designer now can feature more realistic results that has dynamic interaction between objects. This achievement aid to first puzzle games that need player interaction. As a result, environment artists both have the opportunity bring player interaction in virtual worlds and also adopt new technical for virtual interaction field.
- **The introduction of shaders (2000s):** Shaders are special programs run on GPU and define how video card render a scene. Shader's introduction was early 2000s and have great influence on visual quality. By usage of shader artist can add realistic visual effect and create highly complex materials for games (Foley, T., 2015). Introduction of shader increased the efficiency of game development by allow artists and developers create complex visuals without any needs on pre-rendered contents.
- **The development of global illumination techniques (2000s):** Global illumination was development in 2000s as it allowed realistic lighting solutions for game environments. Global illumination is the simulation of light bounces and reflections which results soft shadows and natural lighting (Dutr  , P.et al, 2006). Right after its development artist and designer used it to create visually stunning and more cohesive environments. Today, global illumination also known GI is one of the main lighting solutions for standalone renderer and game engines.
- **The use of modular game development (2000s):** Modular game development which means breaking game environment into smaller and self-contained components. Modularity become a workflows practice in 2000s. This method

allows more efficient and flexible design and development process. Another advantage for this technic is working for individual elements simultaneously without effecting rest of environment (J. Legault and A. Froschauer, 2015).

- **Procedural generation:** Procedural content generation refers to automatic generation of data through the use of algorithm and mathematical functions. Procedural generation used some notable games including Minecraft (2011) and No Man's Sky (2016) but become more relevant in recent years. In games, this technic often uses to create levels and environments in a short amount time without the need for extensive manual works. (Springer 2014).
- **The development of real-time 3D engines (2000s):** Development of real time 3D engines in is a revolutionized steps in game development by providing powerful tools to create immerse environments, from graphic quality to complex gameplay mechanic, real time engines changed the way of making and playing games. Real time engines enable players to explore game world in ways were previously infeasible and widespread using of real time engines has led to creation of more detailed graphics and complex gameplay mechanics. Nowadays, real time engines such as Unreal Engine and Unity are reducing overall development time and enabling creation of longer and more complex world that has higher level of interactivity (Paul, P. S., Goon, S., & Bhattacharya, A. 2012).
- **Physical based rendering (PBR):** PBR was an important milestone for game environment art. PBR allow for more accurate light simulation when it interact with surface which resulting to a more realistic game environment. This technique considers numerous physical properties of materials such as roughness, metallic, base color properties. PBR usage has become more prevalent in years due to improvements in real time graphic and engines (Karis, B. & Lefohn, A, 2013).
- **The rise of virtual (VR) and augmented reality (AR) (2010s):** Introduction of VR and AR technologies brought a new level of immerse to video games. Virtual reality enables artist to interact with three-dimensional world (Lowood, 2022). It not only allows players to interact with virtual worlds, but also led artist and designers work inside them which resulting a high level of interaction in a new and exciting way. Development of VR-AR in game industry led to the creation of specialized tools and workflows for optimized VR and AR contents (Jerald, J. 2015).

- **Usage of photogrammetry (2015s):** Photogrammetry involves creating high detail 3D models and textures from real world objects by taking photographs and process it with tools to create point cloud, high poly mesh and texture projections. This technology has been applied to game development and has been used in games such as Battlefield 1 (2016).
- **The development of AI creation (2020s):** Artificial Intelligence (AI) is a development of using computers to create creative contents by using algorithm and machine learning. AI used in procedural content generation many years but recently become more popular in game development. AI can generate game levels and environments with high degree of randomness and complexity. One of the notable examples is No Mans Sky (2016) which include AI generated universe and planets, each of them have unique flora and fauna.

2.6 Industry Trends

While the core stages of game environment art workflows remain stable and consistent over the years, there are some trends recently emerged to these workflows. These trends are visible in some of the new researches and GDC (Game Development Conferences) while also actively in use for game environment.

One of the most visible trends is procedural content generation. With the increase of open word games, producing game environment in less time become important. Procedural generation is involve using algorithm and mathematical functions to automatically generate assets and environments, this approach allows faster generation of large and complex environment with less time and leave much more time for further creativity in production while also increase variety of game environments.

Real time iterations are also having strong popularity in industry, with the increase of real time game engines and their capabilities, environment artist is able to make changes in real time (Epic Games, 2023). Real time iteration also being used widely for allowing great flexibility and iterations for prototyping. This can be very helpful for early stages where rapid experimentation is key.

Another trend in environment art workflows is the use of collaborative tools that allow multiple artist work in the same environment simultaneously. This can speed up creation process and enhance communication in art team and even other teams such as

design and programming which can result a richer environment with more immerse experience (GDC 2018).

Apart from these trends, virtual reality (VR) as a creation method seems to be popular but due to additional hardware requirements, the usage of VR seems relatively low despite its effectiveness. Modular content creation is also a trend in environment art workflows with along modular pieces to create larger environments (GDC 2017). This method become more popular in variety of environment element creation such as architectural and natural elements. Due to COVID-19 remote working is also become a trend, this trend does not have impact in workflows but caused many studios work remotely. This include using cloud-based collaborations tools and virtual workstations, which allow artist work anywhere in the world (GDC 2019).

AI (Artificial Intelligent) tools such Midjourney and Stable Diffusion is also a trend while we write this thesis, AI might speed up many stages of environment art such as texture creation and models, and it already being used by many artists. The field of AI will be main topic of future research and environment artists will look for potential usage of AI in production.

2.7 Artistic Aspect of Game Environment Art and Workflows

Environment art in video games is vast and multifaced, encompassing a broad range of skills such as art, design, programming and technical implementations. Attempting to caver all this aspect would be simply impractical and would risk diluting the depth of research. Moreover, while considerable body of literature for game environment is consist of programming and more technical perspectives, less of it focus to artistic perspective which create a relative scarcity of exploration into creative process. Therefore, this research only focuses to artistic aspect. The technical and programming sides are intentionally left to be explored in future research endeavors. Through this focused approach, we seek to provide a comprehensive understanding of artistic elements and ideas that contribute game environment art and workflows.

Game environment is not just about creating visually stunning environment, says Jesse Schell (2019), it is a craft of narrative stories, idea and emotions in virtual worlds. Designing an environment that supports narrative and engage players imagination is the meaning of creativity and environment art.

Artistic meaning by itself refers to symbolic, emotional and conceptual importance that a work of art holds for the artist or players. It can be driven from various elements, composition, colors, texture, form and matter itself. As in arts nature, mean is always subjective and may depend on their personal experience, cultural background, and individual interpolation of artwork. The main focus of this work is to explain the question of how rather than why. This research tries to understanding artistic perspectives and intentionally leave technical and programming perspectives for future researches.

2.8 Previous Works and Limitations

In early days of game development, environment art was often created with generalist artist or programmers with very limited resources which resulting simple and less detailed game worlds. However, with the advancement of technology the expectation of players increased. These expectations created highly specialized environment artists, complex and efficient workflows. As environment art become one of the most important stages of game production, environment art and workflows has been the subject of various research, experiments and works by academics, industry proccessional and studios. There are numerous examples of programming and technical side of game environments such as 3D modeling software, game engines, scripting languages, plugins and more. However, there is fewer research focusing on the artistic aspect of game environment and workflows. In this section we will discuss relevant previous works and resource that have contributed to our understating of game environment art workflows.

One of the earlies studies on environment art is "The Art of Computer Game Design" by Chris Crawford, was published in 1984. Chris in his book focuses on technical side of environment with foundation of computer graphics and game design principals, the book provides insights into game environment and highlight the importance of visual design in video games.

Peter Lord and Brian Sibley in their book "Creating 3-D Animation: The Aardman Book of Filmmaking", published in 1998, shares their knowledge in creation of 3D animations. However mostly because of technological improvements techniques and methos were mostly discontinued. Moreover, insights about environment planning, sketching and storyboarding stages are still in use but are outdated in terms of tools.

Todd Gantzler in his book "Game development essentials: Video game art" published in 2005, created a technical guidebook that provides an overview of game environment art. The book covers various aspects with details but in a way of technical foundation and understanding.

In another study, Micheal McKinley in his book "Maya Studio Projects: Game Environments and Props", published in 2010, shares their knowledge in creation of environment in 3D world. The book preliminarily focuses on Maya software modeling. The book keeps the process simple and introductory while also sharing insights for beginner artists.

In 2016, Alex Galuzin in his book "Preproduction blueprint: How to plan game environments and level designs" provides detailed methods for environment art creation. Alex discusses about numerous topics such as level design planning, story planning and more. The resource mostly focuses on planning environment art while does not include any practical creation.

Moving to 2018, Luke Ahearn published his book "3D Game Environments: Create Professional 3D Game Worlds," which provides an overview of the entire workflows. Andrews' work is one of the most important resources for game environment art since it includes case studies from industry professionals and provides tips and tricks to create game world. However, these cases seem to be mostly focused on technical aspects and tool usage.

In 2021 Henry Kelly in his book "Environment Art in the Game Industry: A Guide to Rich and Realistic Environments Using Substance Designer" focuses on realistic environment art creation but only focuses on procedural texture creation while does not mention about other aspects.

GDC and SIGGRAPH like conferences are also valuable events and literature resources. GDC (Game Developers Conference) is a conference first introduced by Chris Crawford with a purpose of game developers, artists, studios and manufacturers come together once a year and share their knowledge. The conference held various topics including environment art and workflows.

SIGGRAPH is yet another conference-based event with a focus on latest developments in CG (Computer Graphics). SIGGRAPH (Special Interest Group on Graphics and Interactive Techniques) held in North America every year and provides a discussing

environment among developers, artists, studios and manufactures for sharing latest CG developments.



3. METHODOLOGY

The methodology section of this study outlines the research design and framework used to investigate game environment art workflows in video game environments. The research design adopted for this study was grounded research method. Grounded research or Grounded Theory, is a qualitative research system created in 1960s by Barney Glaser and Anselm Strauss (Glaser & Strauss, 1967). The process involves of several stages including gathering data through interviews or any other observation methods and collecting data to construct ideas or conceptions based on the evidence itself, rather than pre-existing beliefs or assumptions (Charmaz, 2006; Corbin & Strauss, 2014).

Based on research methodology total of three study type prepared. Preliminary study, experimental study and main study. These three studies generated three types of data. Preliminary data was a type of validated and detailed recent literature. Experimental data was a type of observation data generated from practical base of preliminary data. Last data type was semi structured interview data based on participant contributions; this data will be called as main data. Overall, preliminary study, experimental study and semi structured interviews were our data collection methods which resulted three data set, preliminary data, experimental data and main data.

Preliminary study was a literature-based study, this study focused to recent literature data. This study created to validate literature finding and observations, as the research topic is extremely dynamic, there was a need to ensure which part of literature being replaced or obsoleted. Because it would be impractical to identify workflows and provide strategies based on old, unused or unrelated data.

Preliminary study focused to environment art creation stages and their recent developments. Since all workflows mainly refers a need, to refine, change, improve one or more environment art creation stage, any changes in these stages dictated to workflows or method itself. The purpose of focusing each environment art stages was pinpoint areas where any refinement, replacement or obsolete happened. Although,

based on grounded research methodology, we updated this study and data as much as needed, the end result of this study created preliminary data. However, preliminary study finding faced a limitation. As this study fully based to recent literature data, some of them may be too new, methods or strategies may not have a practical base. This problem disturbed research goals, since it would be impractical to provide strategies or techniques that has only theoretical base. Therefore, an additional experimental study was needed. Experimental study prepared to validate preliminary study and examine if workflows or methods has practical base in terms of software and tool support, has usage examples, learning resources and so on.

Experimental study and preliminary study were made simultaneously. Meanwhile, after each preliminary study chapter a practical study prepared. For example, preliminary study started with very first environment art creation stage, planning and reference stage. Right after detailed discussion and recent literature examination, experimental study made for planning and reference stage, this logic continued for every stages. This way we had a chance to understand stages while also measure and observe practical base.

Data generated from these studies were used for semi structured interview framework, in this interview we created various questions based on open, axial, and selective data analyzing methods which is part of grounded research methods. We particularly focused research goals and research questions. While preliminary and experimental study fully answered our first research questions, they were unable to fully cover remaining two research questions. Therefore, the interview specifically focused results from previous studies and last two research questions. The interview was conducted with four industry artists and all process was recorded; this recorded data transformed to text data. Semi structure interview created third and last data set, this data called main data.

Data analyzing methods were based on Grounded Theory data analyzing steps. At the beginning of analyzing, we grouped all three data types, preliminary data, experimental data and main data. These data sets broke down into key concepts and assign codes. For example, finding related to concept art, 3D modeling or texturing. This first step is open code phase. In the second phase which is axial coding, each of these key concepts categorized to explore their interconnections, as 3D modeling and texturing like categories can be under asset creation group while lighting and

optimization like findings can be grouped under implementation and testing group. Axial coding also indicated analyzing between these categories, for example how changes in concept art influenced workflow adaptations. After axial coding, we passed to selective coding phase. Preliminary study and experimental study analyzing were stopped here as there were incomplete data for theoretical sampling, saturation and final memo writing. In the selective coding section, we connected each of these groups and tried to find their connection. For example, how procedural workflows changed asset creation stages or how AI can emerge to concept art and planning stages. This phase ultimately explored the interconnection between axial coding findings.

After main data added to data sets, all previous analyzing steps conducted again. In the Theoretical sampling phase we passed all data to literature review and see if we missed any data or there was a need to update data sets. For example, research about AI and AI tools were not research intention, however as participants contribution in interview process raised this topic, we had to go to literature review and add data for each of these types of finding. Theoretical saturation is one of Grounded Theory phase for collecting data until there is no insights for categories. Therefore, each study and data sets were updated multiple times. The last steps of analyzing were memo writing, in this step we wrote each category and their interconnections to create final theories.

In the first chapter of this section preliminary study and experimental study were prepared, these two studies were conducted simultaneously. At the end of these studies, open coding, axial coding and selective coding methods used to analyzed findings, these obtains used for semi structure interview framework and main study.

The second chapter of this section is main study. This section of thesis proceeds with detailed description of participant selection and recruitment methods; interview protocol design, validation, data collection and analysis methods. Participant selection and recruitment process include criteria for participant selection and methods for finding participants. Interview protocol design include framework for creating and conducting semi structure interview.

Data collection and analyzing methods include final data collection methods and analyzing process. This research adopted Grounded Theory as methodology. Therefore, both data collection method and analyzing methods were same as theory instructed. Data collection methods are literature observations, experimental studies and semi structured interview.

This research adopted Grounded Theory analyzing methods. The investigation starts with open coding all data types, Following with axial coding and selective coding, theoretical sampling, theoretical saturation and final memo writing. Analyzing started with experimental and preliminary study analyzing as this initial data was needed for creating interview framework. At end of final data collection, all phases conducted multiple times, means whole analyzing process was dynamic, all data sets and studies were dynamically updated and changed. The final analyzing step was memo coding which create final theories and findings. Below diagrams shows framework for each research steps. The diagram separated to three pages but they are all connected to research framework. In the first page, diagram shows initial research planning and definition framework. (Figure 3.1). In The second page, the diagrams show data collection frameworks. (Figure 3.2). In the last page, the diagram shows analyzing methods which include each phase in grounded research analyzing techniques. (Figure 3.3).

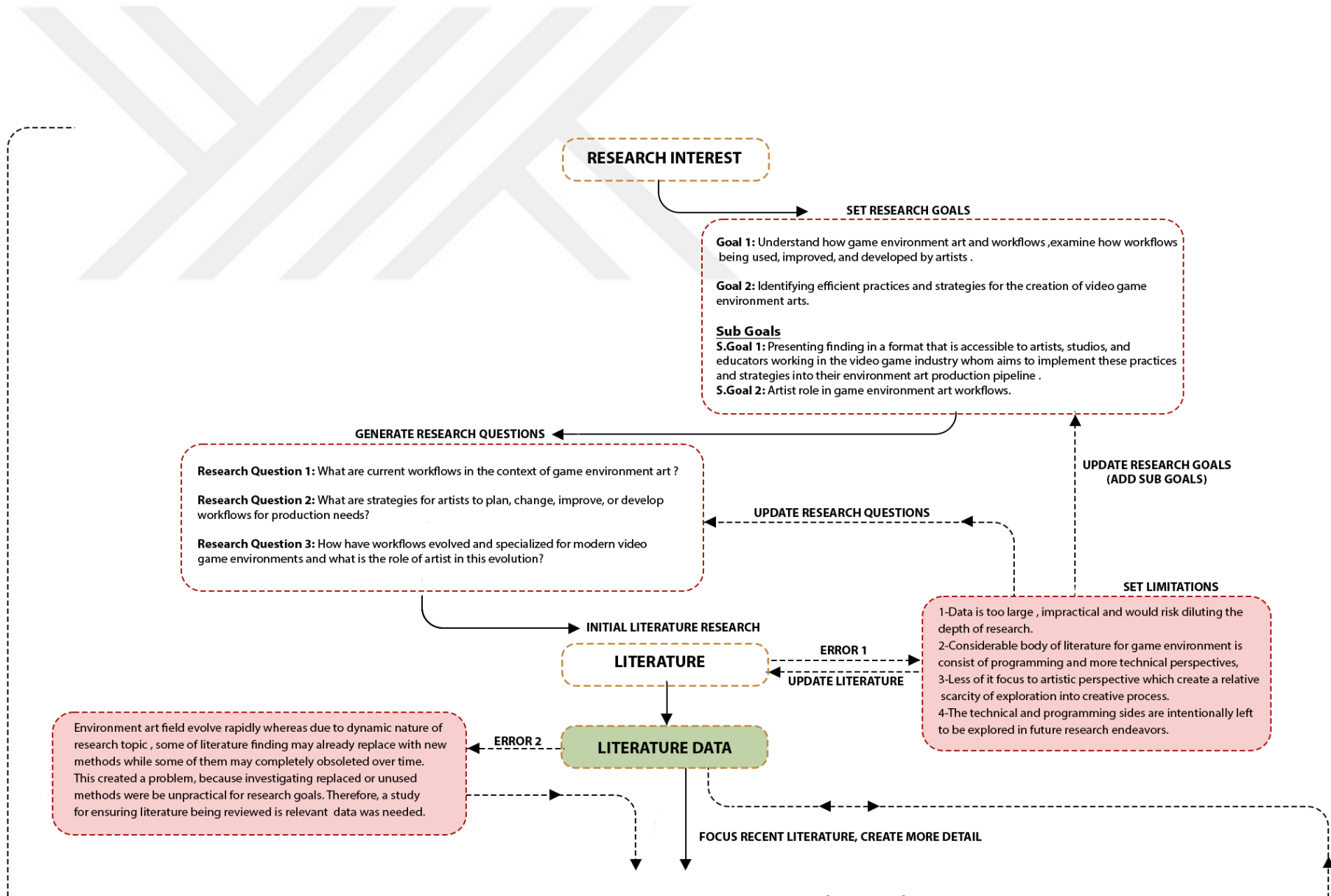


Figure 3.1 :Methodology planning. (Research definition framework).

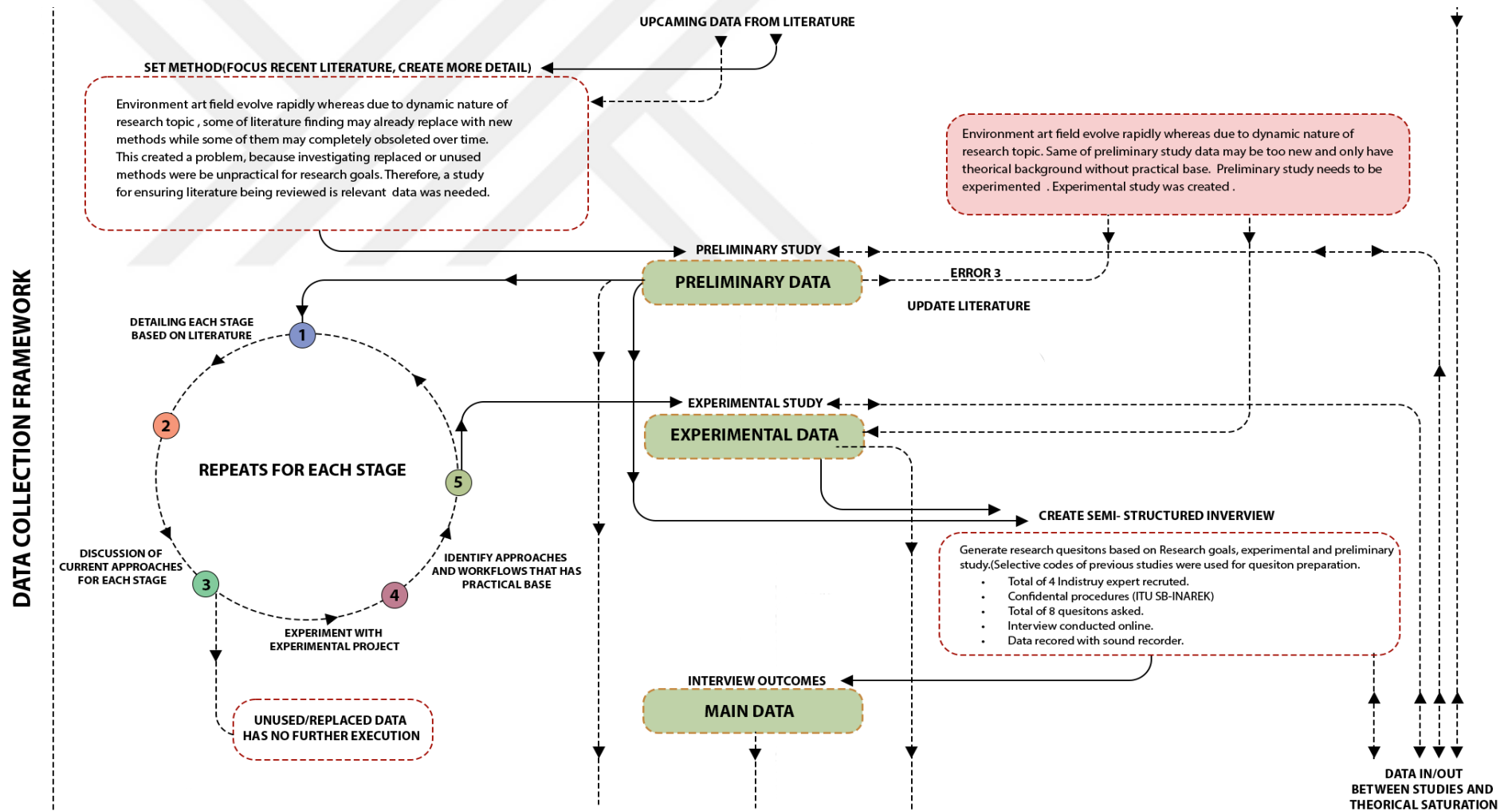


Figure 3.2 : Methodology planning. (Data collection framework).

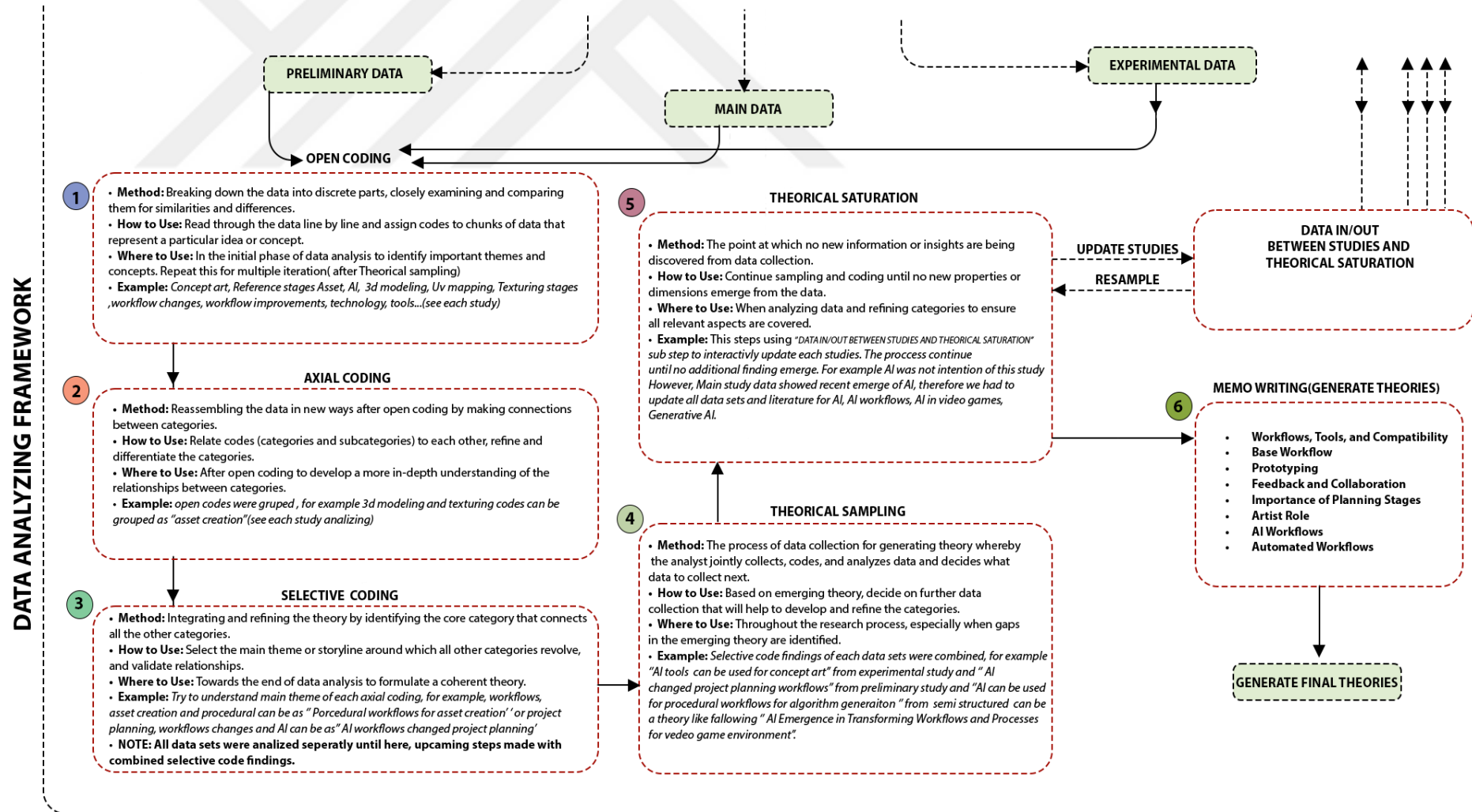


Figure 3.3 : Methodology planning. (Data analyzing framework).

3.1 Preliminary and Experimental Study

This section of research is a detailed literature research focused last years in game environment art and workflows. Additionally, the section includes a full environment art creation process from starting to finalization with workflow strategies, approaches based on literature findings observations the purpose of this study was understanding practical base of detailed literature research, the preliminary study. The process includes detail explanation of each stage (Figure 3.4), workflows and thought process with support of various art assets and figures created especially for this purpose.

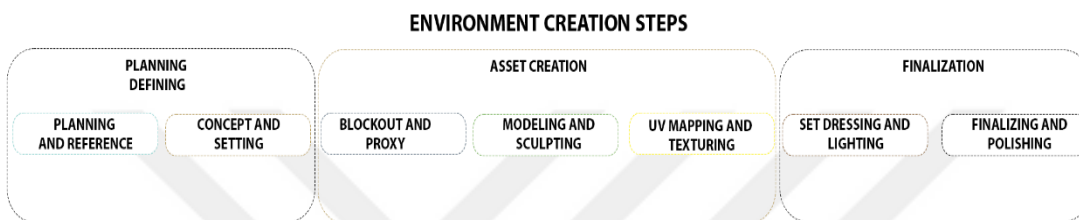


Figure 3.4 : Environment art creations stages.

It is important to note that this thesis focused and examined each finding with an artistic perspective while intentionally leaved tedious technical and programming aspects. The study framework designed as follows. In each environment art creation stage, we detailed it with current approaches. After that we discuss methods and strategies to establish efficient approach for each stage. After detail examination and important aspects out of way, we set details and goals for our experimental study. Therefore, we experimented each stage and methods simultaneously. This framework applied to each step from start till final art work.

Preliminary study was a literature-based study, this study focused to recent literature data. This study created to validate literature finding and observations, as the research topic is extremely dynamic, there was a need to ensure which part of literature being replaced or obsoleted. Because it would be impractical to identify workflows and provide strategies based on old, unused or unrelated data. Preliminary study focused to environment art creation stages and their recent developments. Since all workflows mainly refers a need, to refine, change, improve one or more environment art creation stage, any changes in these stages dictated to workflows or method itself. The purpose of focusing each environment art stages was pinpoint areas where any refinement, replacement or obsolete happened. Although, based on grounded research

methodology, we updated this study and data as much as needed, the end result of this study created preliminary data.

However, preliminary study finding faced a limitation. As this study fully based to recent literature data, some of them may be too new, methods or strategies may not have a practical base. This problem disturbed research goals, since it would be impractical to provide strategies or techniques that has only theoretical base. Therefore, an additional experimental study was needed. Experimental study prepared to validate preliminary study and examine if workflows or methods has practical base in terms of software and tool support, has usage examples, learning resources and so on.

The experimental study can offer several benefits to our preliminary study. The first benefit was validation of proposed approaches discussed in each stage. This validation adds credibility to study and contribute body of knowledge in environment art field. The second benefit was by experimenting each stage we can identify potential weakness and strengths of workflows. Since environment art field is extremely dynamic by experimenting current workflows, we can understand if certain workflows are still in use or may not meeting today's needs. This way we can prevent ourself study workflows and techniques that not even meet today's needs or already replaced. Ultimately, experimental study brings a practical application to preliminary study which later on become a data set for main study and provide further discussion, exploration within game environment art filed.

This preliminary study and experimental study finalized with results and finding section, these results and finding used as a data for interview framework and main study (Figure 3.5).

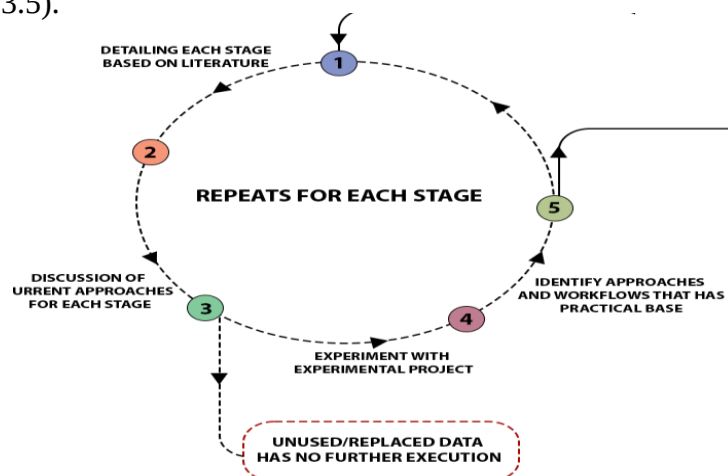


Figure 3.5 : Preliminary and experimental Study simultaneously working.

3.1.1 Planning and reference

Planning is a fundamental step of game environment art creation. This process involves several aspects that artist needs to consider. The first consideration is defining environment art and art style. Artist has to decide what type of environment they want to create, is it a 2D, 3D or isometric. This key note is very important since it effect environment and art creation process greatly (Blevins, 2022). Moreover, defining the visual style is paramount. Whether option for stylization, realism, cartoonish or abstraction, establishing these two key aspects early on provide a framework for further planning (LDB, 2023).

Establishing the setting is also a key consideration. Setting in game environment art concerns to location, theme, time period, culture and story like elements in game (Garth, 2021). Artist has to decide where their environment located and what is the theme of environment. It might be in another planet or Ancient Egypt where their desert climate held and life is challenging. Therefore, location refers many things including how characters live and what kind of activity they do. This is also referring to material NPCs have and possibly use for architectural purposes. Moreover, time period is also important aspects of planning. Artist has to decide what is their time period. It might be a futuristic environment, medieval time or an unknown time frame. This aspect automatically creates an aesthetic as it dictates a lot of assets that artist will need to create.

Additionally, culture and story are key considerations to take into account (Garth, 2021). Not all games have to have culture and story but if artist decide to have, these two elements will directly dictate environment looking. Story is underly narrative process in game environment and culture reveal many information about story and visual looking. Last of Us (2013) and Blade Runner (1982) are both set to near future, but has different culture and story. In Last of Us (2013) characters struggling to survive in a pandemic that cause mass destruction while in Blade Runner (1982) society heavily influenced by corporate power and technological advancements, each title has post-apocalyptic and dystopic future but since both future shaped with different effects the culture and story are greatly changes and shape surrounding environment.

- **Experimenting planning and reference-1:** In our experimental study we decided to have a setting as follows. The location is a multi-dimensional place where time does not exists or refers to an unknown form. The time period is based

to far future where humanity reach an advance technology and can able to travel through instellar, pass into multi dimensional space. The theme underly story of our experimental study focuses to a journey of a man inside a bubble like spaceship in vast space (Figure 3.6). The culture and architecture does not visible in this environment rather refers to advanced human living in a multi-dimensional time. Initial plans and visual references in story are in below (Figure 3.7).

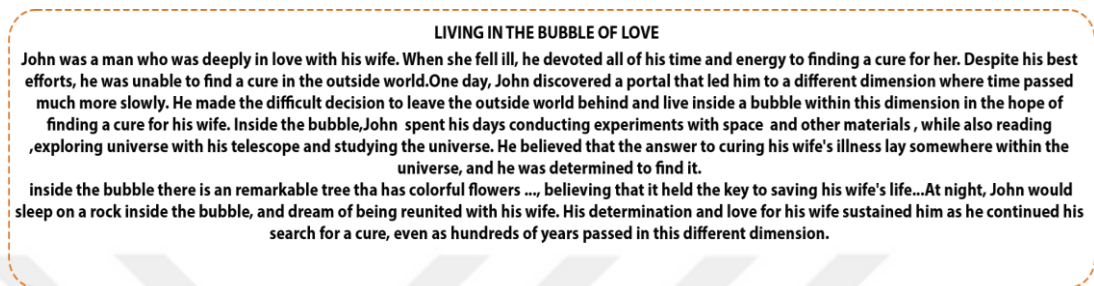


Figure 3.6 : Experimental study environment story.

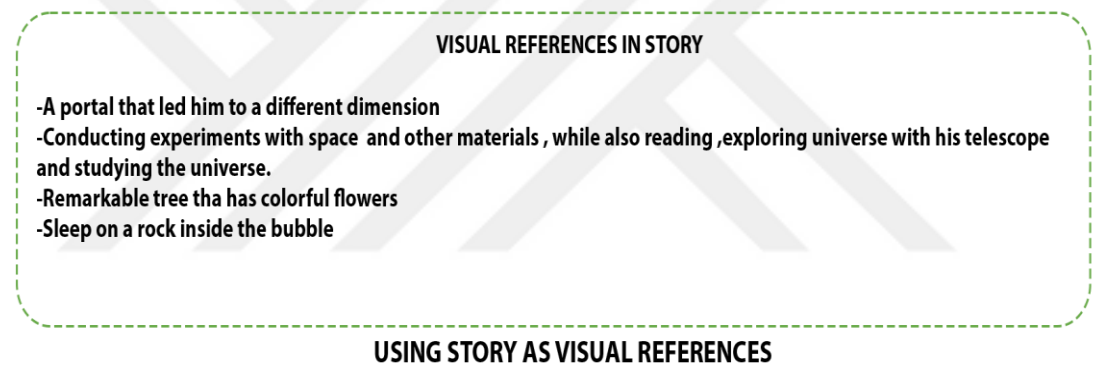


Figure 3.7 : Story include visual elements that artists can benefit from.

In order to evaluate planning stage efficiently, artists may use charts that show what are environmental elements they want. This approach helps artists stay in the line and make a better referencing stage. Jira and Perforce like tools may help artists to track their planning stage and follow plans throughout final artwork. This type of softwares are very useful in a team environment. In a collaborative workplace where there are multiple artists working in same environment, artists can plan the process and follow it without any misunderstands or mismatches.

- **Experimenting planning and reference-2:** In our experimental study, we used PureRef software to track our process, although the tool is mainly created for reference phase, this tool is very useful for solo environment art projects. Jira and Perforce like softwares are mainly for team environment. According to our plans our environmental planning chart was as follows (Figure 3.8).

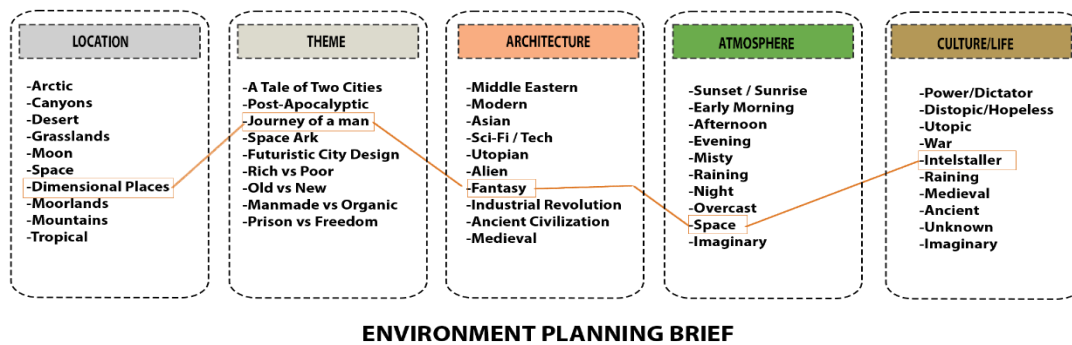


Figure 3.8 : Environment planning chart for experimental study. (The orange line indicates our selections)

Reference gathering is yet another important steps to follow planning phase. References serves as creative fuel for artists. Artists can use various reseources such as internet, books, traditional arts and photography to insights. Artist tent to not attach to importance of reference stage despite its crucial role (Gard, 2023). References serve as an outline of ideas, elements and ensure accuracy in representation. An important rule in this process is to gather high quality and detailed reference in various angles and environments, this way artists can benefit additional inspiration and fully understand elements they willing to do (Dukes, 2023).

In this stage various strategies can be used. In game environment art workflows artists has to understand how to choose a reference, how to gather it, how to analyze it and how to use it. Otherwise, references stages may become a regular image collage. Choosing reference can be broken in several stages. It is valuable to having interest about planned art, even though this may not always be possible in a studio workplace, having enthusiasm for planned art greatly affect whole process, this is vital for maintaining motivation within process.

Therefore, instead of selecting random references, artists may want to collect references they love to see and gain interest about it (Townsend, 2021). The second stage is gathering process, although this process can start even before planning, it is crucial to gather references to match planning stage. Various image search engines may help artists find useful references these are including Google, Flickr, Usplash. These websites have high quality image references to gather. Books, magazines, films and games may also provide useful references. These sources may help artist to fully understand planned art and even provide additional information's to benefit (Dukes, 2023). Reference gathering stage may be quickly overwhelming. Therefore, artist has

to organize references based on their quality, variety and so on. High quality images may help artist to interpolate and understand small details while blurry references may not be accurate and become a problem in further stages. Reference variety is also important, it is worth to mention some references may modified and not show actual representation of environmental elements or assets. Ultimately multiple reference may help artist to design environment with combination of features seen in different references (Vaccaro, 2023).

Analyzing references are particularly important for art creation process. In this stage artist may use various techniques such as difference reference collection or generalize them. This can ultimately help artist to create a list of assets and possibly look for room to use various workflows. While analyzing references, artist may find common features which can indicate a modular workflow. Different assets or elements may see overwhelming amount of work, but by analyzing references artist can decide to use procedural techniques which can able to create infinite number of assets based on given parameters. After analyzing references artist can use these references for next stages. These references can be Following with Pureref like software or Miro in a collaborative workplace. In an asset-based task, artist has to check references and compare each process with references (Garth, 2021).

Overall, references are crucial element of environment art creation process. While this step can help artist to optimize their workflow and creation process, it is important to know how to make successful references stage. Artist has to decide what to choose as a reference to gain further interest to artwork by selecting various reference with clear and high-quality image resolution, these kinds of references can be found in internet, book, magazine like sources (Aava, 2022).Analyzing references is important because this step ultimately affect all upcoming process. In this stage artist may difference or generalize assets based on their similarities or common features. This technique can benefit artist to use various workflow which can greatly affect costs and art quality. References are main source of further environment art creation process and artists can use various software's and tools for organizing and following throughout process.

- **Experimenting planning and reference-3:** In our experimental study we used various image libraries such as Usplash, Pinterest to gather high quality references. It was important to gather enough reference, but too much references may

overwhelm artist and block possible project direction. Therefore, it is important to gather just enough reference and leave unrelated ones.

- **Experimenting planning and reference-4:** In our experimental study we defined a giant tree and portal as our main assets since we planned that most of visual interest will be there. Therefore, we used various sources to collect a reference board. We will be using these references along process (Figure 3.9, 3.10).

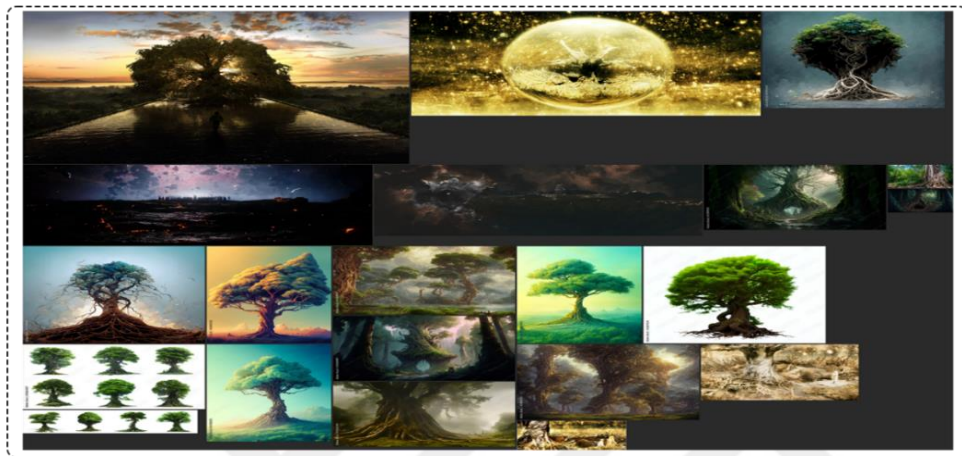


Figure 3.9 : Reference board for experimental study.



Figure 3.10 : Vegetation reference board for experimental study.

3.1.2 Concept art

Concept art in game environment art creation as it serves as the visual manifestation of ideas and decisions made in planning stage. It is a common language for communication and collaboration among other departments in game development. Artists uses various techniques to create themes, moods and visual styles to inform early ideas. This stage is an intense stage because of its vital role in environment art

creation process. Therefore, mainly in large games, concept arts made by concept artists rather than environment artists. Concept artists are specialized artist creating visual ideas for game creation (Lilly, 2015). These artists have strong understanding of drawing, illustration and digital painting.

The concept art stage starts with rough sketches, where artists quickly visualize ideas. In these sketches, artists aim to convey concepts rather than detailed artworks. Following rough sketches and feedback iteration, concept artists begin to create key concepts, establishing the visual identity of the overall environment (Figure 3.11). These concepts serve as reference points throughout the environment art creation cycle (Rässa, 2018). Once key concepts are established, concept artists delve into detailed visuals, such as further sketches, mood boards, and color studies, to flesh out the overall look and feel. The purpose of detailed concepts is to establish blueprints for upcoming stages, such as modeling and texturing and final lighting.



Figure 3.11 : Concept sketch (top)and key concept (bottom) made by Mizuko Matsumura. (url-16).

Concept art stage is intensive and time-consuming due to its manual nature. Therefore, concept artists primarily focus on key concepts and leave smaller areas or assets to

other disciplines, including environment art team. In this workflow, concept artists define shape language, colors, and mood boards. Based on these visuals, other disciplines can create the required assets and environmental elements. This technique allows artists to iterate on remaining aspects of art without overwhelming the concept art team.

AI (Artificial Intelligent) can be useful for this stage. AI has the ability to create visuals based on given text or images (called as Generative Artificial Intelligent/ GenAI). Therefore, concept artist can use these tools for further creativity or creating base visuals. In this method, concept artist can feed GenAI tools with initial sketches or thumbnails and create mood boards, colors or detailed sketched with AI. Adopting AI in concept artist may speed up the process and allow artists to create more visuals for other departments benefit. GenAI tools can increase creativity because of faster iterative process, artist can create multiple results at the same time and can find visuals that match game story and narrative (Figure 3.12).



Figure 3.12 : Concept art image created with GenAI (Url-17.)

- **Experimenting concept art-1:** In our experimental study for concept art stage, we created basic sketches to understand colors and main objects, main objects are tree and a portal This process made manually based on our planning and references stage finding. The process is highly depended on artistic skill and experience. We also used AI tools like Microsoft Designer and Stable Diffusion to create various concept art for experimental project. Therefore, we used our concept sketching as

an input for AI processing. The prompt was ‘‘create this image in realistic style, tree and portal, space background, surreal’’. GenAI created various images, we will be using both our concept art and AI based concepts as key concepts for further stages (Figure 3.13).

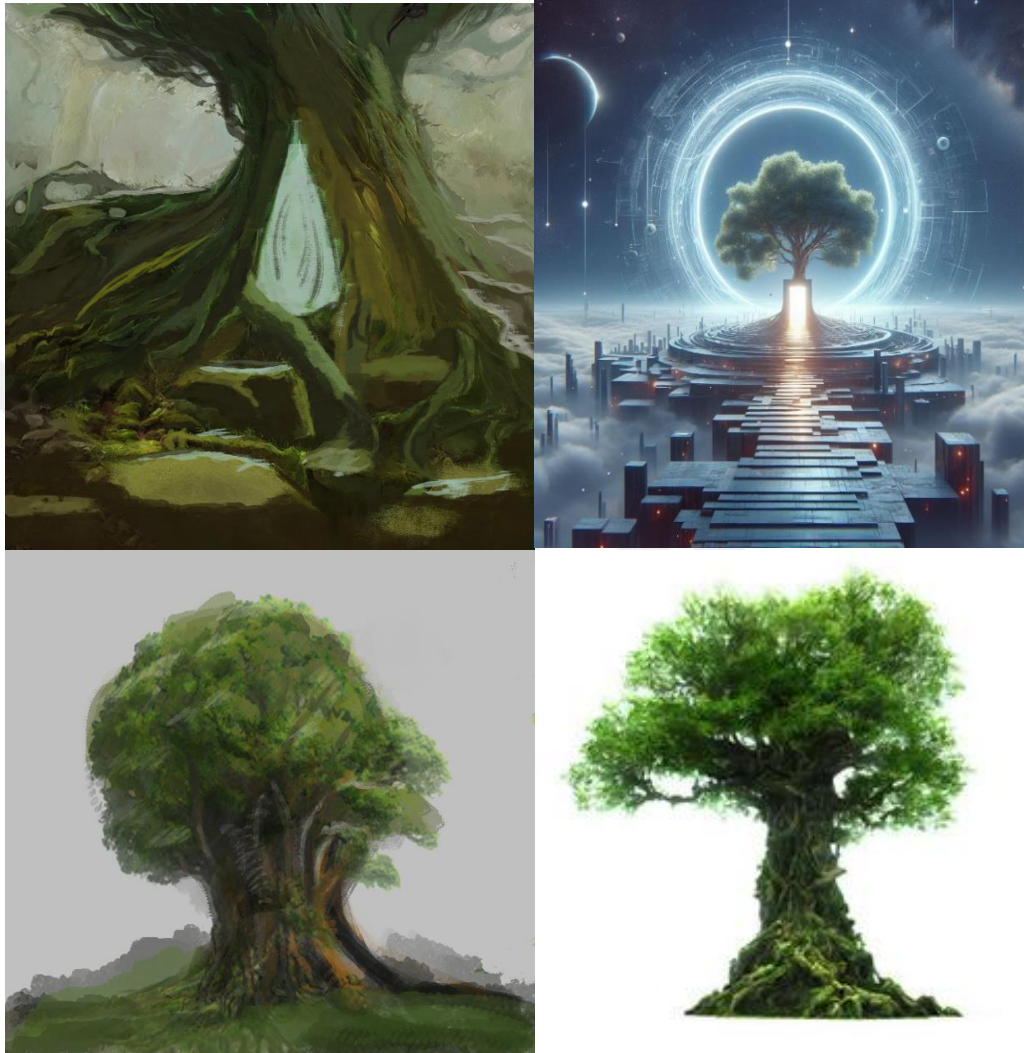


Figure 3.13 : Concept arts created for experimental study, manually sketched on the left and GenAI on the right.

3.1.3 Blackout and proxy mesh

Blackout or gray meshing is first production step coming after planning and conceptualization in game environment art workflows. In this step artist and designers create a rough layout or ‘‘blackout’’ of environment using simple primitives and shapes (Figure 3.14). The purpose of this step is establishing a basic structure of level with key elements such as landmarks, environment borders or Point of Interests (POI) locations (Keudel & Quixel, 2023).

Blackout helps artist and other departments to understand overall scale and volume while also visualize potential gameplay, flow directions and level structure before investing time and effort in detailing assets and elements. This step tends to be quick and loose in terms of detail (LDB, 2023).

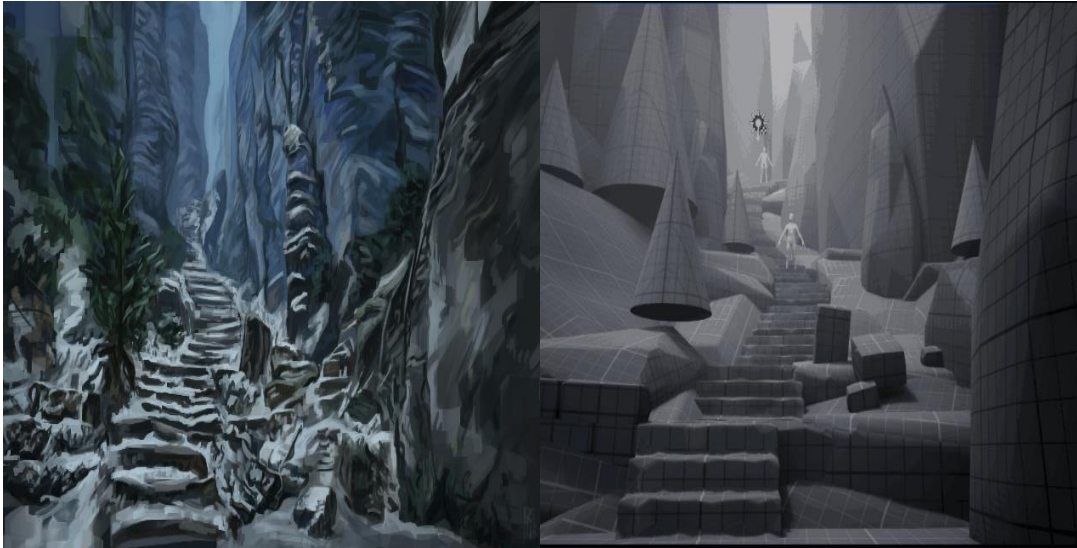


Figure 3.14 : Concept art (left) and blackout environment (right) (Url-18).

In this stage artist can use a representative scale indicator. This indicator can be a basic human model or even a simple box. Depending on either first person or third person environments, artists have to check scale and gameplay. It is a common mistake to not use a scale reference which results in a lot of redo work.

Once the blackout phase is approved, the artist moves on to the proxy stage. Proxy environments are more defined than blackouts. In this stage, the artist uses various modeling tools to further define the mesh and create a low-poly placeholder. This placeholder is an approximate of the final asset. This way, artists are giving a more concrete form to assets while also having flexibility for design changes.

The importance of this step is very crucial in terms of workflow. Proxy meshing allows artists to plan and shape their workflow while also revealing potential mismatches in previous stages. This way, artists can turn back to previous stages and make further adjustments. In a production scenario, an artist can perform proxy meshing to measure potential reusability or modularity. This way, an artist can decide to adopt a modular workflow or can decide to automate the process for certain mesh procedurally.

- **Experimenting Blockout and Proxy-1:** In our experimental study we first created a blockout of main tree asset and its proxy stage, later on we used various primitive geometries to create overall assets such as rocks, foliage's, water volume. We placed a few human mesh as a scale indicator. All these blockout and proxy models will be passed to modeling and sculpting stages for further detailing and definition, Figure 3.15 shows the difference between blockout mesh and proxy mesh for main tree asset.

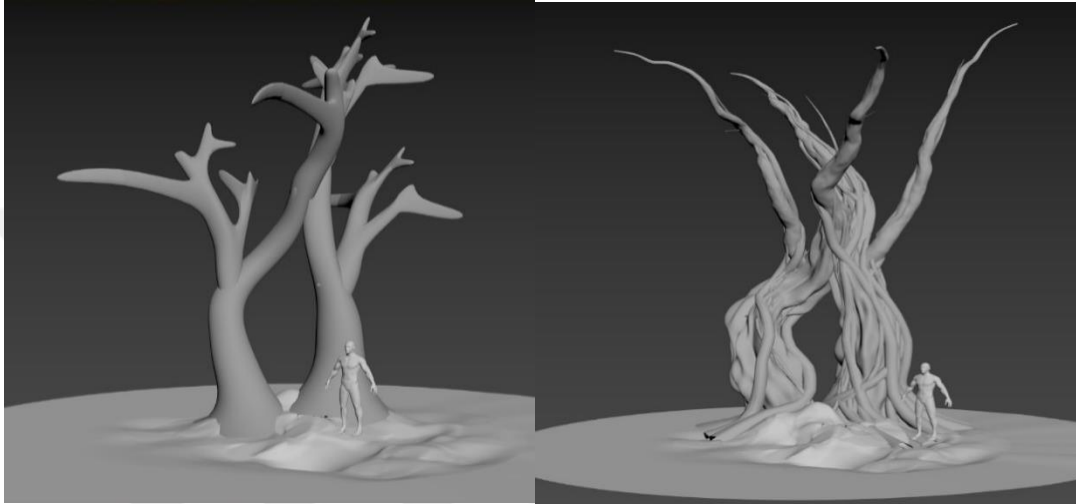


Figure 3.15 : Experimental study main asset, Tree blockout (left) and proxy mesh (right).

As a result, both blockout and proxy meshing are crucial for rapid iteration in environment creation. These steps allow artist and designers to see overall level layout. They allow artists to quickly test idea, feel volume and proportions while also aid artists find potential weakness of initial planning. Additionally, blockout and proxy meshing can identify opportunities to increase productions efficiency such as planning and selecting workflows that streamline asset creation and integration process.

- **Experimenting blockout and proxy-2:** In our experimental study we used basic primitives to quickly blockout our scene. We also used a few human models in scene with different location. This way can quickly feel our environment while also set a proper scale in overall environment. Additionally, we used various colors for each individual asset needs to be create, this way we can create an asset list and prevent ourself not do overwork (Figure 3.16).

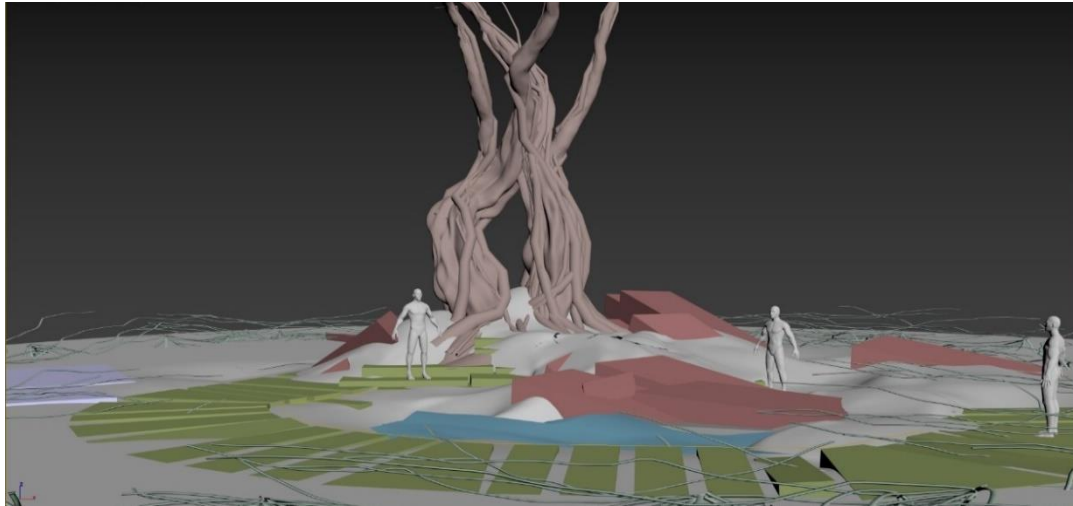


Figure 3.16 : Experimental study blackout, colored assets help artist how many assets need to be done.

- **Experimenting blackout and proxy-3:** Our environment was going to be an environment diorama rather than a large open world environment. Therefore, we need rather low number of assets to be created. These were a few vegetation models, rocks and some visual effects. These were plans that matched our initial planning and references stages, below Table shows our asset list (Table 3.1).

Table 3.1 : Experimental study asset list.

Giant Tree	Water and Portal Visual Effects (VFX)
Rock x3 var	Grass x3 var
Roots x2 var	Flowers x3 var
Bubble	Bushes

3.1.4 Modeling and sculpting

Modeling is a fundamental stage of game environment art creation. This stage involves of creation 3D assets by manipulating vertices, edges, polygons and elements within three-dimensional space (Silverman, 2022). The purpose of this stage is to create 3D models of objects and structures to populate game environment. This includes everything from vegetations to architectural elements, props and terrain objects, any object in 3D world must passed to this stage, for many cases modeling is enough, but for further small details sculpting may require. Below image shows one of vegetation asset modeled manually (Figure 3.17).

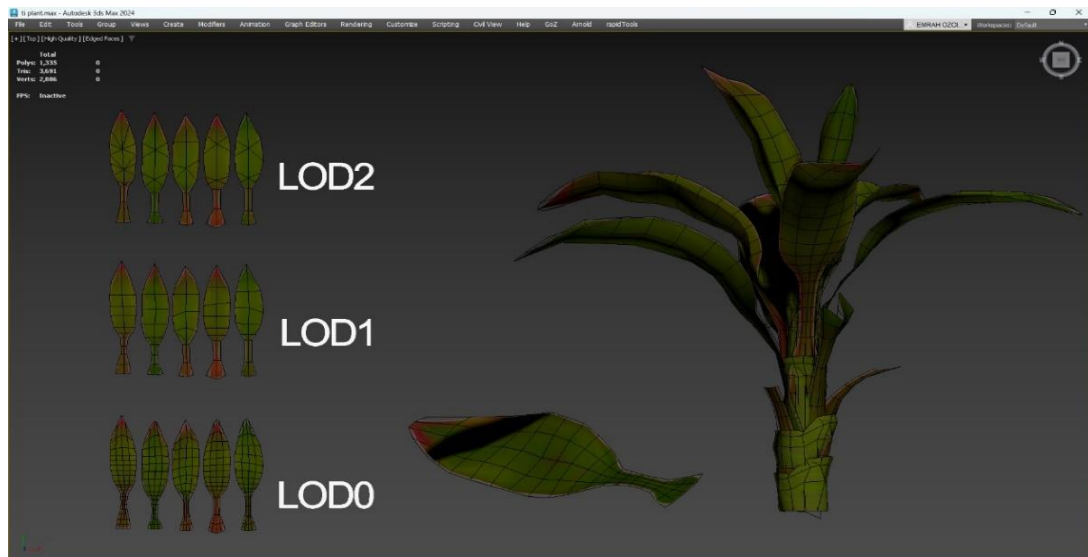


Figure 3.17 : Manually modeled vegetation mesh for experimental study (T-Plant/Cordyline fruticosat).

Modeling is a time-consuming process because of manual manipulations and steps involve of this stage (P. Cignoni, et al., 1998). There are mainly two common methods used for this stage. Polygonal modeling is the most common technique to create 3D objects. Artists manually edit vertices and edges and gradually create desired objects. The technique allow artist have precise control over the geometry and allow artist to create wide range of assets and environmental elements.

Procedural modeling is another modeling technique used commonly. Instead of manual editing and creating assets, procedural modeling involves of using parameters to generate objects. Although this technique generally requires manual editing, it saves a lot of time and generate variations of an object based on given algorithms.

Procedural modeling is part of procedural workflows, this workflow mainly targets to time consuming process and lack of variety in game environment. Unlike traditional polygonal modeling this technique allows artists create objects much faster which allow artist to spent more time in creativity rather than manual editing. The technique can create multiple variations and allow artist to decide desired looking.

- **Experimenting modeling-1:** In our experimental study we used both procedural and traditional workflows. The advantages and disadvantages of these two workflows measured with foliage creations for game environments. Foliage' are all sort of plants used to populate environment. But in this process artists face to a crucial problem which is repetition and similarity problem. Therefore, artist have

to create multiple variations which takes time. To overcome this problem artists, adopt procedural tools such as SpeedTree and Houdini, these tools allow artists define a range instead of constant value. These tools randomize and select a random constant in defined range to create multiple variations, resulting a much more efficient process comparing to manual modeling, Figure 3.18 shows main tree creation in SpeedTree software (a procedural tool for foliage creation).

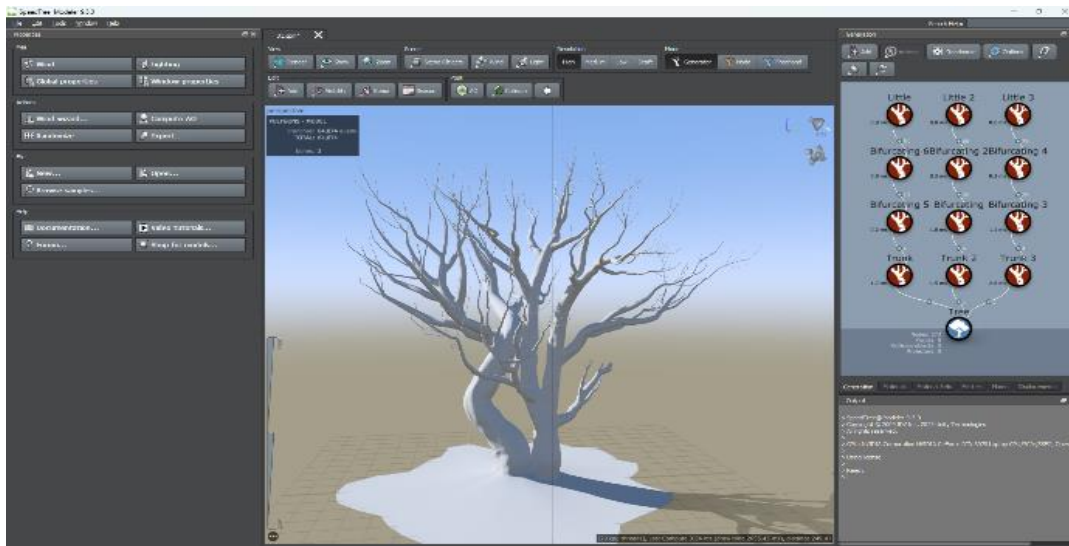


Figure 3.18 : Modeling Giant Tree using procedural techniques for experimental study project.

Sculpting is a technique originally used for highly detail organic modeling but later on used for verity of asset creation tasks. This technique involves to manipulating geometry to add details that harder to add with regular modeling approaches. The purpose of this step is further defining modeled assets by adding more details and character. We started with modeled or proxy meshes and with the help of various sculpting tools artist able to add texture detail or various features such as damage, smoothing or imperfections.

- **Experimenting sculpting-1:** In our experimental study, we used sculpting to add details to plant leaves, the purpose of doing this, getting details that harder to get with regular modeling techniques. Sculpting process takes time while the result is incomparable (Figure 3,19 and Figure 3.20). Sculpted leaf atlases created for baking process in texturing stage, these leaf variations will be baked into a plane to extract data sets such as normal map, ambient occlusion (AO) and curvature map. The maps used for realistic texturing in Substance Painter software.



Figure 3.19 : Sculpted leaf plant for experimental study, sculpting used for small details (experimental study).

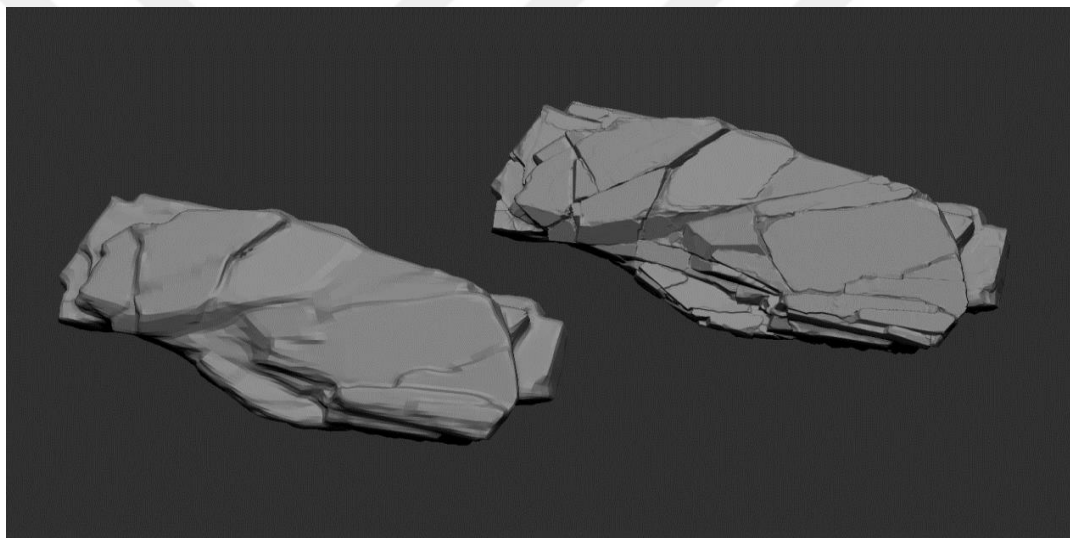


Figure 3.20 : Sculpted Rock asset for experimental study shows detail difference between modeling and sculpting.

Sculpting process is a step mainly for traditional workflows which mostly depend on low poly and high poly logic. In order to create a highly detailed assets artist has to use more polygon which create a problem for performance (Silverman, 2022). As the graphic cards preliminary handles low polygonal geometry rather than high poly geometry. The intention of highly detail artwork and optimization needs are often at odds with each other. Thus, artist need to find a method to create more detail but optimized geometry (Ahearn L. , 2017). In order to accomplish this purpose, artists transform geometry data to specialized textures like normal map and displacements and apply this data to low polygonal mesh. As a result, a low poly mesh looks like a highly detailed mesh in game engines (Figure 3.21).

- **Experimenting sculpting-2:** In our experimental study we used traditional workflows and procedural workflows together. The main purpose of using these two workflows was to understand the speed and efficiency in asset creation stage.

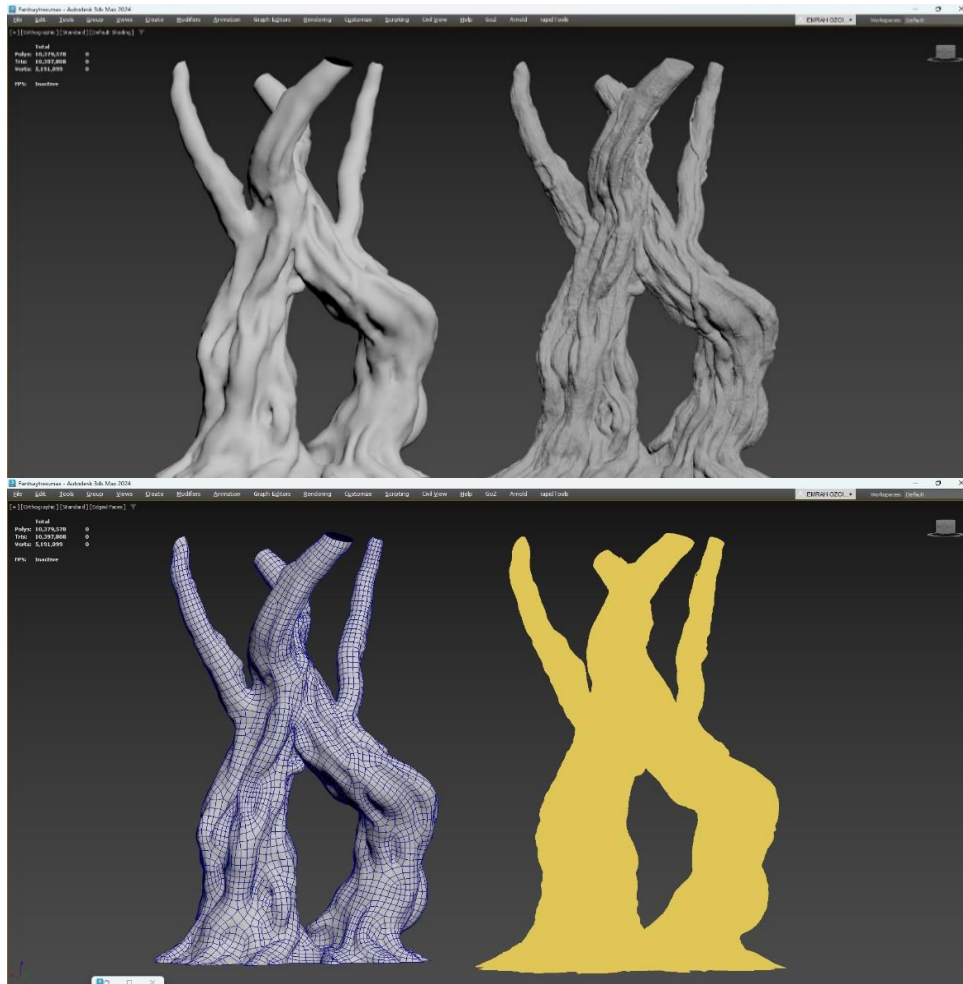


Figure 3.21 : Main Tree, high poly-low poly and detail compression (experimental study).

Overall, modeling and sculpting stages are intense and time-consuming processes in game environment creation process because of amount of manual work. Yet, artists use special workflows like procedural or traditional workflows to create high quality and efficient assets. Traditional workflows used for creating more detailed assets while also optimize performance.

3.1.5 Texturing and UV mapping

UV mapping is the process of unfolding an object surface to 2D representative form. This process also knows as UV unwrapping. This step is crucial because it define how textures will be applied to 3D surface area (Flavell, 2010). In this process artist cut 3D

model and flattening surface area onto a 2D plane. This process resulting in a 2D image called UV map (Villanueva, 2022). This process essentially creates a blueprint for texturing. A proper UV map ensure textures appear correctly on asset surface without stretching, distortion and enough texture density. All these features directly affect asset quality and performance in video game, Figure 3.22 shows main tree UV mapping.

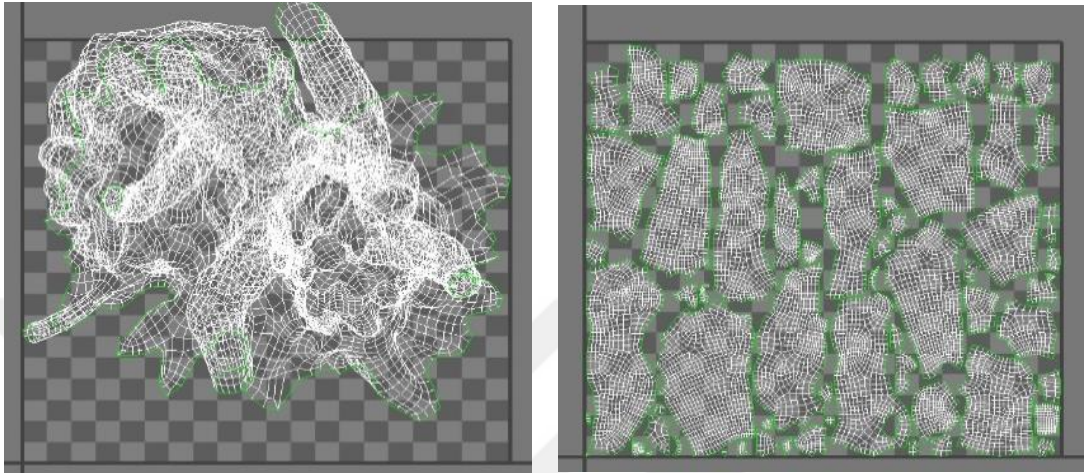


Figure 3.22 : Before and after UV mapping
(Tree Asset for experimental study).

A typical UV mapping consist of three main steps, the first step is unwrapping process, the process begins with cutting 3D model to create seams which is UV islands border. This process has to be done a with texture resolution Because UV seam may create a visual artifact.

Editing UV is further editing process after seam creation. A desired UV map uses UV space area effectively without stretching, distortion while maintaining texture density. Artist has to edit UV maps to create efficient UV maps. A common workflow for this process is having seam on hard angles and consistent on soft surface. Therefore, artist should create seam on right angles and leave curved surface as a single UV island and smoothing group (Poranne, Roi, et al, 2017).

Packing UV is the last step in UV mapping stage. In this process artists arrange UV islands within UV space while maintain maximum resolution and minimize texture distortion. UV space is a 1x1 texture space and it is expected to fit all UV islands to that area. If any case artist requires additional UV space, they may use U and V tile texture array-U DIMension (UDIM) workflows. In this technique artists use multiple

UV space for an asset, while this workflow can produce higher quality it produced textures for each UV space. This may require further optimization and packing needs.

All 3D modeling and sculpting tools has inbuilt UV mapping tools, these tools aim to give best options to make efficient UV mapping which uses most of UV area with minimum amount of UV cutting. There are tools like RizomUV and UVLayout specialized UV mapping process. These standalone tools aim to generate high quality UV maps quickly and efficiently.

- **Experimenting UV mapping-1:** In our experimental study, we used Rizom UV software to generate UV maps for all our assets. Rizom UV is a partly procedural software created to apply various UV map related task. Comparing to other software' such as 3dsmax in-built UV mapping tools or Maya UV mapping tools, Rizom UV or UVLayout tools are faster and more effective (Figure 3.23).

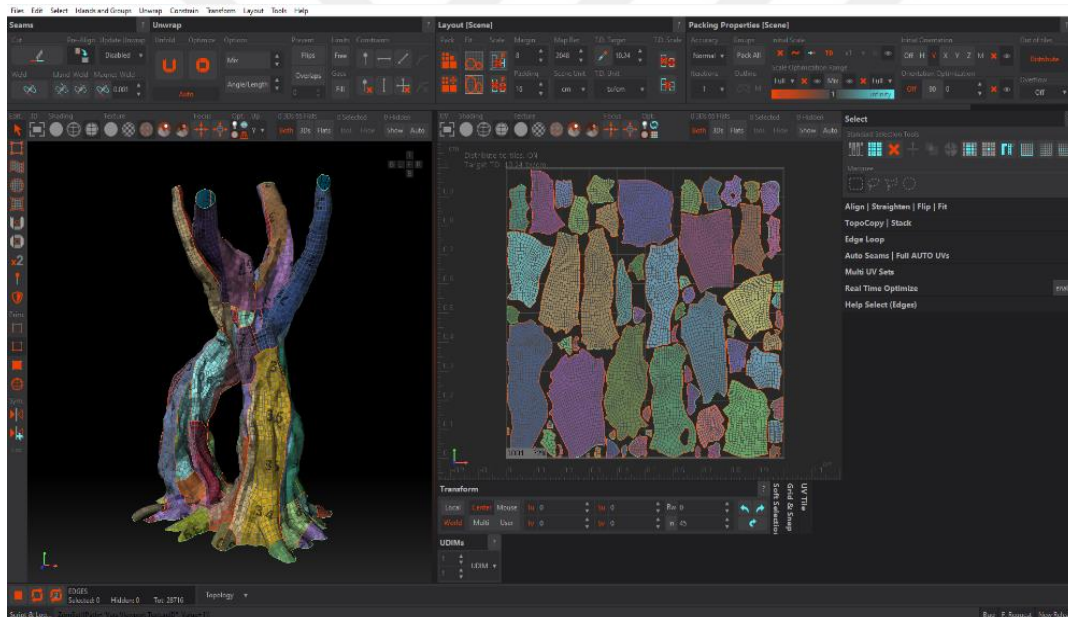


Figure 3.23 : RizomUV specialized in UV process. (UV mapping of tree asset).

Texturing is the process of applying 2D images to object surface, these 2D images are called textures. Textures are data sets contain various information's about visual attributions of a surface (Kelly H. , 2021).There a lot of data sets but most known are albedo, normal, roughness, metallic, opacity, ambient occlusion and specular maps. Each of these textures hold different information, for example albedo map define surface color information while roughness map defines how much surface rough. These maps are applied to final object based on its UV map attributes.

However, textures cannot work by themselves. Textures need to be assigned to a material component and a shader module to work. Materials are a collective of data that define how light interacts with a surface, meaning a material is a data set that tells how light will interact with assigned textures. A shader is a script created by artists to define how GPU renders or calculates materials. Textures, materials and shaders all together create the final form of attributes that allow artists to use textures within a game engine (Eberly., 2006).

Texturing can be an intense process. Artists have to decide which approach they need since there are multiple ways to accomplish the texturing stage. Artists can decide to create certain textures for terrain needs. In this case, procedural workflows may benefit to them. Substance Designer like tools use various procedural nodes to create textures, artists use nodes and blend them to create desired looking (Aaltonen, 2022). Each node within substance designer has parameters and properties to procedurally create textures. Artists can build a node graph within substance designer and play with parameters to create multiple texture variations for game environment usage. In another scenario, artists may need manual painting approaches to have full control over the texturing process, Substance Painter, Quixel Mixer like tools can be used for such needs. These tools use a baking approach to generate various maps. These maps help artists manually paint objects. Another useful approach for texture creation is photogrammetry workflow. In this workflow, artists take photos of objects or surfaces and use a scanning pipeline to create textures and objects. This approach can be useful for realistic texture needs.

Procedural texturing techniques are widely used in game environment art (Ebert, David, et al. 2002). In this method artists use procedural tools such as Substance Designer, Houdini, Gaea. These tools allow artists create rules and mathematical functions to generate textures. This technique is flexible and allows artists create multiple variations by randomizing pre-defined functions. Another important advantage of this method is scalability. Each texture in video games is resolution dependent, meaning the quality of textures depends on amount of pixels they have. In any case, artists may need to upscale the texture which makes texture blurry. But procedural textures are resolution independent, they can be scaled up without losing quality. This feature makes it suitable for use in different resolutions and platforms and provide consistent visual quality in any devices.

Hand-painted texturing involves of manually painting textures using various tools such as Substance Painter, Photoshop or Kriti. This technique offers various benefits. Hand painted texturing provide full control over artistic direction (Neppius, 2022). Artist can manually draw subtle details, story visuals and characteristic elements, in procedural texturing it is harder to have such intricate details. This technique is commonly in use because it can convey a sense of craftsmanship and artistic expression (Bubenová, 2016). Such textures, always has imperfections and visuals that express artists personality, emotions. Overall, this technique enhances aesthetic appeal of artwork. Moreover, some art style does not fully support other techniques, stylized or cartoonish art styles require artistic touch and may not fit procedural or photogrammetry techniques. Therefore, artist use hand painted techniques to create such art styles.

- **Experimenting texturing-1:** In our experimental study, we used traditional (hand paint) texturing techniques to texture one of our vegetation assets. The work was made in Substance Painter software. Traditional techniques are good for hero assets or assets requires unique looking while it takes a lot of time (Figure 3.24).



Figure 3.24 : Hand Painted leaf atlas for experimental study.

Photogrammetry technique involves capturing real world objects and surfaces to create textures. This technique requires additional tools and gears and does not scale compare to procedural techniques or hand painted methods. But since this technique uses real

world data, it creates detailed realistic textures. Such results may take additional time and cost to create with other techniques due to its complexity. Therefore, artists use such techniques to efficiently create high degree of accuracy and realism in texturing stage.

- **Experimenting texturing-2:** In our experimental study, we used all their techniques to accomplish texturing stage. In ground materials, photogrammetry technique has been used, photogrammetry is an effective technique for fast and realistic textures. We planned to have various ground plants in our environment diorama. Consequently, we used procedural techniques and hand paint techniques to create leaf textures. For main tree asset, we used hand painted methods, this method was useful for adding custom character to asset.

Photogrammetry techniques required additional equipment and certain weather conditions. Finding the desired real-world data was a challenge, but the end result was satisfactory. We used Substance Designer for creating procedural leaf textures (Figure 3.25). This technique allows us to create a variety of leaf samples for our project.

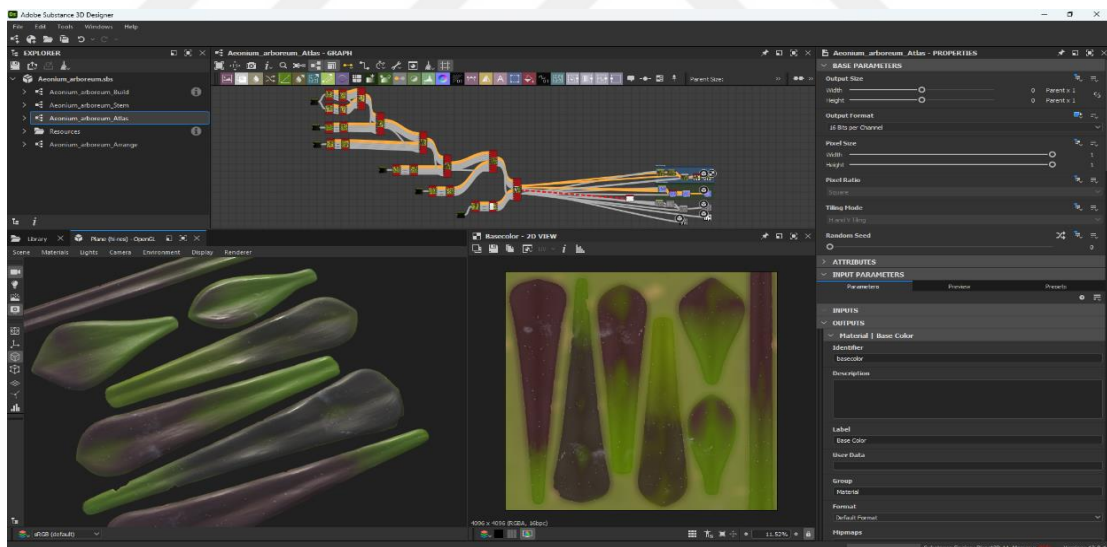


Figure 3.25 : Procedurally generated leaf atlas for experimental study (Aeonium Arboreum).

Having variations in such assets is very important for achieving a natural plant appearance. In some of our plant assets and main tree assets, we used the hand-painted method. The tree asset was modeled with SpeedTree and sculpted in Zbrush.

UV mapping was done with RizomUV tool, and the baking and texturing processes were completed with Substance Painter. This technique costs a lot of time since it

requires manual tasks. The end result was better because it allows us to add various imperfections that resemble the story and narrative.

3.1.6 Set dressing and lighting

Set dressing and lighting are final stages on an environment art in games. Set dressing include final distribution of assets and environmental elements to game world. In this stage artist placing objects like furniture's, foliage's, debris and interactive elements within game environment. Set dressing contribute to narrative, storytelling and gameplay, making it feel cohesive and as a whole. In set dressing stage artists uses various compositions techniques to create final environment scene. These composition principals not only help artist to create visually appealing and harmonious artwork, but also create a guidance for viewer's eye. These techniques convey the meaning, create balance and evoke emotions or impressions in video game environments. Lighting is a crucial stage to set mood, depth and dimension or emphasize point of interests within an environment scene. Although, lighting is a different stage, it is highly dependable to final set dressing order. Artists may use various lighting options in early stages to create prompt lighting scenarios but final lighting can only be done with a finalized set dressing process.

A typical workflow for set dressing is using level of obstruction and hierarchy to set overall compositions and cohesive looking. These principal of composition techniques are commonly in use. Level of obstruction and hierarchy include primary objects, secondary objects and tertiary objects. Preliminary objects are biggest and most dominant objects in composition. These assets are typically easily recognizable and draw player attention. Secondary objects are smaller objects adding more detail and cohesive looking to preliminary objects. These assets are generally placed to around primary objects. These objects define the relationship of primary objects and surrounding environment. Tertiary objects are smallest objects or assets for further defilements and detail, these objects generally placed between primary objects and secondary objects. They are less prominent but play a crucial role in creation sense of realism.

Another fundamental composition technique is using contrast (Freeman, 2007). This technique relay on using opposite things to create overall visual interest. In this technique artist can use colors, value, textures or shapes to draw player intention

(Drucker, 2013). Balance and rhythm are another important composition techniques. In balance method, artist use symmetrical, asymmetrical or radial distributions of objects, colors or values to arrange overall visual weight within game environment (Rivotti, Vera, et al. 2007). Rhythm, refers to repetition use of visual elements in a scene, artist tend to create many objects or details for artwork, but the end result may not visually interesting, an artwork without certain amount of repetition and rhythm may seem as noise or visual distraction. Therefore, artist may use similar elements in a game environment to create sense of rhythm and balance.

Overall, set dressing is one of the final stages in game environment art, this stage contributes to final narrative, storytelling and gameplay needs. In this stage artist create final distribution of visual elements (Figure 3.26).

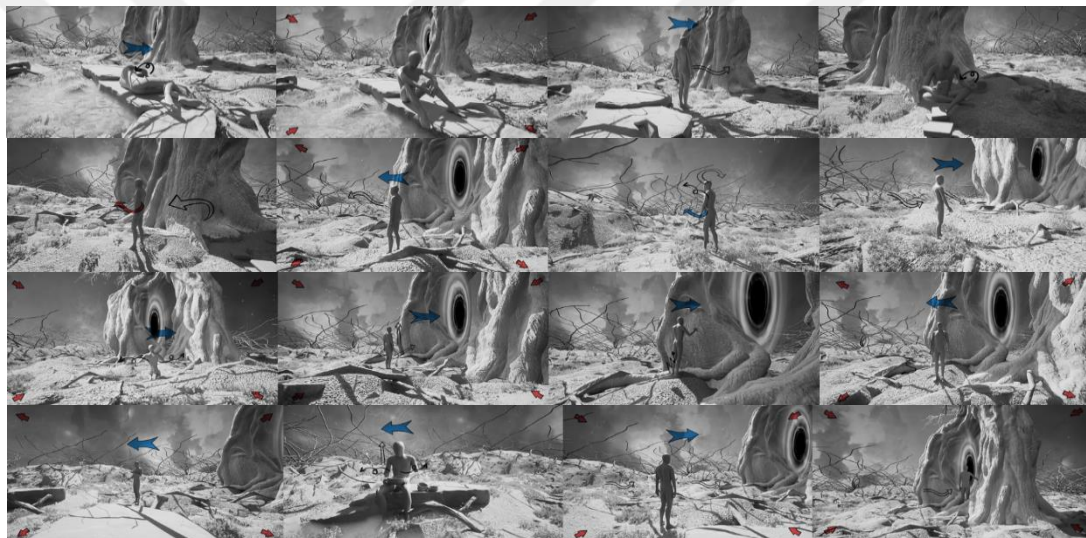


Figure 3.26 : Final distributions and story plans.

While doing, artist uses various compositions techniques to make environment visually appealing and interesting. There are many compositions techniques but most known of them are hierarchy and obstruction, contrast, balance, rhythm. It is important to note that, set dressing abilities are highly depends of artists experience and visual knowledge. Therefore, unlike other stages, this stage requires high level of experience and practice. Thus, in many game studios, such task made with most experienced artists in the team.

Lighting is final stage of game environment art, as this step relay on final order and distribution of visual elements and objects this stage remain as final step. In this step artists use various lighting techniques to evoke story emotions and expressions within

a game environment. Lighting influence the mood and atmosphere of a scene, whether it is creating a sense of warmth or tension of fear. It evokes emotions with intensity, color, or light placement and direction. Lighting in a scene create sense of time and place while also create the illusion of depth and dimension with casting shadow (Figure 3.27).

- **Experimenting set dressing and lighting-1:** In our experimental study, we used various composition techniques to perform set dressing phase. The here asset (main tree) was placed to center of the scene. We placed various small plants to create a primary, secondary and tertiary language. The colors and final lighting were created based on references. The idea was creating a warm yet mysterious multi-dimensional place for a character to live. The portal was placed between tree trunks, which indicate a connection between tree and portal. As this environment was relatively small, many other techniques discussed in preliminary study were not applied to this scene.



Figure 3.27 : Final Environment with basic character to describe activities.

3.1.7 Finalization and polishing

Finalization and polishing stages are not direct stages of environment but rather final stage of project itself. In this stage, artist, designers, and programmers check final quality and technical specifications of environment, lights, performance, collisions and gameplay before final release. This stage consists of various steps such as quality

assurance, optimization, light adjustments, player collisions, gameplay refinements (Piskunov, 2023).

In Quality Assurance (QA) checks, teams conduct quality expectations to identify and address any issue related to project. These tests include graphical glitching, texture or mesh error, lighting inconsistencies or collision like technical issues. These issues directly affect player experience. Therefore, many studios hire specialized QA tests to perform such task. In any case if QA team find a problem, artists have to turn back addressed visual elements and fix it. This step is similar for other disciplines.

Optimization tests is a need for any game project. In this step teams test performance, frame rate and loading times. This involves of further optimization of visual elements by reducing polygon count, implementing level of detail approach or light performance adjustments to ensure smooth and flowless gameplay experience.

Collision testing is another step-in finalization stage, in this step teams test player collisions to ensure player and objects interact with environment correctly. This step is important because, unexpected glitches or clipping issues are most common problems in video games. Therefore, teams man needs to further test collisions and adjust the boundaries of collisions if needed. This step ensures smooth navigation and player interaction in the game.

Overall, finalization and polishing stage are game development stages. However, they include various environment art quality and optimization test. Quality assurance test ensure all environment visual work as expected while optimization and collisions tests ensure best possible performance and smooth, flowless gameplay experience for players. As these are some of the main polishing tests, there might be more test depending to project and target platform. Gameplay refinement test and final documentation test are some of them. In gameplay tests, team ensure level layout, flow, navigation and overall gameplay work as expected. This may involve enemy placement, adjusting difficulty or fine-tune interactive elements. Final documentation and delivery test consist of testing project in various platforms define system reequipments for project and plans for future maintenance. At the end of this stage, game project delivered to publishers or distributions platforms for release. Even it is not desired have visual issued after release, testing and polishing stages may continue with real player feedbacks.

3.1.8 Analyzing preliminary study

As we discussed each environment art creation stage, there are various findings both focused on each individual stage and overall environment creation. With the help of Grounded Theory analyzing methods, the first step was getting open coding findings. For preliminary study, main subjects showed that game environment art and workflows are constantly changing and evolving. Some of the workflows and strategies were completely replaced with better or improved pipelines, the main reason for all changes are technological advancements, demand for quality and better experience. Some of the open codes were, evolving workflows, replaced workflows, improvement workflows, technological advancements, software and tool capabilities, asset creation, quality demand, testing and implementation, game engines, concept art, reference stages and texturing.

The axial coding of these findings was the common relationships between each open code. They are all based on technological advancements, software capabilities and increased demand for quality for video games. For example, project planning, concept art, reference and any changes in these stages can be grouped as planning and concept art. Similarly, modeling, UV mapping and texturing were all grouped as asset creation. Therefore, open codes can be grouped as planning and concept art, asset creation, technological impact, implementation and testing.

In Selective coding we tied all axial coding to main categories, these were categorized under 3 main groups. Planning and concept art, asset creation, implementation and testing. Planning and concept art group include changes related to project planning, concept art, reference stages. This group indicates that the industry shifted from small projects to complex projects which resulted in more digital tools and specialized roles in environment art. The asset creation group includes changes related to asset production. For example, any changes related to 3D modeling, UV mapping or texturing stages were included in this group. The last group was implementing and testing, this group includes changes for game engines, technological advancements, software implementations, testing abilities and more. For example, any changes related to game engines or rendering features included in this group.

The analyzing of preliminary study stopped in selective coding phase, single data analyzing was not enough to generate any result as there was no additional analyzing

results for data compare or sampling. The main purpose was generating selective codes for all data sets and generate theoretical sampling, theoretical saturation and memo writing after all data sets analyzed. Therefore, selective code finding for preliminary study were planning and concept art, asset creation, implementation and testing.

Below Table shows detailed analyzing steps for open coding, axial coding and selective coding of analyzing for preliminary study, selective coding passed to semi structured interview for question generation and main study for further analyzing. Table 3.2 shows preliminary study analyzing steps from open coding phase to selective coding phase.

Open coding shows key worlds can be found within preliminary study, axial coding shows what these keyboards about, for example 3d modeling, texturing and sculpting keyword are all about asset creation. Therefore, these keywords were group under asset creation axial code. The selective coding is the relationship about these axial coding. For example, shifting from small projects to big and complex projects affect both project planning and asset creation. These final selective coding will allow us to generate theoretical sampling with the help of other two studies, all these analyzing data can be seen in Table 3.2.

Table 3.2 : Preliminary study analyzing.

I-OPEN CODING • Changing workflows • Replaced workflows • Quality demand • 3d modeling • Quality demand • Software implementations • Asset production • Technological advancements • UV mapping • Software capabilities • Project planning • Testing abilities					
2-AXIAL CODING <table> <tr> <td> Planning and Concept Art: • Project planning • Concept art • Reference stages • Evolved workflows </td><td> Asset Creation: • Asset production • 3D modeling • UV mapping • Texturing stages </td></tr> <tr> <td> Technological Impact: • Project planning • Concept art • Reference stages • Evolved workflows </td><td> Implementation and Testing: • Game engines • Software implementations • Testing abilities • Changed workflows </td></tr> </table>		Planning and Concept Art: • Project planning • Concept art • Reference stages • Evolved workflows	Asset Creation: • Asset production • 3D modeling • UV mapping • Texturing stages	Technological Impact: • Project planning • Concept art • Reference stages • Evolved workflows	Implementation and Testing: • Game engines • Software implementations • Testing abilities • Changed workflows
Planning and Concept Art: • Project planning • Concept art • Reference stages • Evolved workflows	Asset Creation: • Asset production • 3D modeling • UV mapping • Texturing stages				
Technological Impact: • Project planning • Concept art • Reference stages • Evolved workflows	Implementation and Testing: • Game engines • Software implementations • Testing abilities • Changed workflows				
3-SELECTIVE CODING • Planning and Concept Art: Digital tools and specialized roles enhance project planning, concept art. Shift from small projects to complex projects. • Asset Creation: Advanced modeling and texturing tools streamline asset production. Workflows and strategies evolve and are replaced due to new technologies and quality demands Technological advancements drive changes in tools and methods. • Implementation and Testing: Modern game engines with advanced features improve implementation, testing processes, debugging and performance.					

3.1.8.1 Planning and concept art

Analyzing under planning and concept art theme mostly examined workflow and methods changes for project planning, concept art and idea developing. These includes programmers and tools for better and detailed concept art needs and control

mechanisms for project planning and monitoring. Some of the most striking changes in this are that we observed in preliminary study were increasing share of digitalized content over manual and hand paint, the specialization of artists and designers in more specific areas and increase amount of expectation for game projects. For example, at early stages of game development, there was no need for detailed concept arts or project planning, because projects were not complex while game visuals were simple and 2 dimensional, because of technological advancements on computer hardware and tools for specific needs, modern 3D games developed, these games were complex and required professional planning and concept art needs. Furthermore, these needs required specialized artists. So, at the early times of game environment arts, there were a small team for project planning and concept art, these are called generalist artists. However, in modern video games, there are specialized artists for concept art, prop art, lighting and more which require new tools, jobs and workflows. COVID-19 like factors emerged the development in collaborations workflows methodologies and remote working models.

There are mainly three types of working models in game industry, working on site, working hybrid and working remote. At first, majority of game studios were using on site working models.

Planning and reference stages were very first environment art creation stages. Based on open coding analyzing technological advancements and quality demand greatly effected these stages and changed them. This stage was a stage for all planning, referencing and concept art phases. Very first planning and conceptualization techniques were hand drawings and paper sketches. With the advancement of technology and tool improvements, these methods replaced to new digital drawing techniques and approaches. Photoshop, Procreate, Krita like software's are current concept art tools. Photoshop was very first tools for digital content creation, these tools allow artist draw their design while also manipulate their content in various way. Procreate and Krita like tools were created based on Photoshop like tools, these are similar tools but specifically created for concept art and daring purposes. Additionally, there are recent tool implementation for platforms only. For example, Procreate only uses MacBook (OS) platform, so it does not work for any other platform. Furthermore, with the increased complexity of game development, planning and concept art separated to two different stages.

In the early years of game development, planning and conceptualizing a game were made by same artists while in modern video games there are large group of artists separately managing and creating plans while some of them only creating concept arts. Later on, concept art stage required specialized artists, these artists are specialized artist for creating key concept and concept art for game environments, game elements, assets and more.

There were some improvements on planning stage, especially with COVID-19, many studies had a remote based working approaches, therefore there were cloud-based tools for game planning, tracking tools for game environment. Some of these tools are Jira like tracking and managements tools, SVN, perforce like repository tools and Miro, Pureref like referencing, planning tools. These advancements referred to collaborative workflows and feedback-based work approaches. Nowadays, these workflows and method changes are actively in use by many art studios teams that has remote based work models.

Recent AI tools have many new improvements in both planning and concept art stage. AI tools like Midjourney, Stable Diffusion are tools for concept art creation. AI tools has increased capabilities for planning, tracking purposes. However, as we experienced in experimental study, visual creation tools (Midjourney, Stable Diffusion) have some limitations for legal registration and copyright (Xiang, 2022).

Overall, planning stage were separated to planning and concept art stages, manual and hand painted methods replaced to modern digital approaches. These two stages have respective tools and applications developed for their purposes. These tools have learning resources and usage examples. Starting from 2020s AI emerged to these stages. However, there are legal some legal problem for usage of AI in concept art due to AI training methods and training sources (US Copyright Office, 2023).

3.1.8.2 Asset creation

Analyzing under the asset creation category provides any literature changes related to asset creation stages. In this case, any changes or improvements in blackout-proxy mesh, modeling-sculpting, and UV-texturing stages. Similar to planning and concept art stages, preliminary studies show that primary developments in vector graphics and 2D workflows were replaced with modern 3D workflows. Meanwhile, there is an increasing number of automated, procedural workflow usage, while traditional and

manual workflows such as box modeling and subd modeling have been losing their popularity. Furthermore, instead of a handful of popular tools, there are an increasing number of tools for very specific needs such as terrain generation, plant generation, and more. In addition to that, starting from the 2010s, technological improvements have led to an increasing number of photogrammetry, procedural, and modular workflow usage.

AI, similar to the previous category, has some usage in asset creation stages, particularly in texture, pattern generation methods and depth map generation.

However, complex 3D asset creation and intricate procedural generation are not yet possible with AI. Early pixelated art creation stages were replaced to low poly 3D software tools. These software's were helped to create first 3D video games and environments. Starting from 2000s developments improved 3D modeling tools were actively used in traditional workflows. These workflows consist of a low poly meshes, manual modeling methods and UV painting techniques. In this method artists create required assets and UV map the asset. The final UV map was rendered as an image, after that artist import these UV maps into Photoshop and start manually paint this UV map outliner. These approaches were changes after some of improved texturing and software advancements. In new methods there were low poly meshes and highly poly meshes. Artists uses regular modeling tools to create low poly meshes, however with the help of modeling tools and sculpting tools artist was able to create detailed or sculpted high poly models. Later on, high poly mesh details baked into low poly mesh to have small details on low moly mesh (detail often means more geometry, higher poly count and lower performance). These tools supported with various sculpting tools such as Zbrush and Mudbox while also Substance painter like software's helped artist to use PBR workflows in texturing stage These workflows create various surface features such as roughness and metalness to mimic realistic lighting and accurate surface imperfections.

Coming to recent years, procedural and parametric workflows start to partly replace manual and time-consuming workflows, box modeling and subd modeling. Although the dominance of traditional workflows remains strong, there were increased amount of procedural workflow usage. This was mostly because increased amount of large open world needs and various methods to create or distribute natural elements across terrain. Furthermore, procedural or parameter-based workflows create more natural

visual while also provide high level of control and quick iterations. However, comparing to traditional workflows, procedural workflows are not suitable for characteristic assets, as procedural workflows create more randomized and natural looking while traditional workflows are suitable for hand paint art styles like stylized or cartoonish art styles.

In 2010s, photogrammetry-based workflows introduced in game environment art workflows, this workflow aims to create highly realistic environmental elements by scanning real world objects like vegetations, rocks, terrain parts and surface. The end result of this workflows was referred to stage elimination and asset library workflows, that means entire asset creation stage was replaced with various scanning, geometry and texture constructions. However, this workflow requires equipment's such as camera, color checker, drone. These workflows require suitable environmental conditions such as overcast weather and calm environments (wind, rain) for scanning and capturing process.

Last few years, the emerge of AI workflows has been increased. AI can create various tile able (seamless) texture across objects and generate basic 3D models for asset creation stage. However, similar to previous stages, amount of learning resources, legal obstacles, and quality level didn't match current needs. AI workflows may need further definition, improvements and legal base in future.

Overall, early pixelated art creation techniques were replaced to low poly models and traditional workflows, these workflows had many advancements and developments, including high poly modeling and sculpting. Due to time consuming and manual nature of these approaches, automated or algorithm-based workflow dominance increased. Photogrammetry, real time features are recent workflows for environment art creation while AI tools have basic practical base due to legal, copyright, quality level and tool requirements.

3.1.8.3 Implementation and testing

Implementation and testing analyzing for preliminary study consist of several changes on game engines, real time workflows, additional VR/AR platform supports and various debugging systems for testing. As the projects become more and more complex, there were greater needs for debugging and performance monitoring. In time,

advanced game engines allow artists and studios create content for various platforms such as mobile, personal computer (PC) and console.

Implementation and testing abilities were another aspect of game environment creation. These development stages have many improvements and changes. Editors like Doom Editor and Quake Editors were replaced to early game engines like Unreal Engine 2 (UDK 2). Similar to this, early debugging and performance testing tools were replaced to editor's default performance profiles. Early day performance needs were heavy which aided to modular workflows and optimization-based methods.

Starting from 2000s, Unreal Engine 3, Unity like specialized game engines were arrived. These engines used dynamic lighting features and PBR workflow methods to accurate light calculations. Moreover, these tools introduced very first Procedural Generation (PCG) features for in editors use. Similar to these features, UE3 and Unity like modern game engines included real time feedback abilities, performance profiling and optimization and in game testing capabilities.

Nowadays, with the help of advanced game engine like Unreal Engine 5, traditional workflows were started to replace by Nanite and Lumen like features. Besides, these tools support ray tracing, path tracing and various procedural features or procedural approaches (PA) for more creation possibilities. AI implementation to game engines limited but offer numerous testing tools, fast feedback and bug detections and more. Also, cloud-based collaboration tools and teamwork workflows are now usable in game editor.

The need for higher quality video games and realistic visuals implemented to video game industry with Unreal Engine 4 and Unity 5. The engines supported real time, interactive, global lighting and procedural workflows for video games. These engines were supported by real time testing and VR/AR platform support for experience needs.

Below Table 3.3 shows various workflows and their first project usage, target stage and reason to use.

Table 3.3 : Workflows and their usage (reason, target stage, project used).

Period	Workflow	Project Use	Reason	Target
1980s	Traditional	Pac-Man (1980)	Limited hardware capabilities required efficient, artist-driven texture creation.	Texturing, modeling
Mid 1990s	3D Polygonal	Virtua Fighter (1993)	Advancements in hardware enabled 3D rendering, leading to the adoption of polygonal models.	Modeling
Late 1990s	Modular	Half-Life (1998)	Efficiency in asset creation and ease of reusability across different levels.	Asset creation
Early 2000s	Procedural	Rogue (1980)	To create vast, varied worlds with limited manual input.	Level design
Early 2000s	Normal Mapping	Doom3 (2004)	To add detailed surface textures without increasing polygon count.	Texturing
2010s	PBR	Star Citizen (2014)	To achieve more realistic and consistent material appearances.	Texturing
Mid 2010s	Photogrammetry	Battlefield (2016)	To create highly realistic textures and models	Asset creation
Late 2010s - 2020s	Collaborative	Remote work tools (2020s)	COVID-19 pandemic, the adoption of remote collaboration tools and workflows.	Entire pipeline

Overall, early editors were replaced by game engines like UE2, these engines came with many testing and optimization features. The need for high quality yet optimized environment creates modular workflows. PBR workflows, procedural workflows, real time feedback aptitudes were introduced with UE3 and Unity game engines. These engines supported extensive performance profiling tools for artists.

In 2010s Unreal Engine 4 and Unity 5 game engines supported real time interactive environments, global lighting and various procedural tools with VR/AR like platforms. Currently, Unreal Engine 5 has Nanite and Lumen like features for higher geometry capabilities and realistic global lighting needs. This may replace traditional workflows

entirely. AI implementation for game engines is ongoing process while collaborative and team workflows-based tools are available within game editor.

3.1.9 Analyzing experimental study

Experimental study analyzing measures practical base of preliminary study and performance of each selective coding. Similar to preliminary study open coding, axial coding and selective coding findings were prepared. Theoretical sampling and theoretical saturation phases were prepared in main study. Experimental study showed that automated workflows like procedural workflows are much faster than traditional workflows. However, automated workflows may lack unique characteristic features on assets or environments. AI can greatly improve project planning and documentation but was weak on other stages. Additionally, as one of preliminary finding was industry shifting from simple projects to complex projects this mirrored to practical base. There a specialized software's and tools created for specific needs. Therefore, instead of single tool for multiple purposes, there are multiple tools for specialized needs.

Below, Table 3.4 shows detailed analyzing steps for open coding, axial coding and selective coding of analyzing for experimental study, selective coding passed to semi structured interview for question generation and main study for further analyzing.

Open coding shows various key worlds. In this phase we read whole text transcripts form experimental study and created key world for each section. These key words were group in axial coding, particularly with help of their close relationship. For example, advancements, procedural workflows and asset creation created a group as automated workflows for asset creation. These data analyzing passed to selective coding phase. For example, asset creation, technological advancements and automated workflows create a selective code like; the shift towards automated and systematic workflows increases efficiency, with procedural, parametric, and modular workflows replacing traditional methods. These selective coding will be discussed with other two selective coding from main study and preliminary study. For example, shift from small projects to big and complex projects was one of selective coding of preliminary study and shift from traditional workflows to automated workflows was one of experimental study selective coding. In this case, the question is, is there any relationship between small to big projects and manuel workflows to automated workflows. We will be discussing these questions with the help of next study, the main study.

Table 3.4 : Experimental study axial coding and selective coding.

1-OPEN CODING

- advancements • modeling • asset creation • automated workflows
- systematic workflows • AI workflows • traditional workflows
- procedural workflows • parametric workflows • modular workflows
- advantages • disadvantages • specialized software • specific tasks
- few software • multiple tasks • specialized software specific goals
- lack of uniqueness • lack of story elements • procedural workflow

2-AXIAL CODING

- **Workflow Evolution and Efficiency:**
 - Trend towards automated and systematic workflows
 - Procedural, parametric, modular workflows replacing traditional methods
 - Efficiency gains in automated workflows over manual ones
 - Workflow implementations for AI may be a trend, legal requirements.
- **Specialized Software and Tools:**
 - Use of specialized software for specific tasks
 - Transition from few multipurpose tools to specialized tools with specific goals
 - AI has potential but expensive and limited software.
- **Advantages and Disadvantages of Workflows:**
 - Automated workflows efficient for quick, complex asset creation but lack uniqueness
 - Traditional workflows suitable for hero assets and story elements but slow in iteration and production
 - AI improves concept art and reference stages but limited.
- **Role Specialization:**
 - Separation of game environment art stages into specialized roles
 - Shift from generalist artists to multiple specialists for each stage

3-SELECTIVE CODING

- **Workflow Evolution and Efficiency:**
The shift towards automated and systematic workflows increases efficiency, with procedural, parametric, and modular workflows replacing traditional methods,
- **Specialized Software and Tools:**
The industry's movement from a few multipurpose tools to specialized software enhances specific tasks in asset creation, exemplified by tools like Substance Designer for texturing and SpeedTree for vegetation.
- **Role Specialization:**
Modern game environment art stages require specialized artists for different tasks, moving away from generalist artists to teams of specialists, ensuring higher quality and more efficient workflows.

The advancements of modeling and asset creation techniques has many improvements. Instead of fully manual workflows. There is a trend for more automated and systematic workflows. Traditional and time-consuming process were replaced with procedural, parametric, modular workflows. The capabilities of manual workflows and procedural workflows measured in experimental study. In experimental study we aimed to create a few vegetation assets. The creation process, techniques and workflows performances are as follows.

As it is visible in Table 3.5, automated workflows are much more efficient than manual workflows. A comparison between similar assets shows that amount of time and required software expertise/count are greatly differing.

Table 3.5 : Procedural and Manual Workflow comparison (Experimental Study).

compassion Parameters		
Name of Asset	Aeonium Arboreum/Ground Plant	Cordyline Fruticosa / T-Plant, Ground Plant
Used Workflow	Procedural Workflows (Automated)	Traditional Workflows (Manual)
Process Summary	Asset creation consist of planning and reference gathering, atlas creation and manual assembly of geometry.	Asset creation consist of planning and reference gathering/ modeling base/sculpting high poly/ baking low poly/ Hand painting/ manual assembly of geometry.
Outcomes	• Infinite number of variations • Nondestructive and automated • Parameter based changes within seconds.	• Only one variations • Destructive workflows • Asset needs to be created again if any changes require. (from start or problematic stage)
Time	• Planning and • Atlas creation 8 Hours • Manual Assembly 2 Hours Total=10 Hours	• Planning and base modeling 2 Hours • Sculpting High Poly 22 Hours • Baking and Hand Painting 8 Hours • Manual Assembly 2 Hours Total=34 Hours
Required Software	Pureref, Substance Designer, 3Dmax/Unreal Engine	Pureref/3Dmax/Zbrush/MarmosetToolbag/ Substance Painter/Unreal Engine

Another finding was, for each specific task there were specialized software's to perform it. In early days of game environment art workflows, there were a few software to perform many tasks. While in modern day workflows there are specialized software's has very specific goals. Some of examples showed below (Table 3.6).

Table 3.6 : Software's used for experimental study vs their ancestor.
(Experimental Study).

Software Name	Photoshop	3Dsmax, Maya	UDK (Engine)
Ancestors=Column Modern=Raw			
Substance Painter	Hand Paint Texturing	-----	-----
Substance Designer	Procedural texturing		
Zbrush	-----	Modeling, Sculpting	-----
UE		-----	Game Engine
Pureref	Planning, Reference	-----	
SpeedTree	-----	Vegetation Generation	-----
Gaea	-----	Terrain Generation	-----
Marmoset Toolbag	Baking Hand Paint Texturing	-----	Presentation
RizomUV	-----	UV mapping	-----
Topogon	-----	Retopology	-----

As it is visible in above Table (Table 3.6, only include tools used for experimental study), comparing to older approaches there are new software's for specific tasks. For example, Photoshop was used for all texturing and painting purposes while now there are specialized tools for hand paint texturing, procedural texturing, baking and more. Likewise, 3Dsmax and Maya like software's were used for modeling and general 3D object creation while in modern workflows there are specialized application for specific asset type and task type. SpeedTree and Gaea are specialized packages for vegetation and terrain like assets while RizomUV and Topogon for specific tasks like UV mapping and Retopology.

Similar to previous findings, workflows have advantages and disadvantages for certain tasks. For example, a procedural workflow often good for creating complex asset quickly while these assets may not have unique characteristic features or story

elements. Likewise, traditional workflows are good for hero assets or story elements while may not be useful for quick iterations or production, some of examples showed below, all these workflows were used in experimental study (Table 3.7).

Table 3.7 : Workflows and their potential usage (Experimental Study).

Workflow Name	Usage
Modular Workflow	Modular Workflow are involving of creating reusable asset parts, this part can be assembled in different combinations to build environment scene. This workflow is useful for architectural elements, or constructed elements within environment scene.
Asset Library Workflow	Asset Library workflows are useful for asset management and reusability across different project or environment level. This workflow can save a lot of production type while help artist create a cohesive looking in environment.
Photogrammetry Workflow	This workflow involves of generating asset from real world assets. This workflow is useful of highly realistic and detailed scene needs.
Traditional Workflow	This workflow is useful for artistic, key assets, assets have a character or unique looking. However often takes more time.
Procedural Workflow	This workflow is useful for creating verity of asset or open worlds quickly. It allows artists dynamically create highly detail elements However these elements may not have character or artistic expectations.
PBR Workflows	This workflow is useful for visual realism, accurate lighting needs.

Through the improvement of technologies and demand for better game experience. Game environment art stages were separated to specialized artists. Meanwhile instead of one generalist artist for environment art creation, there are multiple specialists for each stage or each type of environmental assets.

3.1.10 Results

In order to understand results for preliminary and experimental study, we need to evaluate thesis goals once more. Based on our research questions, one of our goals is understand current workflows in video game environment art. With the help of preliminary study and experimental study this goal accomplished. Both preliminary study and experimental project allow us to validate current literature and observations.

In each environment art stage, we detailed and experimented various art stages and methods available within game environment art field, this allowed us uphold current workflows and understand if certain methods are still available or replaced and has a practical base availability.

Another research goals were identifying strategies for improving and developing workflows. Based on preliminary study various strategies suggested and experimental project can be seen as a tool to validate these suggestions.

It is essential to acknowledge that experimental study may be limited based on sample size, scope, team dynamics or tool and technological availabilities, additional strategies may be available and experimental study may not cover them. Therefore, it is not safe to say, preliminary study and experimental project encompass all potential strategies or nuances. As a result, this goal will be further addressed with main study.

Our last goal was understanding how game environment art workflow evolved and what is artist role in this evolution. Although, preliminary study added some nuances to this question with addressing technological advancements or tools for workflow evolution, this understanding was limited and may need larger sample size with more perspectives. Therefore, this goal needs further insights within main study.

Overall, preliminary study allowed us to understand and validate literature while experimental study helped use for deeper understanding of current workflows and their practical applications. This study goals were, understanding current game environment art workflows; identifying strategies for improving or developing workflows, understand how game environment art workflows evolved and artist role within this evolution. The first goal was accomplished while second goal only partly succeed because of project limitations. Third goal was also not fully achieved. Therefore, main study will be additionally focusing these two research goals.

3.2 Main Study

This section of thesis proceeds with detailed description of participant selection and recruitment methods; interview protocol design, validation, data collection and analysis methods. Participant selection and recruitment process include criteria for participant selection and methods for finding participants. Following this, data collection methods for this thesis are defined, which involves of preliminary data, experimental data and main data.

All three studies used Grounded Theory to complete and support each other. Preliminary study and experimental study were created for research topics special requirements while these two studies allowed to collect data from real life and real experiments. Process of these two studies generated further data and understanding as there was literature gap for research topic. Both preliminary study and experimental study used to create semi structure interview framework while interview data, preliminary and experimental data used for final and most important study, the main study.

There was total 3 data set for this research. Preliminary data was from early existed literature and observations while experimental data was based on practical base of preliminary data, the last data was main data which was semi structured outcomes from interviews.

Data analysis and interpretation process are discussed which include Grounded Theory analyzing methods. For this purposes, preliminary data, experimental data and main data analyzed and open coding, axial coding, selective coding of these studies were generated. Main study used generate selective coding for final theories and result for thesis.

This main study consist of analyzing selective coding of all data sets and generate theoretical sampling, theoretical saturation, memo writing steps and final theories for research. Theoretical sampling is a step of grounded theory where researcher joins selective codings to create initial theories and decide if data sets are enough or additional data required, theoretical sampling phase is a interactive phase, meanwhile additional data inputs possible. Theoretical saturation is next steps where there is no additional data and data sets unable to generate new theories or variations. The final step is memo writing. In this step research saves initial findings and examine if initial

theory reached final saturation. At the end of this process, researcher write final theories and results for research.

3.2.1 Participant and criteria

To explore game environment art workflows by gathering insights from industry experts, four game industry experts in environment art field were selected as participants of this study. The participant were carefully selected based on some criteria including extensive experience in game industry and their expertise in game environment art. In order to ensure the validity of study, a set of selection criteria, methods and confidential documents were needed. This section of thesis will discuss the selection criteria of participant as well as recruitment process. Additionally, as this study is an academic work, the procedures for informed consent and confidentiality will be presented.

For this study, participants were selected based on their relevant field, years of experience and availability. To be considered, participants needed to have at least 3 year game environment art field experience. Additionally, participants were selected to represent a range of backgrounds and experiences within the field, this was important to discuss research topic in various perspectives. A list of potential participants was compiled and contacted in order to participate in the study. In cases where a participant was unavailable, the next potential participant on the list was contacted until a minimum of 4 participants were secured for the study.

3.2.2 Recruitment methods

In order to find participant for this study, various recruitment methods including professional networks, online forums and referrals has been used. Professional networks such as Artstation and LinkedIn were most effective method of recruitment process. These networks are known formal information about artists such as their CV or relevant artworks and give required data for participant selection criteria. For this we contacted with industry experts which has our selection criteria and requested their contribution. This approach helped to ensure our study has enough professional for our research goals.

Apart from professional networks we also adopted a referral method to find additional participants. For this we asked artist from professional networks or participants to refer

experts who can potentially contribute the study, we reached them through networks and asked for their assistance.

Online forums were another useful recruitment methods, online forums alike game development communities were searched for potential participants who fit our study criteria. These methods adopted in case first two methods cannot utilize required participant number. Overall, professional networks, referral methods used as main recruitment methods while online forums used as an additional method in case any other participant requirements.

3.2.3 Confidentiality procedures

Wester (2011) says that researchers must make efforts to protect participants in any study that has an ethical threat, such as fishing for specific results with interview questions or samples provided by participants or contributors. It is important to ensure the structure and outcomes are fully secured and participants are aware of the potential benefits and risks of the study.

Since semi-structured interview is our main data collection method, we asked the participants' permission to record the interview process and inform the participants that their names or organizations will not be named and instead will be demonstrated as P1 for the first participant, P2 for the second participant, and so on. The whole interview process has been deleted once data collection and analysis are complete. It must be noted that the research topic and motivation were our own interests, but they were prepared under Istanbul Technical University (ITU) ethical community guidelines, and ensured the whole interview process matches ethical requirements.

3.2.4 Data collection and types

This study structured with three data type. The first data was preliminary data, this data was based on early literature and observations. This data collected with the help of various academic data bases including Google Scholar, IEEE, ResearchGate. Besides, some of reliable industry-based portals including 80.lv journal and Artstation were some of study' resources. These journals include direct artistic vision which was important for this study. The second data was experimental data. This data created based on preliminary data to identify practical base of preliminary study discussions. Experimental study was a practical study for this need. Therefore, we created an

experimental project based on preliminary data. In this study, we created a dedicated environment art project named ‘Living in the Bubble of Love’. This study focused preliminary data and measured the practical base of it. The last data set was semi structured interview data. Based on preliminary study and experimental project, a set of interview questions were prepared. These questions were used for semi structured interview, this interview data, preliminary data and experimental data used for main study (Figure 3.28).

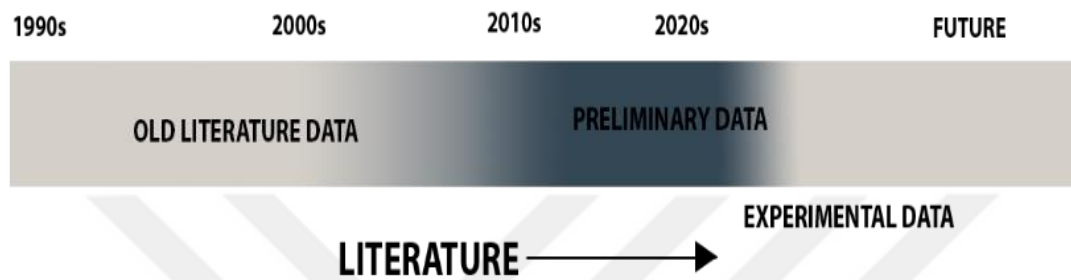


Figure 3.28 : Data types (preliminary data and experimental data).

3.2.5 Semi-structured interview layout

This section of study discuss decision making of interview layout to accomplish research question goals. These goals were, understanding current game environment art workflows; identifying strategies for improving or developing workflows, understand how game environment art workflows evolved and artist role within this evolution (Table 3.8). The first goal was accomplished with preliminary study while second goal only partly succeed because of project limitations.

Third goal was also not fully achieved. Therefore, main study and semi structured interview will be additionally focusing these two research goals.

Table 3.8 : Research questions.

Research Question 1: What are current workflows in game environment art context?
Research Question 2: What are strategies for artists to plan, change, improve, or develop workflows for production needs?
Research Question 3: How workflows evolved and specialized for modern video game environments and what is artist role in this evolution?

The second research goals were identifying strategies for improving and developing workflows. Based on preliminary study various strategies suggested and experimental project can be seen as a tool to validate these suggestions. It is essential to acknowledge that experimental study may be limited based on sample size, scope, team dynamics or tool and technological availabilities, additional strategies may be available and experimental study may not cover them. Therefore, it is not safe to say, experimental project covers all potential strategies or nuances. As a result, this goal will be further addressed with main study.

Our third goal was understanding how game environment art workflow evolved and what is artist role in this evolution. Although, preliminary study added some nuances to this question with addressing technological advancements or tools for workflow evolution, this understanding was limited and may need larger sample size with more perspectives. Therefore, this goal needs further insights within semi structured interview. Overall, preliminary study and experimental study helped to understand one of our research goals while only partly describe remaining two research goal. There were several reasons such as sample, size and scope of our preliminary project and experimental project. Additionally, both studies made with us and may not include anything about team dynamics and additional perspectives. Therefore, all our interview questions will focus remaining research goals and will not additionally discuss first research goal. Likewise, these interview questions will intentionally focus different perspective, participant within team dynamics with various projects, size and scope. Based on our decision-making interview layout will be as Table 3.9.

Table 3.9 : Research questions, decision making.

Research Question 2: What are strategies for artists to plan, change, improve, or develop workflows for production needs?

- Q1: Could you explain your definition for workflows and provide a brief overview of your typical workflow when working on a game environment art project?
- Q2: Can you share examples of innovative workflow strategies or methodologies that have proven effective in your environment art production pipelines?
- Q3: How do you adapt environment art workflows to meet project-specific requirements or constraints, and what strategies do you employ to do?
- Q4: In your experience, what key parameters contribute to the efficient planning, adaptation, or improvement of a game environment art workflow?

Research Question 3: How workflows evolved and specialized for modern video game environments and what is artist role in this evolution?

- Q5: How do you approach changes or improvements to the workflow during the production?
- Q6: Are there any notable differences in workflow approaches between different types of game environment projects (e.g., indie, AAA), and how do these differences impact the role of artists in workflow evolution?
- Q7: Looking ahead, what do you see as the future direction of environment art workflows, and how do you see artists contributing to shaping this evolution?
- Q8: Can you briefly explain how game environment art workflows evolved over time and how this evolution affects your approach? (Asking your thoughts about workflow changes during your career regarding any stages of environment art creation and how it affects your workflow)

3.2.6 Analyzing and findings

This section of research discusses final analysis and findings based on these analyzing. The participant is recruitment mostly artists and designers whom working in both art studios and production companies. The interview process was conducted within 5 business day Following by 10 days for analyzing process. The analyzing process uses Grounded Theory analyzing methods. In this section, open code, axial code and selective code of semi structured interview created. These selective codes and

preliminary study, experimental study selective codes used for final theoretical sampling, theoretical saturation and memo writing.

3.2.6.1 Analyzing

Questions created from preliminary study and experimental study are asked to participants. Based on participant answer and interview questions. All answers were analyzed with open coding, axial coding and selective coding. The final selective coding was grouped under 3 main categories. The first category was Workflow understanding, innovative strategies and workflows adaptations.

This group categorize participants current workflows, their unique approaches and adaptation strategies First 3 answers of all participants are generally about this category. The second category is workflow planning, improving and changing. This category group and takes anything about workflows planning, improving or changing. 4-5-6 questions answers were under this category. The last category was workflow evolution and artist role over time and mainly focuses participants answers for their workflow development thoughts and future direction of workflow. Last two questions were focused this category. Table 3.10 shows analyzing for interview.

Table 3.10 : Open and axial coding analyzing for semi-structured interview.

I-OPEN CODING -Planning, project requirements -automated workflows, systematic workflows, AI -workflows, adaptation, experience - Traditional workflows, procedural workflows, parametric workflows, modular workflows	-Future direction, consumer needs -Technological integration -Base workflow -Experimentation, prototyping -Artist role, skills, feedback, communication
2-AXIAL CODING Category 1: Workflow Understanding, Innovative Strategies, and Adaptation Core Concept: Understanding and adapting workflows to meet project needs. Planning and Structuring: Emphasizing detailed planning and organized structuring (PI, P3). Adaptation Based on Project: Adapting workflows to suit project requirements (P 1, P4). Preference for Traditional Methods: Maintaining traditional approaches with iterative feedback (P2).	

Table 3.10 (Continued) : Open, axial coding analyzing for semi-structured interview.

Category 2: Workflow Planning, Improving, and Changing Core Concept: Effective management and continuous improvement of workflows. Comparison and Calibration: Using similar works for benchmarking (P1). Experimentation: Testing new methods through experimental projects (P1, P2). Importance of Skills and Communication: Relying on technical skills and team communication (P2, P 3). Category 3: Workflow Evolution and Artist Role Core Concept: Evolution of workflows influenced by technology and artist roles. AI and Automation: Exploring AI for future workflows (P1, P4). Artist's Influence: Artists shaping industry trends and perspectives (P1, P2, P3). Shift from Manual to Automated: Moving towards more automated workflows (P1, P2). Dependence on Consumer Needs: Future workflows shaped by consumer demands (P2).
3-SELECTIVE CODING • Workflow Understanding and Adaptation: Detailed planning and structured approaches are crucial, with adaptations based on specific project requirements. Traditional methods are valued for their iterative feedback process. • Workflow Management and Improvement: Effective workflow management involves benchmarking, experimentation, and leveraging technical skills and communication. Workflow Evolution and Artist's Role: The future of workflows is increasingly automated, influenced by AI and procedural methods. Artists play a pivotal role in shaping industry trends, with workflows evolving to meet consumer needs.

- **Workflows understanding, innovative strategies and adaptation.**

Workflows understanding and innovative strategies were asked in first 3 questions. Participant 1 (P1) define workflows as a blueprint and emphasizing the importance of planning stage, they stress the importance of structural approaches, participant shared insight about it, which is “ I start with idea and planning stage; I think this step is very important because this step define everything from start too final art work. It is always a good idea to spent more time in this stage” and they continue with the importance of structured

approaches, which is'' One special treatment would be creating folders for each step and make sure all the creation process is on the same folder. So, instead of saving your work in random places, it is a good idea saving them in a folder so that you can find or link them across all tools''. P1 uses modular workflows and indicate its frequent use in industry.

P1 says adopting new workflows can based on project reequipments and emphasize the importance of project needs while evolution workflows options such as asset library workflows and procedural workflows.

Participant 2 (P2) define workflows similar to P1. They mention about procedural and modular workflows but express their preference for traditional approaches. P2 outline a general approach and they emphasize feedback iteration. P2 stress this as follows *“I think all artists should have a basic feedback workflow for any environment art creation stages.”*

Therefore, they can improve their final artwork. They discuss the effectiveness of asset library workflows and real time technologies, emphasizing being practical and time saving aspects of both real time and asset library workflows. Similar to P1, P2 also stress the importance of planning stage while adding a unique aspect.

They say *“I would try to balance workflow choices with project reequipments’, it is important to note that, workflows limitations may mostly depend to our own skills and experience level. Therefore, if our skills and experience level are not enough, we may not be able to define project reequipments’ a result, my strategy is to understand project reequipment, my skills and a balance in between them.”*

Participant 3 (P3)’s workflow definition is similar, P3 also thinks planning stage is the most important stage. They follow a typical traditional environment creation workflow, starting with concept arts and mood board to final scene creation.

They referencing to planning performance expectation like texture count, object count or even Level of Detail (LOD). They approach workflows with a more technical mindset and always prioritize technical limitations such as project size, texture density and overall asset creation process. P3 thinks this approach ensure efficient production. P3 does not directly adopt workflows or new features. They use experimental or prototype projects to measure feature

efficient. They mention this as follows *“To understand what can be done most effectively, I make small tests while producing the assets. For example, as I stated earlier that I plan any material and textures to be used before modeling the mesh assets. To see if I can get the desired result in the engine, I create the fundamental shaders beforehand. So, the production of assets never goes linearly”*. Participant (4) does not define a workflow but emphasizing the importance of project requirements based on client or job owner needs. P4 focuses a collaboration-based workflows models and suggest brainstorming sessions to demonstrate project as quick as possible. P4 prioritize adoptability and flexibility over predefined workflows. P4 does not adopt methods directly and they think project size and level of detail should be main parameters, they describe this as follows *“I think the first limitation would be project size, so this is a project-based limitation, or let’s say map size, how huge your environment going to be. The second thing would be project detail level, so if there are high demand on detail there will be a different workflow while in a more basic or less detailed scene you can go with different workflow.”*

- **Workflows management**

Participants answers on 4-5-6th questions were grouped under workflows managements which is include insights about workflows planning, improving and changing if necessary.

P1 discuss workflows planning, improving strategies. They suggest artists to compare their works with similar artworks to identify areas for improvement and learning opportunities. They strongly stress the importance of calibration between goal and similar works. They suggest as follows *“I think with a good calibration between your goals and similar artworks, you can easily find what you need to learn and possibly how to evaluate the project. This includes planning your workflows, adopting or improving it”*. Regarding to workflows changes, they prefer not to change workflows or add- remove any methods.

They suggest an experimental or prototyped project would be a good place to try and learn new methods. Because a direct adaptation my create undesired results in project like incompatibility. They add insights about workflows based on different type of projects. P1 says, based on end platform optimization like technical limitations affect artistic freedom, therefore it dictates workflows and overall creativity.

Unlike P1, P2 suggest software skills and overall experience as crucial for workflows management. They emphasize the significance of technical abilities to avoid time wasting, P2 indicates that artists technical knowledge and experience dictate workflows management. A more experienced and technically skilled artist will most likely make a better choice. P2 also mentions the importance of communication in a team-based project. P2 adopts new workflows or methods by first experimenting it, they suggest that this would be more beneficial for project. New methods or workflows may bring new advancements but also can disturb main project. P2 discuss important aspects of project such as project size and requirements, a larger project will likely be more complex and may require a heavier planning and management.

P3 has similar suggestions about workflows planning but add more, they highlight artist skill and abilities, they indicate that a more experienced artist will make a better workflows management. They mention seeking feedback from other artists to overcome challenges and improve efficiency of workflows. P3 stressing the need for clear planning to avoid unnecessary time consumptions. Unlike P1 and P2, P3 suggest staying update with tutorials and industry development to adopt new methods. P3 does not suggest an experimental project but experimenting methods directly in main project. They indicate a more proactive approach to workflows changes or improvements. Similar to previous participants, P3 acknowledges the difference in workflows, stress project requirements such as visual quality and performance, they suggest that artist can improve their workflows with a good understanding of project requirements.

P3 insight this as follows'' *One project might prioritize the visual quality of the environment; another might look after the performance first. To give you an example, the Rockstar's popular game Red Dead Redemption 2 offers the best visual quality and narrative, but not 60FPS game performance. Whether it is indie or AAA (Informal Classification of games, games with higher development time and budget among other tiers of games), these preferences challenge the artist to push the limits, as long as they are well-defined and clear. If the overall perspective and decisions of the game is well defined, the artist will better understand the scope of the project and the game needs, so*

that they will make the production process more efficient.'' P4 highlight project tools and skill levels in workflows planning and improvements.

They indicate that tool availability and artists own experience level are the most important parameters for workflows managements. For any workflow's changes, P4 suggest similar strategies but in a different perspective. They indicate that workflows changes or updates should base on project progress, suggest to be caution when making and alternation in mid progress to avoid distributions. Furthermore, P4 makes suggestion for approaching different type of projects, they stress various nuances such as available resources, various constraints. They highlight optimization needs and task management process based on project scope and team size.

- **Workflows evolution and artist role**

Participants last two answers were grouped under workflow evolution and artist role in this evolution. This category provides various thoughts for workflows evolution during participant careers and their adaptation process. Lastly, this category includes answers about future direction of workflows and artist role for shaping this future.

P1 is not sure about future direction and thinks it is blurry while also indicate the potential of Artificial Intelligent in their workflows. Similar to our results for experimental study, they stress that there is not enough regulation of AI in terms of copyrighting. P1 suggest that, AI can be a perfect tool for planning and general documentation task while suggest that using AI in visual production may not be legal yet. P1 mentions their though about artist role and highlight artist role for feedbacking the industry and defining trends to follow. P1 continue with workflow changes during their career, they mention parametric and procedural workflows trends and indicate workflows become less and less manual.

P2 gives similar perspective for artist role in workflow evolution and shares as follows ''... I mean, artists and designer create ''the perspective'' for game industry. Other fields (programming, sound etc.) are Following this perspective''. P2 thinks the future of game environment industry will be mostly depend on consumer's needs, shows that it is unpredictable.

P2 continue with workflow changes during their careers and similarly to our preliminary study results, they mention about previous manual approaches. P2

gives particular examples about texturing stage and share a personal demand for more automated approaches. P3 highlight the artists role in evolution and indicate that artistic perspectives create new destination for industry. They mention about various art workflows such as photo scanning and their impact for realistic art style. P4 has a more technical perspective and thinks that industry will shift towards for automated workflows. They share their own desire for AI-Procedural workflows combinations. Likewise, they demonstrate artist role as desire for more. P4 shares insights about them though about manual and time-consuming workflows, and give example about their approach to adopt new technologies and methods.

3.2.6.2 Findings and result

Open coding, axial coding and selective coding of all three studies were jointed to theoretical sampling, theoretical saturation and final memo writing. In theoretical sampling we focused repeated patterns and themes while also centered on gaps in literature. Theoretical saturation phase was a data updating phase, in this phase we examined and made additional data collection for each study. This cycled approach continued until no additional insights found. Meanwhile, when we saw data repeat itself and unable to generate new variations, we finalized theoretical saturation. At the end of each data analyzing cycle, we wrote memo writings, these memo writing were potential theories for final contributions of thesis (Figure 3.29). At the end of theoretical saturation and final memo writing, the founded theories were, 1- Base workflows, 2-Tools and compatibility 3- Prototyping, 4- Feedback and collaborations, 5-Importance of planning stages 6- Artist role, 7- AI workflows and 8- Automated workflows. Below Figure 3.29 shows the process of final analyzing. Final theoretical sampling, theoretical saturation and memo writing, last three steps of grounded analyzing methods. These steps take selective coding of all data sets and recycle the process until no additional insights found.

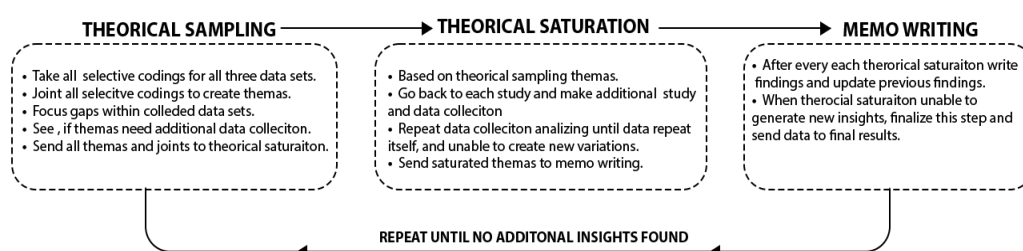


Figure 3.29 : Final theoretical sampling, theoretical saturation and memo writing.

- **Base workflow:** Analyzing selective codes of data sets emphasize industry use traditional workflows as a base for all other workflows. Advancements in software and creation tools led significant improvement in workflows. However, traditional workflows remain as a trend and all other workflows are optimized version of traditional workflows. Among all other workflows only traditional workflows cover all creation stages. Meanwhile procedural, PBR or modular workflows, were only for specific stages. The Following diagram shows where workflows mainly in use. (Figure 3.30).

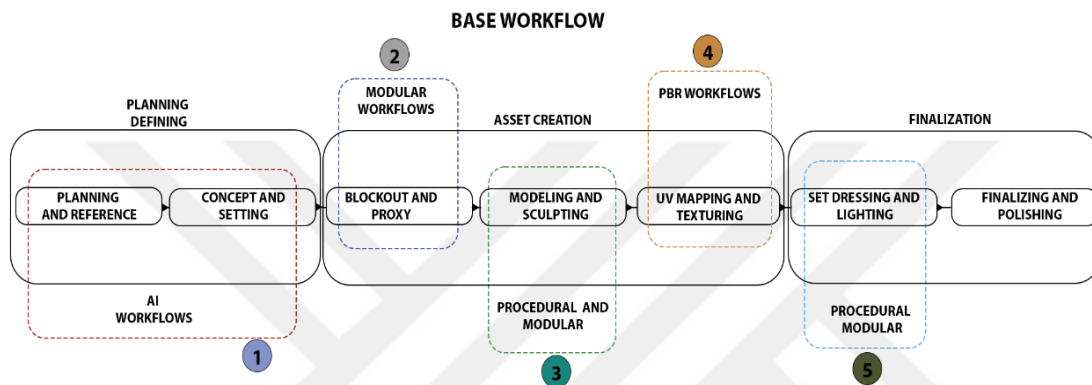


Figure 3.30 : Base workflow.

- **Tools and compatibility:** The advancement of technology allowed new asset creation techniques and led significant improvement in workflows. Traditional and manual tools replaced with procedural and parametric tools. Specialized tools offer more control over art creation and offer substantial time saving. The industry evolves to automated tools. However, tools with different working methodologies create various compatibility problems in industry. These problems are mostly performance and optimization difficulties. New tools and methods aim to overcome such problems. However, tool compatibility remains as a problem. Artist uses various tools in each environment creation stage. These are Max, Maya Blender like modeling tools, Zbrush, Mudbox like sculpting tools, Substance Painter and Designer like texturing tools and Unreal Engine, Unity like game engines. A solution for a specific problem has to be available in whole pipeline. For example, Unreal Engine as a game engine has a solution for high polygonal meshes, while substance painter as a tool to paint or texture that mesh does not. Therefore, artists unable to efficiently use the method since solution does not applicable to previous stages and tools.

- **Prototyping:** Theoretical sampling of selective coding suggest that prototyping and experimenting are most used techniques for workflow changes or improvements. As the industry has constant improvements some of older features may turn legacy, and may not behave as expected. Similarly, some of new features or methods may lead distraction on project. The possibility of such problem increases in late stages of production (Figure 3.31). This incompatibility problem can lead serious problems in production environment. Prototyping and experimenting are vital step to testing or refining new workflows or tools.

Experimenting new tools or workflows allow artist to understand effectiveness and of new methods. Prototyping ensures a smoother translation before full scale implementation and reduce the risk of workflow distribution. Overall, incompatibility needs to be prevented in an environment art project. Making prototype and experimental new tools, features create an awareness of effectiveness which reduce the risk of incompatibility



Figure 3.31 : Prototyping

- **Feedback and collaborations:** Feedback and collaboration are significant part of game environment art workflows. The importance of these strategies addressed in all selective code sets. Feedback and collaboration are important for setting a workflow and improving workflows outcomes. Regular feedback loop and effective communication can help teams to identify area for improvements and ensure alignment with project needs. Therefore, feedback and collaboration can allow all team members in the same line and prevent any misunderstanding. Furthermore, main study data stress the importance of having external feedback for environment projects for solo artists, this may expand artists perspective and help them to overcome improve art quality substantially while also realize some of problems early in creation. It is safe to say feedback iteration is important for artists to gain experience and learn while

also collaboration in a team is a need to ensure alignment and prevent misunderstanding.

- **Importance of planning stages:** Among all other environment art creation stages, all data sets highlight planning stage. Planning stage is the first workflow step for environment art creation, this stage is where artist decide what to build while also define project type, scope, establish setting and project requirements. Detailed planning is essential for workflows. This stage fundamentally sets the foundation of entire process, aligning goals with capabilities and ensuring efficient resource management. Therefore, planning stage is one of the most important stages in environment art and art creation workflows. Planning needs can vary, however project visuals such as art style, mood board and setting, scope to define how much time require for a project to finish.

Both visual and technical requirements are crucial. As all three studies contribute this stage, main study specially stresses the importance of planning. Following diagram shows how many times participants pointed for each environment art stages (Figure 3.32).

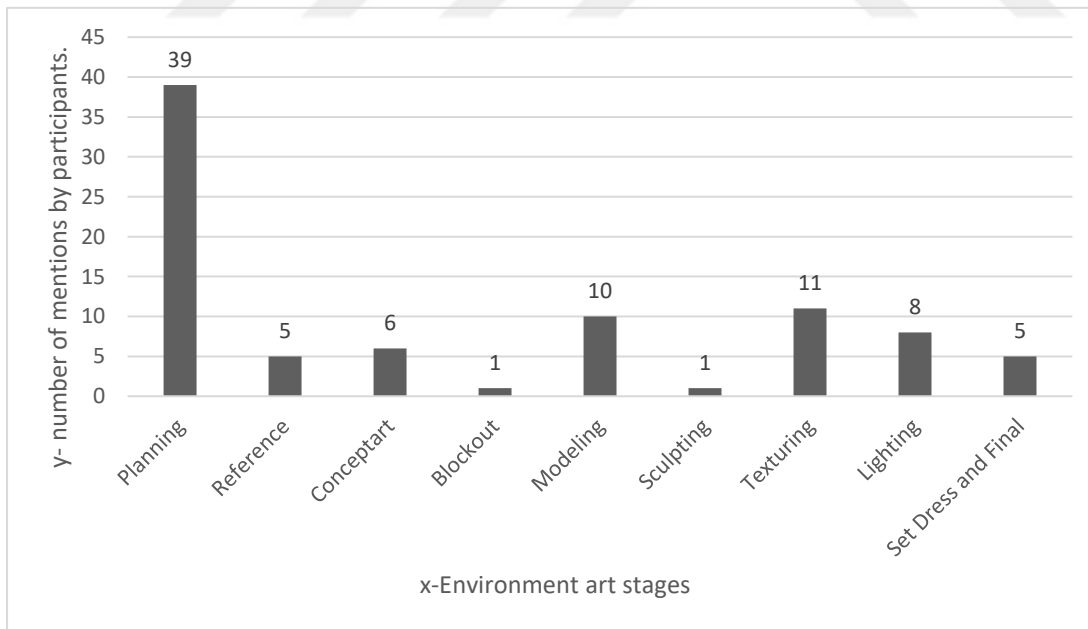


Figure 3.32 : Word usage in all participant answers, shows mentions for each stage (y-number of words used by participants, x-environment art stages).

- **Artist role:** As there is a constant evolution in environment art workflows, one of study goals were answer artists role within this evolution. The role in workflows evolution can be generalized under three categories. Coding from preliminary study showed that artists contribute the evolution for being important part of feedback cycle. to point one of artis role thought the evolution of workflows which is feedback. This finding was validated thought participant answers. Artists constantly give feedback to industry and point of improvements. Nowadays, almost all art software's has forums, feedback websites or inbuild feedback systems to take ideas from community, the execution of these feedbacks can vary but it is safe to say, artist help industry to evolve and improve by giving feedback. Secondly, artists constantly push the industry to higher destinations, the desire for better workflows, tools, plugins push industry and allow it to evolve. Another artist role can be visible in workflow evolution and artist role analyzing section. P2 mentions this as perspective or direction. During evolution phase changes or improvement can be expected but in which direction.

Participant answers shows that artist guide industry to a desired direction. Whatever it is a more realistic direction or rise of handcraft. Artist defines a perspective and create the trend for next destination. The theorical resampling of these statements can be theorized as follows. Artists contribute workflows evolution and influencing workflows trends. Artists feedbacks, defining final perspective and industry direction are critical for shaping the future of environment art, methods, tools and workflows.

- **AI workflow:** All three data sets provide findings for AI (Both AI and GenAI) potential in game environment art and workflows. AI can be particularly useful for planning and documentation stages and may implements to other stages. Coding about AI can be discussed under three perspectives. Each of these perspectives has its own can opportunities and challenges. These were AI usage, current limitation for AI and future direction of AI based workflows. The first concern how AI can be used in industry. Based on preliminary and experimental study selective coding, AI can be directly implements to planning stage since this stage are mostly documentation. While the implemented to other stages may take some time, both experiment study and main study insights showed that AI usage is limited.AI as a planning tool is in use and

accessible, planning stage of experimental study were prepared with AI while there was not enough tool for visual creation process with AI. This included any 3D- object or environment creation. AI capabilities were limited to 2D visuals. Similar results were visible in main study, none of participant uses AI in their current workflows while shared thought for future AI based workflows. The second perspective is legal concerns. Is it possible to use such tool in a project that has commercial purposes. AI has some legal and copyright concerns; this result can be found both in preliminary study and main study. AI uses various machine learning techniques to create visuals. Therefore, there is a need for legal base to use, these concerns were visible in preliminary study research. Particularly, from late 2020 to nowadays there have been strong protest about AI training techniques (Xiang, 2022). Artists in industry claimed that AI companies used their works to train AI tools and demand copyright. However, while we execute this section of research, same legal documents published (US Copyright Office, 2023). The document shows that AI training sources may be under copyright while AI based artworks cannot be registered for copyright.

Although there are strong protests about Generative AI and AI capabilities are extremely limited, industry wants to implements AI to workflows as soon as possible. These expectations particularly visible in main study. Participants answers shared similar desire towards more AI based workflows. P4 explain this as a combination of procedural and AI workflows. While P1 share some concerns (AI workflows needs further tools support, documentation and legal base) but said that AI can be used in planning and general documentation purposes or in a new artist directable workflow.

P1 '*Because AI uses other artists artwork to create a new image, However, AI seems to be very useful in planning stages and general conceptualizations, I think artist don't have to use it to create images but rather use for creating plans and idea*'. Therefore, AI future in environment art creation workflows were not visible while there were different idea and possible implementation opportunities.

One of this implementation possibilities can be stage elimination approach. Starting from 1990s early developments, there were very few stages for environment art, later on this stage separated with dedicated specialist artist.

Therefore, environment generalists become prop artists, lighting artists, material artists and so on. Based on workflow evolution and artists role finding, there are implementation to eliminate some of these stages back. Automated and AI based workflows may replace asset creation stages and vanish various art creation stages. The new workflow may include further AI training, input generation, and refinement phases. After these stages artist can have final environment product. This workflow may create new jobs and artists titles like AI Trainer Artist, whom train AI for environment art needs and refinement Artists, whom have expertise overall composition and cohesive art principals and can further assist AI (Figure 3.33).

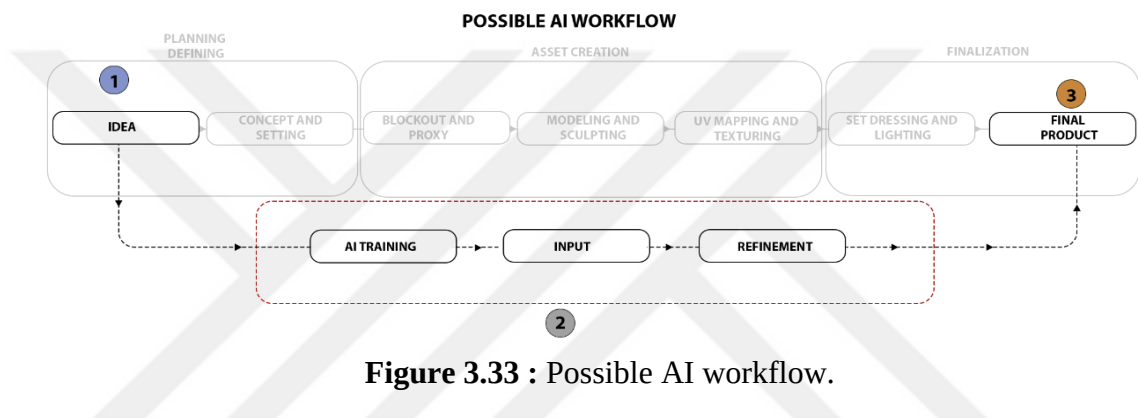


Figure 3.33 : Possible AI workflow.

- Automated workflow:** Selective coding of data sets shows that industry implemented manual or traditional workflows in early times. However, the implementation of more automated workflows has a trend due to project complexity and need for faster iteration. Instead of manual and traditional modeling techniques (Box modeling, Subd modeling) industry prefers to implement automated workflows such as parametric modeling or procedural modeling. Although, such workflows require a longer learning time and strong technical knowledge, industry will keep improve the process to automate environment art creation. One of the recent examples of autotomized workflows are visible in terrain generation. Previously artists have to manually create high maps or sculpt terrain within game engine. Nowadays World Machine, World Creator and Gaea like software's are able to generate terrains. These generation uses procedural workflows and by randomizing node properties, artist can quickly iterate results. Final data can be exported to any game engine for final usage.



4. CONCLUSION

In this chapter of thesis, we discussed final contribution of the research and discussion about research, finding and results and environment art filed. In the second title of this section, we provided further strategies for artists and educators working in environment field. We finalized the document with future direction of research topic, potential research expectation and PhD studies.

4.1 Contribution and Discussion

The purpose of this thesis was to understand how game environment art workflows were being used, improved, and developed by artists with a focus on well-organized, optimized and high-quality work. While there were many examples in the literature emphasizes the technical and programming aspects of production, there are fewer studies for artistic perspective and practical base of environment creation. Thus, this thesis aimed to fill gaps in the literature. Based on literature there were some study's specifically focus this area. "The Art of Computer Game Design" by Chris Crawford, was published in 1984. This book focuses computer graphic foundations and game design principals. Although some of finding and underly technology still in use, methods and workflows were not in use. This resource, similar to our work, highlighting the importance of visual design for video games. However, our work mostly focus art while intentionally leave technical and programming part of topic to future studies. Furthermore, our research aims to modern techniques and workflows while also provide comprehensive strategies and efficient methos for artists, educator or studios. Peter Lord and Brian Sibley in their book "Creating 3-D Animation: The Aardman Book of Filmmaking", published in 1998, shares their knowledge in creation of 3D animations. However mostly because of technological improvements techniques and methos were mostly discontinued. Moreover, insights about environment planning, sketching and storyboarding stages are still in use. These techniques have slight changes such as tool usage and workflows approach but the general understanding remain still. Our research adds further understanding based on modern tools, project needs and industry conditions. In 2005, Todd Gantzler in his book "

Game development essentials: Video game art " which is considered one of the first comprehensive guides on environment art workflows. This book covers each environment art stages and create a comprehensive understanding for environment art creation. Similar to other resources, some of techniques and methods were replaced. The book mostly focuses traditional workflows as these workflows was a trend at that time. In our work we extended this understanding and provided further workflows variations such as procedural workflows, workflows and todays modern workflows such as PBR, asset library, collaborative and photogrammetry workflows. Therefore, our research can be seen as an update to previous literature. In another study, Micheal McKinley in his book "Maya Studio Projects: Game Environments and Props", published in 2010, share their knowledge in creation of environment in 3D world. The book preliminary focuses on Maya software modeling. The book keep process simple and introductive while also share insights for beginner artists but similar to many other literature resources these books insights were greatly replaced and turn legacy. But, especially with the help of preliminary and experimental study, this study updated many of shared insights.

In 2016, Alex Galuzin in his book'' Pre-production blueprint: How to plan game environments and level designs'' provide detailed methods for environment art creation. Alex discusses about numerous topics such as level design planning, story planning and more. The resource mostly focuses planning environment art while does not include any practical creation. This book was similar to our preliminary study, we made addition with the help of experimental study and provided additional strategies with semi structured interview. Moving to 2017, Luke Ahearn published his book "3D Game Environments: Create Professional 3D Game Worlds, " which provides an overview of the entire workflows. Andrews' works is one of the most important resources for game environment art since it includes case studies from industry professional and provide tips and tricks to create game world. However, these cases seem to be mostly focused on technical aspects and tool usage. We used similar approach with semi structured interview. However, similar to many other resources these case studies mostly focused to technical and tool usage. Overall, our thesis specifically filled a gap in literature by focusing artistic and practical aspect of environment art creation.

Our research had no intention to prove any theory or pre assumption. The research topic and motivation were our own interests. However, similar to research topic itself, this research was extremely dynamic. As we had to add further literature details even at the end of research. This was mostly because of our research technique and topic dynamics. Therefore, after each study we added further titles to each study, meanwhile the research was not a linear approach. For instance, initial research for AI was not fully detailed as there was relatively small sample size in literature and this topic was not our main interest. However, in preliminary study we found recent discussion about AI usage. Main study and participant contributions showed similar outcomes. Therefore, we made further detailed research for AI and experiment it in experimental study.

Preliminary study showed us AI has a strong trend. There were a lot of recent literature based on these technologies. At the time we wrote this document there were numerous AI features for environment artist. These were visual concept art creation, various planning and documentation tools, skybox tools, shape and pattern generation, rendering tools, 2.5D depth map tools and some basic 3D model creation tools. However, experimental study showed us the practical base of AI needs a lot of improvements. First of all, the practical base of AI was limited, because of legal problems. US Copyright Office (2023) published document shows that AI training sources may be under copyright, means AI based artworks cannot be registered for copyright. There was no update on this document while we finalized our research paper. This is an important problem for environment art field because, similar to traditional arts like painting, sculpting digital arts have to be protected by copyright. The question is, does a game or an asset can be used for commercial use, if no, that would be impractical. If yes, how it will be protected.

Nowadays there have been strong protest about AI training techniques (Xiang, 2022). Many artists in industry demands their rights as they were allegation about AI training resources or training base data. Artists claimed that, AI developers used their artworks without any permission to train various AI models which created yet another problem. Overall, the problem about AI and its legal base will be one of the main discussions in future. Another problem was cost, as we constantly research practical base of each finding in preliminary study, AI was more expensive than any other procedural or traditional tool. For example, A company has over 20 tools and software's for many

art fields. As this company uses subscription-based business model, there were options for full subscription, which was roughly 20 US dollar and there was student or educator-based discounts, location-based prices. However, almost all AI tools have a constant subscription model with more expensive options.

This might be additional cost for environment art production. Apart from these legal and cost-based problems, despite their satisfaction for planning and documentation, AI tools were not able to create expected quality with required technical limitations. Although, technical limitation for environment art such as Graphic Processing Unit (GPU) and Central Processing Unit (CPU) memory optimizations and draw calls was not our focus area, there are strong connection between art and performance optimizations. However, AI tools at this time has no intention for any performance optimization which makes it impossible to use in an interactive and third dimensional space-based games (3D games). This limitation might change in future but at this time these problems remain still.

The study identified efficient practices and strategies for the creation of video game environment arts. The final document presented finding in a format that is accessible to artists and educators working in the video game industry whom aims to implement these practices and strategies into their environment art production pipeline. The document has a sequence-based format, means each stage is connected to before and after stage, which aims to help artists to execute their own environment project by Following each stage and study. The research is a unique study for this field, unlike any other literature resources, this document provides further details for each stage and workflows. For example, reference step is one of environment art creation stage, we were not only highlighting the importance of this step but also provided strategies about how to gather reference, where to gather, how to use and how to measure reference quality. Similar to this, in the concept art stage we discussed concept art types; previous, current and possible future techniques for this stage. This strategy-based understanding created for each stage. Furthermore, we added software requirements, effective methods and workflows used in each stage.

Experimental study was an important part of this study, this study provides a practical base to each strategy and workflows, create a base understanding of theoretical background and its practical base The end result of study created a full environment art project ‘‘Living in the Bubble of Love’’. Meanwhile, artists in industry can both

underrated each stage and follow theoretical knowledge with real environment project. Which hopefully will create a better understanding and help artists to create their environments. Educators, similar to artists, can utilize preliminary study and experimental study to design an outline for possible class plan. The class can aim to train future environment artist in video game environment art. Each week could consist of four hours with two hours theoretical background and two hours practical study. Theoretical background sessions can consist of various preliminary study discussions such as principals of project planning, reference gathering and examining, numerous art creation principals and case study readings.

While practical sessions can consist of various exercises, software proficiency such as modeling, texturing, lighting, level design and game engine integration. These practical bases were discussed in preliminary study and experimented in experimental study. The end result of this format was introduced in appendix B, this document includes a full environment art creation class with total 14 weeks plans and possible class sessions. Educators can follow this class and educate future environment artists while artists can use this document to create their own environment.

4.2 Final Strategies and Advices for Artists, Educators

As one of our goals was providing strategies for artists and educators. Advices for artists and educators in each environment art field can be separated to each stage. These advices were detailed in each study. In this section, we added our personal experience in environment art field that we gained through research process and our own experience.

The research took total of three years. We started with literature research, covering works from the 1970s to 2023. As the topic is very dynamic, we had to prepare a study to validate this literature as old techniques and methods did not fit our research goal, meaning there would be no point providing strategies for 2D sprites, 1980s vector graphics or workflows that includes tools does not exist anymore. The preliminary study was conducted to validate this literature. This study focused on the latest literature from the last five years. We discussed many topics within the environment art field and tried to provide strategies for those who want to know how to use, create, and develop their workflows for environment art. Additionally, we discussed each art creation stage, which will hopefully create a better understanding for future research

and the overall environment art field. The experimental study was created to measure the practical basis of each method and workflow from the preliminary study. However, as we had limited time, we had to create an environment diorama (mini environment), which was a small environment compared to today's open-world environments. Therefore, the experimental project may not cover all nuances. Some important parts, like the concept art stage and modeling stages, could be more detailed. This does not affect the research quality but could be better for artists and educators who will benefit from it.

A semi-structured interview was created based on the preliminary study and experimental study. We had total of three research questions. The preliminary study and experimental study were able to answer the first research question; however, they partly covered the remaining two research questions. Therefore, the semi-structured interview specifically focused on the second and third research questions. As we discussed in the limitations section, we were able to recruit four participants. The number of participants may not be enough for such research, but we were able to generate many insights from the participants. More participants could add more insights and new perspectives.

As we mentioned before, the research topic was our own interest; however, the importance of research is undeniable. The gaming industry has become one of the largest industries in the world and continues to grow. The industry has become a main part of entertainment. Learning, teaching, and researching this industry is critical and will be needed in the future. Artists and educators have to be serious about this. Teaching and learning in this field are full-time jobs and require proper dedication. Meanwhile, educators will not be able to effectively train students just because their profession is close to the gaming industry or shares the similar theoretical background. Just like anything in this world, gaming and game art are strongly connected to other fields such as architecture, computer engineering, or even electrical engineering. We see many academic institutions providing instructors who have no game art background and are not equipped to train environment artists or any type of artist. Knowing architectural visualization will not make them an environment artist, just like scripting cool Python codes won't make anyone a game programmer. Attending game events surely will not make them instructor for this field. Environment art as we discussed in our study is a highly experience based professional field. Therefore, it is

important for educators to have experience to train student. Meanwhile, academicians with only passion for gaming can still love gaming but should stay in their respected profession. Furthermore, unrelated topics like mathematic, derivatives, integral or vector graphics theoretical base matrix and determinants were be simply impractical for an artist to know. Procedural workflows are related to mathematics but that level of mathematics does not apply environment art or any art related field. Academic institutes argued that such topics important for environment art and design. However, such information does not apply industry while surprisingly there is no literature data for this. The reason why academics make such claims could be a subject of research.

Overall, becoming an environment artist is a long and tough path to walk, it is often requiring over 5 to 10 years of experience and learning. The industry changes almost every day and artists have to adopt new trends, methods and workflows. Therefore, the learning will never stop. As we discussed from main study findings, prototyping can be a good strategy to learns and experiment new methods, tools or to follow trends. Artist can create small projects and while creating these projects, they can research for latest improvements in the field or any environment art stages. Therefore, they can both learn and experiment new techniques, methods or tools.

Just like any action in human life, environment art creation requires a planning. In this case, very first point would be the idea. Artists has to understand what they really want to build. While it is not always possible to love their project or task in studio environment (Job environment) it is a legit advice for artists to love their personal project and idea. The process of environment creation is long and there will be a lot of up and downs. Therefore, loving the idea would be beneficial for project motivation. One of the biggest mistakes for beginner and many intermediate artists is they try to make large environment for portfolio purposes, the starting point is similar “ I am going to make a wonderful open world that lots of things live in peace”. Making large environments is a time-consuming process and may take months or even years. Therefore, artists should focus small project or part of a large environments. This way they can have a portfolio project in a shorter amount of time while also problem solving and improvements will be much easier. Small environment projects will be always beneficial for artists in terms of learning, improving or demonstrating skills to potential clients. A high quality efficiently crafted environment diorama is better than a lose large and complex open world environment.

Artist can focus their future dreams and can improve themselves in that direction. For example, if an artist has an intention to work for a specific studio. It is best to check that studios work and improve themselves in that direction. Some studios create games in stylized style while some of them focus more realistic. However, the focus should not be too specific and should allow artists to be hired by other studios. Clients will likely look for their art directions and will hire if they fit their specific requirements. But positions will be limited, therefore become too specific in one area may lower the chance to be hired.

One notable advice for planning stage would be working clean. In an AAA studio work environment, artist can work in a specific task but due to urgent task statements they might be switched to another task. Therefore, another artist will need to continue with that task. Asset naming, scale, folder structure or textures must be correctly arranged. If not, new artist will have hard time to figure out work which means more time and possible misunderstandings. Similar to this, artist should use a logical file structure for their portfolio projects. For example, a main folder with project name and sub folder with references, concept art, modelling, baking, texturing and final game engine file would be better for artist to control their work environment. Some files will be linked across various tools and programs, moving such files will likely break the connection which may become a problem in process.

It may not be possible to create a perfect environment art. As artist might not like their work at all, this is a syndrome in industry and will continue. Therefore artist should not worry about it too much. However, environment arts should not be considered as a landscape work. Meanwhile, an environment art without any human or character actions may not be good for portfolio. For example, a forest scene may allow artists to demonstrate their vegetation skills, but clients may want to see some activity in environments, therefore they can understand if artist has a sense of crafting actions. A basic indication of character movements, point of interests can be beneficial. Likewise, cohesive looking is important. For example, weather conditions in an environment will most likely affect each asset similarly, therefore each asset has to have such features (snow on rock, damaged looking, dusty environment etc.).

As we discussed in literature and detailed in preliminary study, environment art creation can be defined as asking right questions to references. This might be a good strategy to start an environment project. As these questions will be unique for each

project. Some general questions can be applied to any environment project. For example, where does this environment locate? What is the main idea or theme in environment? What are environment conditions? The location can be anything like a desert location, a space location or maybe similar to our experimental project it can be a dimensional place. Location will dictate environment looking greatly, and will affect gameplay itself. For example, an Arctic location will be cold, so there can be some survival actions like finding fire or any special equipment's to keep character warm. Therefore, location indicate many information's about actions, gameplay, environment and character looking. Furthermore, environment artists should try to live in their world with their imagination. This was they can balance their world. Architecture and culture/life style will be defined by story and location like elements. Same games may not have a story so it will be harder to indicate a culture or a lifestyle of NPC.

While some of game may not have culture or architectural elements, if intended, environment project should visually represent these cultural or architectural elements. The question about architectural elements will be greatly connected to surrounding environment. For example, in a forest environment, architectural elements might be wood made structures as this material is abundant in that location. However, it might be harder to settle in a wild forest, so characters may use tents as their home. These are some of the questions that help artists to define architectural elements for their projects. For cultural and lifestyle like elements, artists should ask question like how living live there? Why they live like that? what happened in that environment? for example, in a dictator regime and highly political world, the media is completely controlled by ruling power and people to be opposition are actually agents of the regime, lying to public for their own gain. True friends of the people are imprisoned as traitors, even worse, the regime and its tightly connected racist allies demean the folk and their true friends, stealing their labor, freedom and morality. There will be lock of freedom and society heavily influenced by corporate power of dictator. Therefore, the culture and lifestyle might be fear and people, families, friends betray each other to make dictator happy. They might imprison people which could be freedom and prison theme. In this case, the story can be "the struggle for justice". These are some of nuances that artist may need to ask for their environment project.

These questions need to be asked to collected references. The process should continue until these questions answered.

If the environment doesn't have a visible story, artist can stick with location and natural environment conditions. For interior scenes artist can focus to actions and assets within environment. For example, in a teenager room environment. Some prop (assets/objects) may indicate teenager life, a few posters on the wall may show what the teenager loves to listen or watch, a bike in the room may indicate that the character has some type of action related to that, the teenager might like biking. Room wall might have a specific color or material, this can indicate if the room is old or new while also can reveal possible time frame in environment, it might be 1970s or anything. Small and darker room may indicate poor living conditions while wide windows with natural light can indicate comfort and so on.

In the concept art stage artist should try to sketch their idea. The problem of doing such a manual work might be unnecessary as this type of works often made by specialized concept artists. However, there are sketch or conceptualize memory within our brain, we can call it as brain muscle, a basic but intentional sketch could help artist to conceptualize their idea and settle the mass in their imagination. These basic sketches can help artists to focus their initial plans and motivation.

AI is in use in this stage but it will most likely be negative for artists imagination and overall skills. Conceptualizing and sketching an idea is one of the most fundamental skills in environment art field. Making this stage with AI might be fast while might negatively affect overall artistic skills and brain capacity for art and design. There will be future studies in academic area for this problem. And we will hopefully see the results.

Blockout stage is a fundamental stage, as we both discussed and experimented in our experimental study. This stage is a must. Many artists in industry doesn't realize the importance of this stage. However, this stage is where artist understand how many assets, textures or objects needs to be created. The main questions could be "Do I really need to create all this block, can I use any of this block multiple times, Can I replace any of this asset with another one". One advice for artists would be trying to analyze the blockout scene and see if there are similar assets. These similar assets might allow a modular workflow which can reduce workload greatly, it is important to mention, in this stage a scale indicator is necessary. For example, In a medieval

town environment. One or two wall assets might be enough for whole town environment. Artist can detail these assets and reuse it with duplicating and rotating with the help of grid and scale indicator. It is important to note, making similar asset with very little difference will not be a smart approach as everything in the scene increase performance stats and overall game size, meaning it will be an unoptimized approach for performance. As every each of these assets have geometry data, texture and UV data, collision and material data and lightmap data (if applicable). Another advice would be creating an asset list based on blockout scene. This asset list might have an update after proxy stage. In proxy stage, as we detailed in preliminary study, artists main intention is creating secondary or mid details for assets. This asset can be used as a low poly mesh for later stages while also give idea if the asset needs to be unique or not.

For example, block outing a cave environment might help artist to understand overall scene scale while in proxy stage artist can understand if open areas are enough for player to move, or wide enough for various animations. Therefore, the intention of blockout is understanding scale and asset lists while proxy stage help artists to understand overall level flow and gameplay, asset detail requirements, potential player collisions, animations, asset functions (if applicable) and final asset list.

In modeling and sculpting stage, there are a lot of nuances that can improve this stage. However, many of them related to prop itself. One advice could be understanding the level of detail. Artists should understand the asset usage and the distance to camera. For example, it would be inefficient to spent time with small details of vista assets. As these details will not be visible in final scene because of the distance. Likewise, the details should look cohesive. As this is mainly knowledge of fundamental of design principals. Detail distribution should be balanced. Big, medium and small details should work with overall silhouette. Other advices would be material-based details. For example, the damage type of wood and metal are different. Therefore, artist has to understand damage types for each material and apply them to assets.

Artists can use any workflows they want; however, some workflows are specifically good for certain type of assets. These types of assets are mostly related to their final usage in game environment. For example, a vegetation asset may need some characteristic details that connected to game story while some of them may be more like a vista asset. In this case using traditional workflows or more manual works may

allow artists add more characteristic features to asset while a procedurally generated asset may not have characteristic features but can be created quickly and naturally. Procedural workflows are mostly because of time and quick iteration needs while traditional workflows are mostly for narrative and quality needs. Procedural workflows can create more natural results and highly complicated assets. These workflows, as we showed in Table 3.2 in finding sections, is extremely fast while traditional workflows are slow and time-consuming sequence of works.

Another related advice for artist would be tools usage. Tool usage is a very important of aspect of workflows. If the artist has knowledge in Houdini, substance designer like software's, they will more likely have a procedural mindset. While an artist without such tools may be more traditional mindset. Meanwhile, tool can affect the way artist approaching things. Some tools are good at certain problems while may not fit others. In this case understanding tool capabilities can be beneficial for artists. In fact, expertise both traditional creation methods and procedural method is not impossible. However, artists will eventually be better in one of them. Similar to this, artists with previous procedural tool experience will most likely have smoother translation into another procedural tool while translation to a traditional tool will be harder (box modeling, subd modeling, sculpting, hard surface etc.) This mindset problem is similar for traditional artists. Perhaps, Traditional workflow and procedural workflow comparison based on artists mindset or previous experience can be another research topic.

Texturing and UV mapping stage was yet another stage we discussed in our research. We shared a lot of insights based on all three studies (preliminary, experimental and main study). For UV mapping, artists have to understand texture size and object surface area these two terms define texel density. As textures are pixel depended, larger surface area requires more pixel data or texture resolution. For high end games, each meters require 512 to 1024 pixel. Therefore, depending on target platform artist can decide necessary texel density. The term of texel density is important for quality consistency. Meanwhile, objects in an environment should have close texture size. Additionally, artist may need to avoid any texture stretching or distortions, but it's not an obligation. Since artist may purposely need texture distortions. There are various techniques for UV creation, as we shared in experiment study, procedural or automatic

UV packing techniques can save a lot of time while these techniques may need further manual works.

Texturing is an important part of environment art and we discussed this stage many times. There are a few ways to prepare textures. Hand painted traditional workflows are better for unique and story-based assets while procedural workflows are better for natural and fast result needs. Photogrammetry is yet another texture creation workflow. This workflow is good for realistic texture or asset needs. Comparing to other two workflow this workflow is new. In this workflows artist take a photo of surface area. This surface area can be as large as artist need but generally 2x2, 4x4 or 8x8 are good choices. This workflow requires some environment conditions too, in order have good results artists need to take photos in overcast weathers, as any direct light or rain, wind like conditions may disturb the process. After capturing process, artists use Metashape or Reality Capture like software's to process the data. Photogrammetry is a very easy workflow; however, this workflow requires expensive equipment and long processing time.

Texturing stage is an approaching problem. Means the end result will depends of how artist start and execute references. A good technique can be separating an asset into materials it made from. As an example, in a scenario where artists need to create a carving from Gothic period. Artist has to thoroughly examine reference board. Details related to silhouette should be created in modeling and sculpting stage. In texture stage artist can add surface details. Firstly, artist need to examine coloring features, such assets are mainly having white colors, therefore assets primary color can be white. Over the time, due to sunlight exposure, rain, wind, dust and similar effects the primary color might change. In this case in same area the asset will has brighter white color while in some are it will have darker colors. Artists need to understand where this effect happened, dirt and dust effects can accumulate in inner areas while sun exposure can affect front surface and change the primary color into a brighter white or a yellowish color. Overall, during texturing stage, artist has to examine references constantly, as the purpose of texturing is transferring each of reference features to asset surface.

Another strategy for texturing can be ‘‘ 4-layer strategies’’ This is a strategy we gained thought our carriers. The method is simple yet need a thoughtful approach. Each asset in real word mostly consists of four things. Let's say four color, four material and so

on. As artist creating asset, they should never forget that each asset has to contribute overall story and narrative. Therefore, artist can make four-layer color, four layer of roughness features, four layer of environmental effects, four layer of story features and so on. Four layers would be enough for most of assets while more than this might generate noise and less than this can make the asset less realistic. In our above example, artist should make four layers of color for gothic carving assets, four layer of dust, rain sun like environmental effects, four layer of material effects, four layer of story, four layer of history and so on.

Optimization and performance needs are necessary steps to follow. However, this research does not focus such technical problems and intentionally leave these topics to future studies. Artist has to have a sense of optimization during asset creation stages. Triangle count, texture counts, texture packing are some of these considerations. In final scene artist may want to use various optimization passes. As an asset is only good as its weakest link, which is final optimization. GPU stats, RHI stats, FPS, draw call, overdraws, lightmaps, base and pre passes, scene light and reflections are some of the topics that artists may need to check.

4.3 Future Predictions

The study provided arguments for environment art workflows. After both theoretical and practical studies made for this thesis, it is easy to say, environment art workflows constantly evolving and changing. With the help of technological advancements new workflows can emerge industry and current workflows can be replaced with automated workflows. One particular direction for workflows nature can be AI implementations. As industry evolving to more automated workflows models, AI can be implemented to all workflows in any creation stage. Procedural and parametric workflows can be very first AI related workflows, as these workflow relay mathematical and algorithmic functions, these functions and equations can be generated by AI. However, as a more dystopic predictions for artists and designers, AI may override each of these workflows and so jobs. AI capabilities may see limited in current time but this can change quickly. First AI implementation may require human inputs but later on AI can generate these inputs too. Meanwhile, AI can create whole environment art without any human interaction. This may aid certain problems as become an expert in environment

creation may take over 5 years of dedicated learning while AI can learn and create in very short time.

Procedural workflows and its related creation methods rely to parametrically builder functions or algorithms. These pre-defined rules are main part of procedural workflows. AI can be integrated to this workflow in two distinct ways. Procedural generation frameworks can take inputs from user, in this case, artist can use AI to generate various functions and algorithms. However, there might be a fundamental challenge. Each procedural tool has differences in their core procedural framework. For example, Gaea as a terrain tool and substance designer as a texture generation tool uses same nodes in different way.

Therefore, same function may not result same or similar outcomes. Artists has to specifically train AI tools for their target software. In this case an AI mode for Substance Designer, another one for Gaea or Houdini and so on. The second application of AI in procedural workflows would be quality measurements. AI can evaluate whatever the outcome is good or bad.

Workflow managements will be one of the most important topics in future, art directors, managers and lead artists are mostly responsible to manage whole workflows in game environment art. As it is visible in literature, very first game development project was made by limited amount of people. These are mainly a group of programmers, With the help of technological advancements, demand for quality and increase amount of interaction abilities. Game development become an industry with millions of artists, designer, programmers working together. In very first game development experiences, there were only one artist whom responsible to all art. Coming to 2000s to 2010s there were specialized artists for specific needs such as environment artists, concept artists, lighting artists and more. Nowadays these specializations need become even more prominent, and vegetation artists, foliage artists, grooming artists or terrain artists were implemented, this will change in future and 3 main job field will be available, AI train artists, input/output artists and refinement artists. Furthermore, comparing to first spirit or 2D games, todays open world games generated massive amount of task and years of consistent work for development teams. All these new jobs and task verity create numerous management needs. Therefore, as like today's game development requirements, future direction of workflows and workflow management will be more and more important.



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APPENDICES

APPENDIX A: Example course plan for educators based on research findings.

APPENDIX A1: Course 1st and 2nd week plans.

APPENDIX A2: Course 3rd and 4th week plans.

APPENDIX A3: Course 5th and 6th week plans.

APPENDIX A4: Course 7th and 8th week plans.

APPENDIX A5: Course 9th and 10th week plans.

APPENDIX A6: Course 11th and 12th week plans.

APPENDIX A7: Course 13th and 14th week plans.

APPENDIX B: Main Interview Questions.

APPENDIX B1: Main Interview Participant Answers.



APPENDIX A: Environment art example course plan for educators, preliminary study as theoretical reading, experimental study as lab/workshop and main study for both theoretical understanding and workshops within Course.

Course Code	GAM XXX	Credit	Lecture (hour/week)	Recitation (hour/week)	Laboratory (hour/week)
Semester (14 WEEK)	-	4	4	2	2
Class Language		English			
Course Coordinator	Leman Figen Gül, Instructor : Emrah Özçiçek (Example)				
Course Name	Turkish Oyunlarda Çevre Sanatı English <i>Environment Art for Games</i>				
Course Objectives	1. To teach the principles of Environment Art, 2. To teach art workflows and process management. 3. To teach Environment art creation for video games. 4.To teach level design, player movement and level flow.				
Course Description	Advance video game art, environment art stages, art management, workflows, art documents, prop art, reference and planning, modeling, texturing, narrative, world building, Location, architecture, atmosphere, theme, NPC culture and life, game story and scenario, narrative in video games, player experience				
Course Structure	Midterm Project (s)				%20 -
	Final Project				%30 -
	Participation				%10 -
	Weekly Assignment				%40 -

Figure A.1 : Example course for educators, created from this research

APPENDIX A1: Course 1st and 2nd week plans.

WEEK 1	Fundamentals of Art, Introduction of Environment Art
Lecture	- Theoretical background, literature reading for environment art. - Student learns course software and course requirements. - Project Planning and Idea Discussion, Course Objectives and Scope
Lab	Project Requirements, Software Reequipments, Initial planning, Idea definition, Introduction of setting in game environment.
Assignment	- Student must prepare an environment idea for course project. Student will be asked to brainstorm an environment art project for the course. - Initial project planning, scope and requirements. - What is art style? - What type of environment will be? (Isometric, 3D, - first person, third person.) - Setting in game environment art (location, architecture, theme, time period, culture, story, atmosphere). (See Preliminary and experimental study.)
WEEK 2	Planning and Reference
Lecture	- Theoretical background, literature reading for planning and reference - Student learns Project Planning and Referencing. - Reference techniques and workflows setup. - Strategies for Project Planning and Reequipments
Lab	- Student Complete their planning and create mood boards. - Student learn how to plan a project and create references using Pureref. - Text based plans (project name, story, narrative style)
Assignment	- Student should create reference board based on their planning - Their environment should answer below questions. - Where gameplay located? (How it looks like? what are environmental conditions look like?) - Who lives there? - How they live? (heir actions, daily life, emotions, society) - What is their culture and lifestyle? - what happened there?

Figure A.2 : Class plan for 1st and 2nd week.

APPENDIX A2: Course 3rd and 4th week plans.

WEEK 3	Fundamentals of concept art, Idea definition, Sketching
Lecture	Theoretical Reading concept art, key concepts, rough sketches, importance of concepts, PIO (Point of Interest), Color and Shape Language
Lab	- Student sketch rough concepts for their environment, key looking, learn how to use AI for concept art, - Student learn shape language and color. - Discussion of previous assignment.
Assignment	- Student must prepare at least one key concept art, decide color and shape language, and prepare concept art with color palette of their environment. - Concept sketch for main object (s), POI (Point of Interest). - Mood Board showcasing environment mood, color and shape language - Student should finalize their planning and referencing.
WEEK 4	Blockout and Proxy Mesh
Lecture	Theoretical Reading, Understand blackout and proxy mesh, basic level design, collision, level flow, player movement, asset list, scale and scene proportions
Lab	- Student create a blackout scene using Unreal Engine and their 3D modeling tool. - Student should consider workflows like modular and procedural. - Student uses their file structure to properly name their assets.
Assignment	- Student must further detail their blackout and convert them into defined proxy meshes. - Student should check scene scale and place a few scale indicators into scene - Student should decide level flow and player movement within scene. - Student should color each individual asset and create an asset list for their environment. (Scene optimization in mind) - Student should decide their workflow, possible modularity, asset library, procedural workflows.

Figure A.3 : Class plan for 3rd and 4th week.

APPENDIX A3: Class plan for 5th and 6th week.

WEEK 5	Modeling and Sculpting
Lecture	• Theoretical Reading of modeling and sculpting, object performance problems, workflows and workflow optimizations • Workflows for modeling, Workflows types based on asset types. • Asset detailing, silhouette • Primary, secondary and tertiary modeling techniques.
Lab	• Student start modeling their main assets. (Each environment has to have minimum one hero asset) • Student start consider sculpting one of their assets. (Each environment has to have minimum one asset that require sculpting) • Student should optimize their workflows based on project needs.
Assignment	• Student must continue with their asset modeling. • Student should decide which asset require more detail. • Student should consider procedural generation, modular workflows and other workflows advantages. • Student must start to import their creation to game engine for testing.
WEEK 6	Modeling and Sculpting
Lecture	Theoretical Reading of modeling and sculpting, object detailing, Low poly high poly, topology, object decimation and optimization,
Lab	• Student must continue with their object modeling and sculpting. • Object detailing techniques. • Object optimization techniques. • Detail level, LOD, Player Collisions.
Assignment	• Student must continue with their object modeling. • Student should import their modeled objects to Unreal Engine. • Student should consider procedural generation, modular workflows and other workflows advantages.

Figure A.4 : Class plan for 5th and 6th week.

APPENDIX A4: Class plan for 7th and 8th week.

WEEK 7	Modeling and Sculpting/MIDTERM
Lecture	Discussion of common modeling and sculpting problems. *Midterm Discussion and Theoretical Recap (Q&A) *Student must prepare a zip file for their midterm submission. *File should Contain • Project Plans and reference boards (Pureref file). • Project concepts (psd, jpg file). • Scene file for their blockout and proxy stage Filmbox format (FBX, Unreal Project) • Modeled/Sculpted Files and scene files for assets (fbx and max, ma or blend. And ztools) • (Student must have expected file structure) • Student must mail this file to Instructor before next class (SurnameName_ID.zip)
Lab	• Student must continue with their object modeling and sculpting. • Discussion of Midterm submissions. (Q&A) and Recap for previous stages.
Assignment	• Student must finalize their object modeling and sculpting. (MIDTREM includes final modeled and sculpted assets.) • Student should research asset UV mapping, baking process and possible texturing techniques. (Hand Paint, procedural, tile base, trim sheet)
WEEK 8	UV Mapping and Texturing
Lecture	• Theoretical Reading for UV mapping and texturing, texel density, seam, UV common problems, UV quality, UV unwrapping, UV editing, UV packing tools. • UDIM usage and requirements for texel density. • AI for UV Mapping.
Lab	• Basic introduction of Rizom UV • Student must start UV unwrapping their assets. • Student should consider texture packing and texture optimizations. • Student should consider optimal UV space • Student should decide texel density.
Assignment	• Student must finish UV mapping for their assets.

Figure A.5 : Class plan for 7th and 8th week.

APPENDIX A5: Class plan for 9th and 10th week.

WEEK 9	UV Mapping and Texturing
Lecture	• Theoretical Reading for UV mapping and texturing, texturing, texture workflows, hand paint, procedural texturing, baking, Substance Painter, Marmoset Toolbag • Manual and Procedural Texturing • AI Integrations for texturing
Lab	• Basic introduction of Substance Painter. • Student must start texturing their assets. • Student should consider texture packing and material expectations. • Student should consider optimal UV space • Student should decide texel density.
Assignment	• Student should continue texturing process
WEEK 10	UV Mapping and Texturing/ Scene Lighting
Lecture	Theoretical Reading for texturing and shading. Theoretical Reading for Lighting, Mood, atmosphere.
Lab	• Student must start importing their textures and final assets to unreal engine. • Basic Introduction of Material Editor in Unreal Engine • Student should finalize texture importing and Final materials.
Assignment	• Student must finalize UV and texturing stages. All assets must be imported to game engine. • Student should prepare lighting scenarios based on their planning. • Student should finalize asset; texture importing and start object placement.

Figure A.6 : Class plan for 9th and 10th week.

APPENDIX A6: Class plan for 11th and 12th week.

WEEK 11	Scene Set Dressing and Lighting
Lecture	• Theoretical Reading for scene compositions • lighting and final presentation, asset presentation, scene lighting, object lighting. • Compositions techniques and PIO. • Project rendering and Cinematic. • Portfolio Presentation and Image Rendering
Lab	• Student must start set dress their scene and place final assets. • Student should consider composition techniques. • Student should consider optimal level flow, player movements. • Student should Focus PIO area. • Student should consider atmosphere, mood for their lighting scenario.
Assignment	• Student must continue scene polishing and lighting
WEEK 12	Final/ Project Optimization and Performance
Lecture	• Theoretical Reading for final scene polishing and presentation. • Player Movements and Level Flow Checking, PIO • CPU/GPU Performance profiling • LOD, drawcall, RHI, memory optimizations. • Optimization techniques. • AI tools
Lab	• Student must take beauty renders for final presentation. • Student • Basic introduction of Portfolio Presentation. • Final Recap for environment art in games. • Feedback for portfolio assets.
Assignment	• Student should continue with their presentation, • Student

Figure A.7 : Class plan for 11th and 12th week.

APPENDIX A7: Class plan for 13th and 14th week.

WEEK 13	AI Implementations
Lecture	• Recap for environment art in video games. • Theoretical Reading for AI usage in game environment art. • Workflow improvements with AI. • Generative AI • AI usage opportunities and Future of AI. • Discussion for Final Delivery
Lab	• Student uses AI tools for workflow optimizations. • Student Discuss Generative AI tools. • AI tools and techniques. • Portfolio Presentation
Assignment	• Student should finalize their project and make final delivery. • *File should Contain ○ Project Plans and reference boards (Pureref file). ○ Project concepts (psd, jpg file). ○ Scene file for their blockout and proxy stage (FBX, Unreal Project) ○ Final Modeled/Sculpted Files and scene files for assets (fbx and max, ma or blend. And ztools) ○ Substance Painter/Designer Files. ○ Text file contain links to artstation or special portfolio website. ○ Unreal Engine Project file ○ Possible AI creations. ○ (Student must have expected file structure) ○ Student must mail this file to Instructor in final delivery time. class (SurnameName_ID_FINAL.zip)
WEEK 14	Term Final/Final Delivery
Lecture	• Portfolio Preparation Techniques for Art Test/Job application process.
Lab	• Final Delivery/Discussion/ Portfolio
Assignment	

Figure A.8 : Class plan for 13th and 14th week.

APPENDIX B: Main Interview Questions.

- **Q1:** Could you explain your definition for workflows and provide a brief overview of your typical workflow when working on a game environment art project? (Asking how you define workflow, your regular approach to an environment art creation, any special treatment that you think unique or important in your workflows regarding any stages)
- **Q2:** Can you share examples of innovative workflow strategies or methodologies that have proven effective in your environment art production pipelines? (For any environment art creations stage or whole production pipeline, e.g.: a strategy you use for environment planning or texturing stage, you can give multiple answers)
- **Q3:** How do you adapt environment art workflows to meet project-specific requirements or constraints, and what strategies do you employ to do? (There are lots of workflows, procedural, traditional etc., how do you decide which one you want to use)
- **Q4:** In your experience, what key parameters contribute to the efficient planning, adaptation, or improvement of a game environment art workflow? (e.g.: Tools, skills, should artists learn more software, or ask feedback for their works, how can artist plan, adopt or improve their workflows)
- **Q5:** How do you approach changes or improvements to the workflow during the production? (In a production environment, how do you change your workflow, for example do you change your workflows when a new tool arrives, or you catch any strategies from industry)
- **Q6:** Are there any notable differences in workflow approaches between different types of game environment projects (e.g., indie, AAA), and how do these differences impact the role of artists in workflow evolution?
- **Q7:** Looking ahead, what do you see as the future direction of environment art workflows, and how do you see artists contributing to shaping this evolution? (for example, implementing AI to environment art, or using a new approach for environment art, how do you see future direction of workflows and what is artist role)
- **Q8:** Can you briefly explain how game environment art workflows evolved over time and how this evolution affects your approach? (Asking your thoughts about workflow changes during your career regarding any stages of environment art creation and how it affects your workflow)

APPENDIX B1: Main Interview Participant Answers.

Participant 1 (P1):

- **Q1:** Could you explain your definition for workflows and provide a brief overview of your typical workflow when working on a game environment art project? (Asking how you define workflow, your regular approach to an environment art creation, any special treatment that you think unique or important in your workflows regarding any stages)

A1: I think a workflow is like a blueprint that we have to follow to build an art work. It is all necessary steps specialized to us and mostly depends on our own experience and skills. I start with idea and planning stage; I think this step is very important because this step define everything from start till final art work. It is always a good idea to spent more time in this stage. I follow other stages as usual; this part of my workflow is pretty common. As we are learning things from similar tutorial, I assume many artists do the same. But I have to point that, having a good plan and knowing what to do is the key. One special treatment would be creating folders for each step and make sure all the creation process is on the same folder. So, instead of saving your work in random places, it is a good idea saving them in a folder so that you can find or link them across all tools.

- **Q2:** Can you share examples of innovative workflow strategies or methodologies that have proven effective in your environment art production pipelines? (For any environment art creations stage or whole production pipeline, e.g.: a strategy you use for environment planning or texturing stage, you can give multiple answers)

A2: Sure, I think there are multiple workflows that I use, I might not recall all of them. It is like having a sense of doing something and after sometime you are starting to do almost automatically. But I can say that all kind of modular approaches are very innovative and I use them all the time.

- **Q3:** How do you adapt environment art workflows to meet project-specific requirements or constraints, and what strategies do you employ to do? (There are lots of workflows, procedural, traditional etc., how do you decide which one you want to use)

A3: This is a hard to answer questions. But I think it's about knowing project requirements and have a good understanding of project itself. Some project may need lots of assets but they might not all hero assets, in this case procedural workflows might be useful. In some case I use Asset Library workflows too, I have my own library and first check if I can reuse something or there is anything I can change to create new thing. After checking what I have and what I or my team have to do, I can evaluate all workflows options and depending our needs I set the workflows. Nowadays I try to use new AI tools to possibly find a way or define a brand-new workflow, but no chance. Maybe a few years later.

- Q4:** In your experience, what key parameters contribute to the efficient planning, adaptation, or improvement of a game environment art workflow?
(e.g.: Tools, skills, should artists learn more software, or ask feedback for their works, how can artist plan, adopt or improve their workflows)

A4 :In my opinion, the key parameters is compering your work with similar works made by other artists, Artstation like websites are good places, actually you should do that at the beginning and collect some references, Many of these references has a text underlay shows which software used and if you are lucky you can find some clue about artist workflow, I think with a good calibration between your goals and similar artworks you can easily find what you need to learn and possibly how to evaluate the project. This include planning your workflows, adopting or improving it.
- Q5:** How do you approach changes or improvements to the workflow during the production? (In a production environment, how do you change your workflow, for example do you change your workflows when a new tool arrives, or you catch any strategies from industry)

A5: I don't really like to change my workflow and try to respect my initial plans. But if there are a new tool or a new trend, I try to make some experimental project, and if I think it is useful, I may use it in my project. Basically, I don't want to disturb my plans without proper experiments and prototyping.
- Q6:** Are there any notable differences in workflow approaches between different types of game environment projects (e.g., indie, AAA), and how do these differences impact the role of artists in workflow evolution?

A6: Yes, there are many differences in different type of projects and they greatly affect artist, one would be artistic freedom. In a performance having project, optimization is key and in generally it greatly limits artistic freedom. But in a AAA game, even there are optimization considerations, it is not that intense and allow artist to create higher quality artworks. This affects all workflows and creativity.
- Q7:** Looking ahead, what do you see as the future direction of environment art workflows, and how do you see artists contributing to shaping this evolution? (for example, implementing AI to environment art, or using a new approach for environment art, how do you see future direction of workflows and what is artist role)

A7: Well, I think future direction of environment and workflows are pretty blurry, some people talking about new AI implementations but there are no regulations in this area yet, therefore It might take some time. Because AI uses other artists artwork to create a new image, However, AI seems to be very useful in planning stages and general conceptualizations, I think artist don't have to use it to create images but rather use for creating plans and idea. Artists are always giving feedback to industry and define trends so artists role in environment art evolution is pretty visible.
- Q8:** Can you briefly explain how game environment art workflows evolved over time and how this evolution affects your approach? (Asking your thoughts about workflow changes during your career regarding any stages of environment art creation and how it affects your workflow)

A8: I have about 4 years of experience and there are some good changes, I think my overall workflows became less and less manual. Back to few years ago things were more manual and take times, but with the improvements of tools, things become more digital and less manual. And of course, I followed that and use more parametric or procedural approaches. There are some more changes too but they are low, for example AI will most likely bring some changes but right now it has no proper usage in terms of direct creation process.

Participant 2 (P2):

- **Q1:** Could you explain your definition for workflows and provide a brief overview of your typical workflow when working on a game environment art project? (Asking how you define workflow, your regular approach to an environment art creation, any special treatment that you think unique or important in your workflows regarding any stages)

A2: Sure, a workflow can be defined as the process of making things, in this case art and design. These workflows can be procedural workflows or modular workflows. I personally prefer to use traditional workflows, as I like to work with a more manual approach. In my regular workflow, I start with concept drawings or basic sketching to conceptualize my idea. I then follow regular traditional approaches with blackout and modeling stages. Following with texturing and lighting stages. This is my typical workflow. Regarding to any special treatment, I would say having feedback iterations is very important. I think all artists should have a basic feedback workflow for any environment art creation stages. Therefore, they can improve their final artwork.

- **Q2:** Can you share examples of innovative workflow strategies or methodologies that have proven effective in your environment art production pipelines? (For any environment art creations stage or whole production pipeline, e.g.: a strategy you use for environment planning or texturing stage, you can give multiple answers)

A2: In my opinion, especially recent asset library workflows are decent workflows. We as designers or artist do not have to draw or model each detail in environment art scene, because it is simply impractical and cost a lot of time. I think taking premade or assets from various asset libraries (Quixel library may be a smart approach. However, it is good for vista or background filling purposes only. Secondly, I think real time strategies are very important. Back to several years ago, making still renders or prototyping was very hard. You basically start to build an asset or a scene and have to go all the steps to have even basic first outcomes. But with real time technologies, you can have almost instant outcomes, which later on saves time and create more for creative and design process.

- **Q3:** How do you adapt environment art workflows to meet project-specific requirements or constraints, and what strategies do you employ to do? (There are lots of workflows, procedural, traditional etc., how do you decide which one you want to use)

A3: Yes, every project has its own requirements' think, in any environment art project, planning stage is the most important one, in this stage it is important to define what is project needs that way we can understand our choices. In short, I would try to balance workflow choices with project requirements' is important to

note that, workflows limitations may mostly depend to our own skills and experience level. Therefore, if our skills and experience level are not enough, we may not be able to define project reequipments' a result, my strategy is to understand project reequipment, my skills and a balance in between them.

- **Q4:** In your experience, what key parameters contribute to the efficient planning, adaptation, or improvement of a game environment art workflow?
(e.g.: Tools, skills, should artists learn more software, or ask feedback for their works, how can artist plan, adopt or improve their workflows)

A4: I think, tool variety is the most important thing to improve or develop an environment art workflow. I mean, workflow planning, improving are mostly depends on artists software knowledge and technical abilities. Otherwise, without proper technical knowledge artists may waste so much time. Therefore, for me the key parameter is software skills.

Secondly, if there is a team work environment a well-established communication and collaboration systems may help artists and teams to plan or improve their environment art workflows.

- **Q5:** How do you approach changes or improvements to the workflow during the production? (In a production environment, how do you change your workflow, for example do you change your workflows when a new tool arrives, or you catch any strategies from industry)

A5: I was always open to learn. When I see new tools or methods, they make me excited. Game industry is a really dynamic work field and has many new techniques and technology capabilities. And, of course environment art is part of this. When I find a new tool or want to adopt new methods, I first use an experimental project and try to understand or learn new techniques. This way I can decide if it can be useful in our main project or not. I think this is a smart way to learn changes and improvements while also protect your project from any distractions.

- **Q6:** Are there any notable differences in workflow approaches between different types of game environment projects (e.g., indie, AAA), and how do these differences impact the role of artists in workflow evolution?

A6: I don't really have AAA experience; I was able to work only for a few months in such projects. But I can make same example for other types. First, I think project size is the point, because project size, in a way, bring certain level of complexity. That means, a possibly more complex workflow and notable differences. In general, project size makes planning and creation stages heavier. But for example, in a smaller map, planning, managing or improving workflows is much easier. In short, project size and scope bring a certain level of complexity to workflow managements, let's say in terms of optimization and performance needs and so on.

- **Q7:** Looking ahead, what do you see as the future direction of environment art workflows, and how do you see artists contributing to shaping this evolution? (for example, implementing AI to environment art, or using a new approach for environment art, how do you see future direction of workflows and what is artist role)

A7: Yeah, tech is improving for sure and surely if effect environment art and workflows, I think, player or consumers almost always demands higher quality and dynamic (interactive) experiences. And we artists trying to create such experiences. I mean, artists and designer create “the perspective” for game industry. Other fields (programming, sound etc.) are Following this perspective. Maybe to future where player can actually create environments, Artists and designers define the perspective and directions.

- **Q8:** Can you briefly explain how game environment art workflows evolved over time and how this evolution affects your approach? (Asking your thoughts about workflow changes during your career regarding any stages of environment art creation and how it affects your workflow)

A8: From the very first years of my carrier, I have seen many changes, and I always try to adopt those changes and synchronize with industry.... I think, in a way It is really hard to keep yourself up to date. As I said before, game industry is way too much dynamic, in almost every month new tools or technique arrive. Some of them does not has a big impact while some of them may bring huge changes on your workflows. For example, years ago many things were kind of manual, let’s say you had to manually paint each texture (texture channels) in Photoshop (software) and surely it took so much time. But later on, PBR workflow introduced, which mainly bring huge quality improvements while also (with the help of specialized software’s) make things much easier. And yeah, last couple of years, automated process and fat forward techniques are in demands (procedural, modular). These types of workflows become common; you also have to make necessary updates to yourself. Maybe by Following forums, art websites, and of course lots of tutorials.

Participant 3 (P3):

- **Q1:** Could you explain your definition for workflows and provide a brief overview of your typical workflow when working on a game environment art project? (Asking how you define workflow, your regular approach to an environment art creation, any special treatment that you think unique or important in your workflows regarding any stages)

A1: First of all, I create the concept art and mood board after deciding on the project’s theme. And second, I gather the references for the game environment. These can be images or even videos. Third, I create the blackout to decide on the scale, modular assets to be used and overall structure of the environment. After all this initial plans Then comes the asset creation, in which first I create the 3D models and object that I am going to use in my environment scene. After modeling, I do the 3D texturing depending on whether it is a tile able or baked. Based on these textures I will be creating my materials. Then, I import the assets into game engine, which is Unreal Engine for me. While creating the scene in the level, I set the lighting and post-process materials together. In the end, I utilize optimization tools like LODs, lightmaps and collisions etc.

- Q2:** Can you share examples of innovative workflow strategies or methodologies that have proven effective in your environment art production pipelines? (For any environment art creations stage or whole production pipeline, e.g.: a strategy you use for environment planning or texturing stage, you can give multiple answers)

A2: In order to meet the requirements of the project, I like to plan everything beforehand. I absolutely love making my plans at first. To clarify, I need to know the number of meshes to be modeled, the number of textures to be used, texel density, the number of props and modular pieces etc. To give you an example, texture sets take the most space in project in terms of file size. Let's say we used 3 png file as a texture set it will roughly take 60mb in disk. So, to keep the file size at optimum and keep texel density at a certain amount, in order to do all these things, I make plans. And I believe this is a good workflow beginning, what means is, at the planning stage I define on which assets will be modeled with which texture and what type of material, shader, this includes even UV mapping which is a more technical detail, will be needed in the planning phase. Not like, I 3D model all the assets, and then 3D texture them one by one but rather plan them all and see what would be the best workflows or optimized strategy to do. Planning this process takes a bit of time, but in the end, the production becomes more efficient and easier.
- Q3:** How do you adapt environment art workflows to meet project-specific requirements or constraints, and what strategies do you employ to do? (There are lots of workflows, procedural, traditional etc., how do you decide which one you want to use)

A3: Before starting any environment art project, I conduct a thorough analysis of the project requirements, including the desired visual style, technical specifications and engine limitations. Understanding these factors helps determine which workflow will best suit the project's needs. To understand what can be done most effectively, I make small tests while producing the assets. For example, as I stated earlier that I plan any material and textures to be used before modeling the mesh assets. To see if I can get the desired result in the engine, I create the fundamental shaders beforehand. So, the production of assets never goes linearly. Afterwards, I can add the needed parameters onto the base shaders. That way, any necessary changes can be done without losing much time, in my opinion.
- Q4:** In your experience, what key parameters contribute to the efficient planning, adaptation, or improvement of a game environment art workflow? (e.g.: Tools, skills, should artists learn more software, or ask feedback for their works, how can an artist plan, adopt or improve their workflows)

A4: For me, the key parameter to efficient planning would be 'knowing what the artist can do and what he cannot do'. As a self-taught environment artist, myself, anything can be done and learned, but managing the time is truly important at production stages. In order to be efficient at production, the planning should be smooth and clear as much as possible. For example, producing foliage assets has always posed a challenge for me. In order to use time efficiently, I consult to other artists for foliage assets. In the end, if the artist plans the stages without knowing his skills and abilities, the process will lack some steps, or it will take much more time than necessary.

- **Q5:** How do you approach changes or improvements to the workflow during the production? (In a production environment, how do you change your workflow, for example do you change your workflows when a new tool arrives, or you catch any strategies from industry)
- **A5:** I believe game art community is growing everyday exponentially. There are more and more tutorials and articles that can be found online. Almost always, there is a better way to complete a task. In order to find the best option, the artist should always keep himself updated by following these developments and other artists' works. For example, if I see a better approach to a task, I quickly try that during the production phase of my environment. If it's a better solution, I use it. If not, I keep it accessible to be used in another future project
- **Q6:** Are there any notable differences in workflow approaches between different types of game environment projects (e.g., indie, AAA), and how do these differences impact the role of artists in workflow evolution?
A6: Even if the planning the stages from blackout to final production are almost always the same, the workflow is almost completely different for any project. The workflow truly depends on the specific requirements of the project. One project might prioritize the visual quality of the environment, another might look after the performance first. To give you an example, the Rockstar's popular game Red Dead Redemption 2 offers the best visual quality and narrative, but not 60FPS game performance. Whether it is indie or AAA, these preferences challenge the artist to push the limits, as long as they are well-defined and clear. If the overall perspective and decisions of the game is well defined, the artist will better understand the scope of the project and the game needs, so that he will make the production process more efficient. Plus, he will carry the project onto the next level when the time comes.
- **Q7:** Looking ahead, what do you see as the future direction of environment art workflows, and how do you see artists contributing to shaping this evolution? (for example, implementing AI to environment art, or using a new approach for environment art, how do you see future direction of workflows and what is artist role)
A7: Overall, artists play a crucial role in shaping the evolution of environment art workflows by embracing new technologies, experimenting with innovative approaches, collaborating with interdisciplinary teams, and advocating for sustainable and inclusive practices. By remaining curious, adaptable, and proactive, artists can help shape the future of environment art production in the gaming industry. Artistic perspective will be more and more valuable in the future, in my opinion. The production tools somehow always improve. This can be said for almost any industry. Yet, artistic creativity is ever-lasting.
- **Q8:** Can you briefly explain how game environment art workflows evolved over time and how this evolution affects your approach? (Asking your thoughts about workflow changes during your career regarding any stages of environment art creation and how it affects your workflow)

A8: It's been 4 years since I'm in the industry, so, I think it can be said that it did not much change during this time. Rather than change, I can give an example for improvement for realistic environment creation. The photo-scanning is much more popular now than it used to be. It has especially revolutionized the production of natural assets, in my opinion. For example, it takes serious amount of time to sculpt a tree-trunk in Zbrush, and to produce the leaves and branches in Substance designer. Instead, photo-scanning the tree with its trunk and leaves is much more realistic, and maybe efficient in terms of time management. Now almost any real-world object can be photo-scanned.

Participant 4 (P4):

- **Q1:** Could you explain your definition for workflows and provide a brief overview of your typical workflow when working on a game environment art project? (Asking how you define workflow, your regular approach to an environment art creation, any special treatment that you think unique or important in your workflows regarding any stages)

A1: Well actually I don't really have a pre-defined workflows for my artwork. I think it is all about project requirements. And of course, while working for client, there are client needs too. So, I define my workflow based on both project requirements and client needs. I want to specially point client parameter, not all client has a nicely defined idea or concept art, which later on become a first step to help client for idea definition. This can be, demonstrating some example project or experimental projects too. After that, we create images or concept arts for client, based on client feedback we start our scene creation. That would be a special treatment in my workflow, we can also call it as prototyping, I prototype environment scenes to help clients define or improve their idea.

- **Q2:** Can you share examples of innovative workflow strategies or methodologies that have proven effective in your environment art production pipelines? (For any environment art creations stage or whole production pipeline, e.g.: a strategy you use for environment planning or texturing stage, you can give multiple answers)

A2: In this industry, we always have to improve ourself, Its always about what you want and what you need, for example a mobile game needs and an even lower-level mobile needs are greatly differ. It is like there is no an A-to-Z workflows. And I really don't follow any specific rule or predefined workflow. But of course, we do some kind of collaboration workflows, so let's say we have a project from start to finish, we try to collect our team and make a brainstorming, or a hook up. All for having something to start, that doesn't have to be a fully defined plan, but maybe a basic demonstration about project, some basic sketch etc. So, my innovation way would be a collaboration-based workflows model.

- **Q3:** How do you adapt environment art workflows to meet project-specific requirements or constraints, and what strategies do you employ to do? (There are lots of workflows, procedural, traditional etc., how do you decide which one you want to use)

A3: Yes, so I think the first limitation would be project size, so this is a project-based limitation, or let's say map size, how huge your environment going to be.

The second thing would be project detail level, so if there are high demand on detail there will be a different workflow while in a more basic or less detailed scene, we approach a more basic or less time consumed approaches. I would say these workflows can be various procedural workflows. This mainly because of a fast result need. In fact, we try to use any procedural or parametric workflows as much as possible. That mostly means a good start, after this stage we try to detail thing and further shape our environment. But of course, if it's possible, we use procedural techniques in detailing too. If not, we try to manually or traditionally add details.

But I really want to point that, if it's possible, we use procedural workflows, because our projects may change in later stages and making changes in procedural workflows is much easier.

- **Q4:** In your experience, what key parameters contribute to the efficient planning, adaptation, or improvement of a game environment art workflow?

(e.g.: Tools, skills, should artists learn more software, or ask feedback for their works, how can artist plan, adopt or improve their workflows)

A4: Yes, yes, let's start with a direct example, so right now we are working for a project, In this project there are a podium like environment and there is a character we want it to move and pose certain movements. Btw this environment is for a more like product design and more like a production project. So, to do this we use Unreal Engine 5.3 version which include some pose and animation features like blend space, and in order to add further details to your animation you have to use yet another software which is root motions. In order to do all this stuff and reach project goals, we have to do many things manually or hardcode each feature. However, in newest version of Unreal Engine (version 5.4) there are much more different workflow. Now everything is really easy to do and in fact there is a brand-new UI with new tools such as Motion Matching.

In short, a tool can change everything about your workflow, this is including planning how to do things, adopting new features and see what kind of improvement you have. And one more addition, let's not forget artist skill level and experience level, it is not easy to take a new tool and adopt it tomorrow. So, let's add this parameter too.

- **Q5:** How do you approach changes or improvements to the workflow during the production? (In a production environment, how do you change your workflow, for example do you change your workflows when a new tool arrives, or you catch any strategies from industry)

A5: Well actually we talk about this a bit in previous questions, but of course workflows changes and improvements are mostly related your project, mainly how big your project, scope, stage and things like that. Let's say if you already did half of project or big chunk of it, you may consider twice to make any changes regarding to workflow, this is simply may become a headache. So, what I mean is If depending on project process, we can either take new strategies or workflows into considerations or not.

- **Q6:** Are there any notable differences in workflow approaches between different types of game environment projects (e.g., indie, AAA), and how do these differences impact the role of artists in workflow evolution?

A6: I would like to talk about Unreal Engine, I will talk a lot about this engine, so yes there are many differences in terms of workflow needs. But with new unreal engine lumen a nanite features I think this gap is closing. There are workflows differences in terms of optimizations. For a mobile based game, we have to be much more carefully about performance, but in an AAA game, optimization is also a big deal, but what AAA mean, is big team, big time, big money or something. So, they have resources to do everything while in a smaller team or a sole development, you need to do thing in time limited and less progressive way, I mean you really can't do something and go back for fixes again and again. You simply would have that time, because you are short in terms of resources. In terms of task management, there are also differences, for texture baking, packing, LOD setup and more.

- **Q7:** Looking ahead, what do you see as the future direction of environment art workflows, and how do you see artists contributing to shaping this evolution? (for example, implementing AI to environment art, or using a new approach for environment art, how do you see future direction of workflows and what is artist role)

A7: As I said before I will talk about Unreal. So, the developers of Unreal in recent time introduced PCG workflows for unreal engine, which is really handfull. So, what we do there is simply connect various nodes or even code new ones to create set of rules or logics, which later on allow us to create procedural contents. What is actually happening here is a more automated workflow model. And what is exciting is in certain time later we will be able to connect procedural workflows with AI, which will be something like AI workflows. In terms of artist role, I think it's all about what artist want. Like you can ask me or any other artist, they will surely ask about some automated process. I think in a way, artist create the final desire, and workflows, tools, software's created to feed this desire.

And let's add this too, I think within next 5-10 years will be mostly adopt AI in our workflows, but AI capabilities may be limited or may need fully match our needs, so we will work together, artist as a driver and AI as helper.

- **Q8:** Can you briefly explain how game environment art workflows evolved over time and how this evolution affects your approach? (Asking your thoughts about workflow changes during your career regarding any stages of environment art creation and how it affects your workflow)

A8: Yes, we can give examples on unreal engine software, so before we had unreal engine version 4 which was a powerful engine but has some more limitations comparing to newest 5 version. For example, there were a light baking process which sometimes take time, and there were some limitations about screen space or regular static, stationary or dynamic lighting options, light baking etc. So, you have to use a lot of fake lighting or decals to give certain surface looking our environment. But in unreal engine 5 there is no need for this, because there is a new lighting system which is Lumen. So, what I mean is a time-consuming process just ended with new feature. So similar to this new workflow, there were high poly-low poly problem within traditional workflows, so you have to create both versions and transfer details from one another to other one which a really time-consuming process. And of course, you have to make a proper optimization and LODs for each mesh. With newest Nanite versions there is no need this too. You can simply create and import your content. And What else, there is new substrate material editor where you can create multi layered materials within unreal engine, this is

also very good feature for texturing and material stages. And also, there are asset library workflows, so you really don't have to create everything, you can find it in Quixel like places and can use them anytime, anywhere you want.



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