



# Development of a product that uses 3D Non-Fungible Tokens (NFTs) to bridge the gap between the digital and physical world

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# Executive Summary

Nowadays, the digital space is gaining more and more relevance in our daily lives. Transactions, documents, education, meetings, and social activities are being digitalised. Companies from around the globe are making steps and taking initiatives to lead the change with concepts like the “metaverse”. Parallelly, blockchain technology is helping the evolution from the traditional internet to the so called “web 3”, a new concept where decentralisation is key, and revolutionary concepts such as digital ownership and authenticity are more possible than ever. In this scope, the graduation project takes place.

Due to the fast changes the digital environment has suffered in the last year 2021 with the surge of the NFTs and the serious investments in the development of “metaverses”, I intend to understand what problems users have while interacting with NFTs to promote this change and remove possible barriers for the adoption of the technology. The focus, therefore, is on the uses of NFTs and how the consumers interact and experience them. The goal is to detect a problem in this regard and propose a solution that improves the current state of the art. Thus, the work conveyed consists of a study of the general environment, industries, users and their problems and a definition of a problem to solve. Afterwards, I provide a solution to the problem detected.

In the study conducted I pinpoint the current trends of NFTs as a hyped and niche market, but with potential to become mainstream in the mid future (5 years). Accordingly, a problem that could prevent this to happen is detected as result of engaging with the users and their current use of NFTs. Here, the present scenario for showcasing NFTs is highlighted as an issue and potential roadblock for the mass adoption of the technology.

The solution developed does not only focus on the user problem but also on the underlying limitation, the technical existing constraints when visualising NFTs. The result of the graduation project not only solves the problem detected, but also improves the current state of the art and sets a solid ground for NFTs to unlock their maximum potential. This is achieved with the use of advanced technologies like Augmented Reality and concentration on the user’s desires.

Finally, future recommendations are suggested to improve the deliverable, including all the functionalities required. A fully working prototype will shed more light to the results obtained and give the users the true complete desired experience.

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# 1. Intro

The report starts by presenting the assignment (situation, objective and vision), methods and approach of the project. First, a brief description of the organisation where the project takes place is described. Then, the situation is presented, in which the objective and vision are described, in addition to the research question that will help guide the whole project. The chapter ends by explaining the approach to the initial assignment, outlining the methods and structure used during the thesis.

## 1.1 Newzoo

This Graduation Project is partially developed with the help of Newzoo, and fully guided by their ex-CEO, CO-founder and chairman, Peter Warman. Newzoo is a gaming-focused company located in Amsterdam, where they generously hosted me during the course of the project. They are the global leaders in gaming market insights, and therefore, they provide deep knowledge and valuable data concerning the top engagement platforms, markets, games, users and much more.

***“The world’s most trusted and quoted source for games market insights and analytics.”***  
(Newzoo, 2019)

Their work and help throughout the project has been of immense value due to their expertise, advice and in-depth insights.

## 1.2 Assignment: Objective & Vision

Since the creation of the internet there has been a proficient shift towards digitalization, where the replication of the physical world into the digital has been a constant. In this scope, a main roadblock has kept both realms somewhat apart: digital ownership and authenticity. With the appearance of the blockchain, a potential solution has emerged for digital assets to be truly owned and have “real-world” value and

significance. The technologies of Non-Fungible Tokens (NFTs) and Blockchain are not exempt from challenges, public scepticism, technological issues and other unknowns as always is the case when new disruptive technologies arrive. The context in which these technologies are relevant for the project is the so-called “metaverse” and the casual social activities derived from it. Further explanation about what metaverse, blockchain and NFTs are, their types and uses will be provided in Chapter 2. Background.

The objective and vision behind this project are summarised as follows:

**Objective:** The future of the digital world includes true digital ownership, authenticity and identity. The value and speed towards mass adoption depend not only on technological advances. It also depends on how this digital future is integrated into the “real” physical world. This is exactly the challenge of this project, to identify consumer and business desires and find solutions that will accelerate adoption.

**Vision:** True ownership, authenticity and identity will be a structural addition to the digital domain. Overlap with the physical world will be one of the key aspects that will determine the speed of adoption and true value that NFTs can bring to the world. I envision a product that helps bridge physical and digital domains with the use of NFTs and other relevant technologies, fuelled by a seamless interaction between users which improves the ease of use of NFTs, especially those thought to be the most relevant for the future: 3D and utility.

Ultimately the project will also involve the design of a concrete physical product to support this aim and vision. The intermediate findings, solutions and product are meant to form a solid base for further exploration of the potential for NFTs across practically any market or business imaginable.

The following research question, framed in the context presented, will help guide the project to a meaningful solution that fulfils the vision presented:

***How can users undergo a self-confident and engaging experience when showcasing their owned NFTs?***

## 1.3 Design Approach & Methods

This project is not about tackling the fundamental underlying technological challenges but to take away barriers from the consumer experience standpoint, with the aim to accelerate the use of NFTs in the “real world”. By doing so, the project should provide a foundation for wider adoption in terms of number and people as well as future areas of application and value creation as the underlying technologies are optimised.

Before conducting any research, an introduction of the context terms metaverse, blockchain and NFTs is presented for the reader to have a basic knowledge of these terms, necessary to understand the whole content of the thesis and how it is framed.

### 1.3.1 Discover Phase & Methods

The goal of the discovery phase is to understand the current state of NFTs, how they are applied and where, in addition to getting to know the industries and users, and how they perceive the present in this scope. Furthermore, in the discovery phase special attention is brought to understand the future trends and how the presence of NFTs is expected to influence the upcoming years.

To do so, several methods are used. In the first place, the discovery of the NFTs and applications is done with an exploration of different use cases. Next, the method applied for industry and consumer insights consists of questionnaires and a comparison, from two different levels: qualitative and quantitative. The combination of both approaches contributes to reducing the limitations of each approach (Trotter, 2012). Finally, the exploration of the users is made with a user-centred approach, involving context mapping and using interviews as a tool. These helped diving deeper into the user’s problems and gathering relevant information. Moreover, I applied external literature research and personal practical field explorations as complementary methods to gather extra information or corroborate certain results.

The discovery phase ends with the identification of a problem, which is derived from the user interviews and the definition of the target group.

The results of the discovery phase led to a redefinition of the scope presented in the project brief. The legitimacy aspect was not directly identified as an issue by the users, therefore, the scope was reduced to the visualisation aspect only.

### 1.3.2 Define Phase & Methods

The goal of this chapter is to precisely identify the problem, target group, stakeholders, and requirements. The proper definition of these elements enables the presentation of a proposed solution at the end of the section, where the values and contributions to solve the problem are also highlighted.

The methodologies pursued to achieve these results are the following. The problem definition canvas is used to cover all the target group definition, problem definition and current solutions in a deep and meaningful way. Most of the insights will come from the discovery phase and will be presented here in a structured matter. The List of Requirements method is applied to unify all the requisites (technical, economic, and user qualities) needed to tackle the problem in the given context. The proposed solution is illustrated with the use of a customer journey map and a breakdown of the main components and their relationships with the user (interaction, experience, service). Finally, the values and contributions of the design proposed are presented with the use of the Value Proposition Canvas, a tool aimed to visualise how the solution targets the user’s pains and gains.

The results of this chapter set the base ground knowledge of what the design solution is, what it solves, for who, why and in what context. Further development on how that was achieved followed.

### 1.3.3 Develop & Deliver Phase & Methods

The goal of this chapter is to explain the design process and motivated decisions that led to a final design, and illustrate how the user interacts with the final solution in a detailed manner.

The approach followed consists of targeting each part of the solution and explaining it in-depth, this is:

**The creation process.** Focused on the user values and what the product must convey or deliver to the users. The methodologies used here are Harris Profile, collages, questionnaires and PrEmo, which help in the decision making of design directions.

**Technology.** Focused on describing the different parts, how they work and prototypes. Main focus on the technology aspect. The tools used are simplified assembly diagrams and architecture flow charts, Cad models (Solidworks), 3D printing and Programming (Unity).

**How they interact with the user.** Focused on the user interactions. The methodology tools used to illustrate are user flow charts.

The chapter finalises with a comparison between the current state for visualisation of NFTs in the physical world and the proposed solution. The method used to illustrate this will be a simplified user journey map for each case.

### 1.3.4 Validation Phase & Methods

To finalise the design phase, the validation chapter focuses on verifying the design solution, from a user and expert perspective. These validations are accomplished with the use of methods such as user tests, questionnaires, interviews and expert validation sessions.

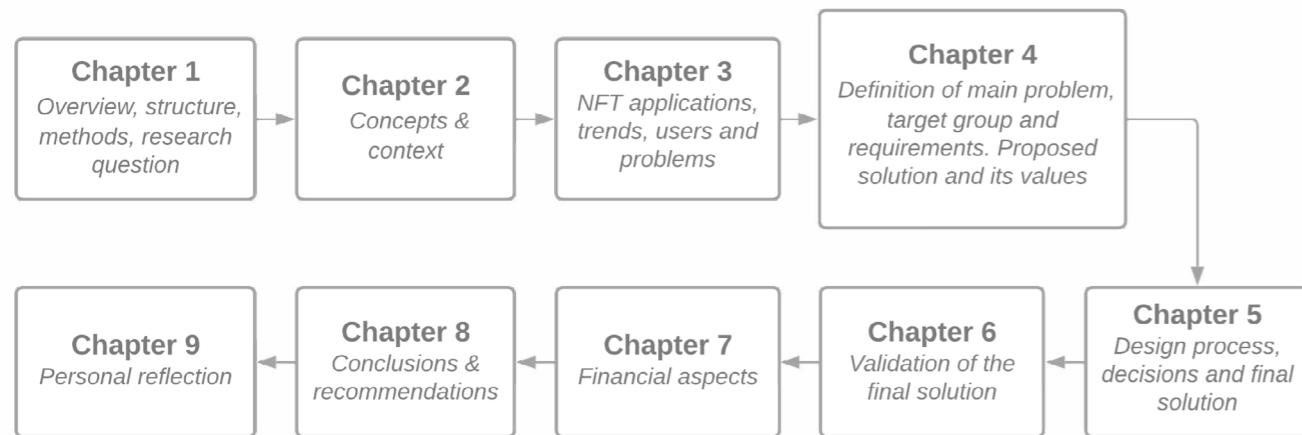
By the end of this chapter, the solution designed will be complete and no further development or changes are made.

### 1.3.5 Viability Phase & Methods

In this chapter the main business topics are covered. The goal is to provide an overview of the estimated cost of the product from two points of view: small scale and large scale production. This goal is achieved with the use of a parametric estimation.

## 1.4 Project Overview

The Graduation Project is divided into 9 chapters that serve as documentation of my work during the past months and all the knowledge created, challenges faced and intermediate steps. An overview of the chapters can be seen in **Fig. 01**.



**Fig. 01.** Project overview

The first chapter gives an overview of what the project consists of, its structure and methodologies as well as the main research question.

The second chapter focuses on the explanation of concepts needed to understand the context. Chapter 3 explains the current NFT applications in different environments, future trends, who the users are and their problems. These chapters form the solid ground over which the project is defined and built.

Chapter 4 contains all the detailed information over which the design is iterated. The problem, target group and requirements are stated, and a solution proposed and analysed in terms of value for the users.

Chapter 5 explains the design process and evolution, motivates decisions, and presents the final solution. All technical and user aspects are covered in this section. Chapter 6 includes the validation of the solution from user and expert perspective. These chapters are where all the design solutions are explained.

Chapter 7 covers the financial aspect of the product, mainly the costs. Chapter 8 includes a summary, conclusion and a set of recommendations to improve the work done. Finally, in chapter 9 a personal reflection of the process, learning goals and achievements is presented.

## 2. Explore

In this section I present the **relevant background** knowledge and the context in which the project is framed. This information aims to provide the reader with the information necessary to dive into the core of the graduation topic. All the information gathered in this chapter comes from multiple external references.

### 2.1 The Metaverse. The Ever-Expanding Digital World

Metaverse is a term first used in Neal Stephenson's 1992 science fiction novel Snow Crash (Stephenson, 2003), (Wikipedia, 2022), where humans interacted with each other and digital agents in a 3D digital environment in the form of avatars (Marr, 2022b)

The word "Metaverse" now has returned to describe the accelerated expansion and increased immersiveness of the digital world that we, as consumers, have increasingly embraced as the means to socialise with others, create, consume content and play. The digital world will become more and more similar to the "real" physical world as new technology introduces true personal ownership, authenticity and identity that all are transferable from one digital or virtual environment to the other.

How serious industry leaders are taking this, is illustrated by the re-branding of Facebook to Meta in October 2021 and the emphasis that Mark Zuckerberg put on the "Metaverse" as the future of his company and overall consumer engagement (Morrow, 2021). Investments and acquisitions also point in the same direction. Last year, Nike acquired the largest virtual sneaker brand RTFKT. This year, Microsoft acquired one of the largest games companies in the world, Activision/Blizzard.

Many have attempted to create a definition of the "Metaverse". The definitions provided by

Tim Sweeney, CEO/Co-Founder of Epic Games (publisher of Fortnite and developer of game engine UnReal) as well as Jonathan Lai, partner at Andreessen Horowitz, seem most to the point and comprehensive:

*"Realtime 3D social medium where people can create and engage in shared experiences as equal participants in an economy with societal impact."*

Tim Sweeney. CEO/Co-Founder of Epic Games. (Newzoo, 2021)

*"A persistent, infinitely-scaling virtual space with its own economy and identity system"*

Jonathan Lai. Partner, Andreessen Horowitz / a16z. (Newzoo, 2021)

Although all of the definitions are different, they agree in the societal-digital environment where an economy exists and users are also creators.

#### 2.1.1 Gaming in the Metaverse

Games already show us a glimpse of what the "Metaverse" could look like. Games have evolved from products to services to platforms. Apart from playing, users can now engage in non-game activities such as socialising, creating and sharing, with potential of replacing traditional social media. Examples of these games include Minecraft (**Fig. 02**), Roblox, Fortnite and early Habbo Hotel (**Fig. 03**) that was launched as early as in the year 2000. It is not surprising that games companies are expected to play a pivotal role in the evolution of the "Metaverse". Gaming has inevitably become core in the metaverse development.

In this new concept of game, economies merged and the genuine interest for avatar identity gained relevance as a natural effect of the surge of communities and socialisation. And it is mainly thanks to these concepts why NFTs have become a hot topic for the metaverse, to the point where many think that they are the future of these environments. However, before introducing what NFTs are, it is necessary to explain their underlying technology: blockchain.



Fig. 02. Minecraft. Source (Rich, 2022)



Fig. 03. Habbo Hotel. Source (Alberto, 2021)

### 2.2 Blockchain. Opportunities for the Metaverse

#### 2.2.1 Definition

A blockchain is a distributed digital data storage system or ledger, where pieces of data are structured in structures called "blocks" (Hayes et al., 2022). These "blocks" or pieces of information have a certain storage capacity and are continuously being added, in a linear way, forming a chain or "blockchain". One of the relevant aspects of these storage systems is that each block makes reference to the previous one, and therefore all the information is linked. This quality adds a higher security level to any other distributed storage system.

#### 2.2.2 History

The blockchain is a fairly new technology that appeared in late 2008 where a white paper introducing a decentralised peer-to-peer electronic cash system - called Bitcoin - was posted with the pseudonym Satoshi Nakamoto. The technology behind the Proof Of Work (PoW) used in Bitcoin's blockchain is the system called Reusable Proof Of Work (RPoW). To understand the principle of blockchain it is necessary to look at the technology at this level.

RPoW was introduced by a computer scientist and cryptographic enthusiast called Harold Thomas Finney II in 2004 (Binance, 2018), which solved the problem of double spending by keeping the ownership of tokens registered on a trusted server. The problem of double spending consists in using the same money (or tokens) to purchase more than one good at the same time (River Financial, 2021). This problem does not exist with physical money, as it cannot be in 2 different

places at the same time. With digital money the problem of double spending is only solved thanks to trusted third parties, such as banks. Each bank has its own ledger, however, they are all accountable to the central bank or government. This way, fraudulent transactions are avoided. However, the current system includes limitations in the amount of money one can transfer, fees and number of transactions a client can execute. Transactions can take days and timing can be dependent on opening hours of individual banks.

#### 2.2.3 Decentralisation & Cryptocurrencies

In the case of blockchains there is no centralised authority to verify the legitimacy of the transactions, and therefore, the referencing system emerges as an alternative procedure to prevent the aforementioned fraudulent transactions from happening. However, as well as with the current system, it is not perfect and possible hacks can happen. More about this will be explained in the future chapters.

Blockchains function as digital economies thanks to the use of tokens called "cryptocurrencies". An example of a token is Bitcoin (BTC). Tokens serve as the valuable coin of exchange and trade in each blockchain. Therefore, each one has its own token and system to regulate the economics.

Within a blockchain, the cryptocurrencies are considered fungible assets. This means that they are defined by their value. A perfect example of this is money. If there was a bill of 10 BTC one could always exchange it for 10 coins of 1 BTC, for example, and the total value would still be 10

BTC. Nevertheless, there are some types of tokens called Non Fungible Tokens (NFTs) that work differently, their value is defined by their properties and market interest. This can be compared to the value of most physical products.

Taking a car as an example: you can buy a car for a certain price and instantly resell it, but its value is lower because it is not considered new anymore. Nevertheless, with time that car can become a collectible and its value could increase. The car is unique, owned by an individual and cannot be interchanged for the sum of all its parts for example. NFTs have this characteristic. More background on NFTs is given in the annex and following paragraph.

Blockchain and decentralised digital economies are seen as an important part of the “Metaverse” and games which largely already operate as a first-generation metaverse. And here is where NFTs gain relevance.

## 2.3 NFTs and their Impact for Digital Assets

### 2.3.1 Definition

Non Fungible Tokens, also known as NFTs, are digital assets (for example an image or a song), that have their ownership information and characteristics recorded in the blockchain in the form of code called **Smart Contract** (Shah & Brown, 2022), (Ethereum.org, 2022b). For more information about Smart contracts see **Appendix 01**. The characteristics of an asset define the NFTs in terms of digital ownership and authenticity. NFTs store these characteristics in the blockchain, make them visible for everyone and identify the owner of that asset.

### 2.3.2 Account, Address & Wallet

To own an NFT, as well as cryptocurrency, an **account** is needed. They are entities that can send and receive transactions. Each account has an address, which is a way to identify it, the same way an address of a house identifies where the house is located. The **address** is a unique string of letters and numbers that has a specific allocation in a blockchain, comparable to a bank account number (Ethereum.org, 2022a).

A **crypto wallet** is an interface to manage your account or accounts if you perform transactions on different blockchains (CoinMetro, 2022). Due to the difference in nature within the blockchains, not all accounts can hold all types of tokens. In **Fig. 04**, an address from an Ethereum account is shown in a crypto wallet.

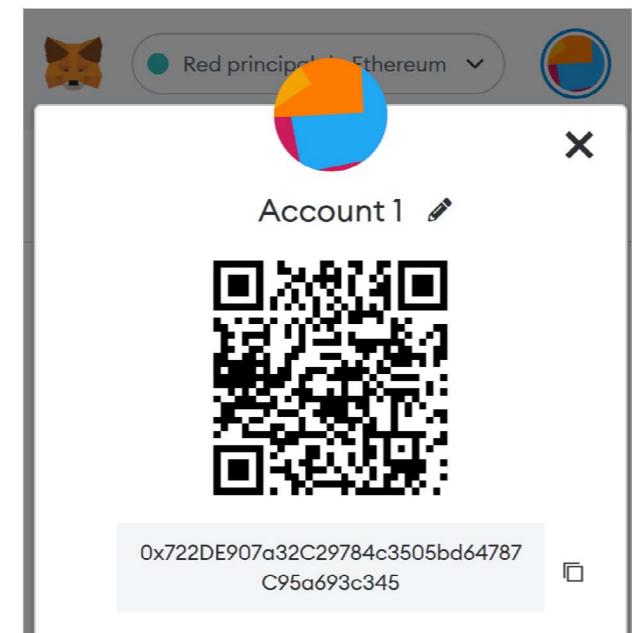


Fig. 04. Ethereum wallet address

Although NFTs can grant that only one account is the proprietary of one asset, there are still concerns about the ownership. This is due to the fact that there are no legal regulations in the NFT space and blockchains are never truly 100% decentralised, as companies and individuals develop the blockchain and run token economies on them. Nevertheless, the risks of an NFT being compromised to the level of someone changing ownership by modifying the blockchain is extremely low.

### 2.3.3 Types of NFTs

NFTs being digital assets can take various different forms and serve for different purposes. In this section the most common types of NFTs existing as of 2022 will be presented, as well as relevant information for the project concerning them.

- **Art.** Images of all types and styles. Collectibles and Profile pictures (PFPs) can be included in this group, as they are images which are clustered in collections and/or used in social media profiles
- **Media.** Videos and Gifs
- **Metaverse Digital land.** Portion of land in a metaverse world. It can be just a pixel area or a 3D model
- **Digital clothing.** 3D models of fashion clothes
- **Utility NFTs.** Could be of any kind: images, 3D objects, media... linked to redeemability and opportunities
- **Credentials and identity portability.** Related to more formal documents
- **Gaming.** Used in blockchain games and metaverse in general. They can be digital clothing, 3D, images or any other kind
- **Music**

It must be said that this classification is not the only one there is. More in depth decomposition can be made, as well as other classifications based on different criteria: format type, usability, industry use, etc.

### 2.3.4 Challenges & Future Developments

NFTs, as every novel technology, is not exempt from challenges that will have to be overcome. The main challenges can be clustered in 3 different groups, these are, derivatives from the technology itself, the use and the fast surge of the NFT industry.

#### Challenges of technology. Scalability

The underlying technology is complex in terms of concepts and functionality. Blockchain technology has been facing problems in scalability and handling high demand of use. This results in high monetary and environmental costs. Nevertheless, solutions are already being implemented to face this issue. For more about this topic see **Appendix 02**.

#### Challenges in use. Knowledge barrier

The technology complexity also creates a big initial knowledge barrier that prevents potential users from joining the space with the needed basic knowledge. These two issues lead to problems in use like hacking and scams.

#### Extreme market surge. Regulations cannot keep up the pace

Moreover, the surge of the NFT industry in the last year, +21000% from 2020 to 2021 (Browne, 2022), has disturbed the stability and regulatory panorama. In times of extreme economic growth in short periods of time, markets fall into speculation, high volatility and unrealistic prices. Even more, regulations and taxes find it complicated to follow the path of the development, leading to grey areas in the use and the validity in the legal context.

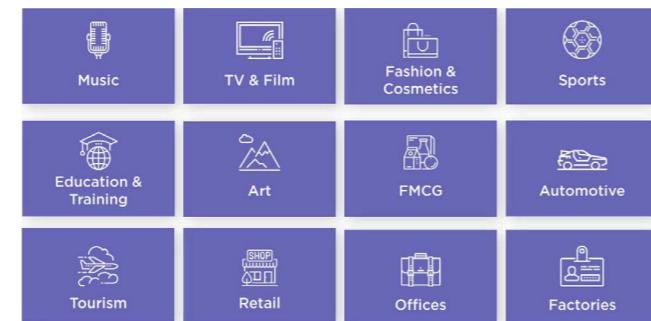
## Opportunities for markets to expand. New frontiers

On the other hand, NFT technology brings new opportunities for development thanks to its characteristics (digital ownership, authenticity, decentralisation and source tracking). They are appealing for new generations which have grown in the technological era, and are comfortable with dealing with advanced technology. This appeal is of great relevance, as it can help create new business models and transform the digital and physical environments. The potential has not been unnoticed for big brands which are already making big moves in this direction. An example is Nike, buying RTFKT (creators of virtual sneakers and artefacts, leaders in the NFT space) as the fourth brand next to Jordan, Nike and Converse. The partnership is a sign of how deeply companies believe in the future of virtual items. For more information about problems and opportunities, see *Appendix 2*.

## Interest in NFTs. Investors Take Action

In 2021, the **Major Venture Capitalist** funds joined the NFT space with **large investments**. Companies from all sectors: Video Game companies, Avatar startups, Marketplaces, and Service providers benefited from multi-millionaire investments from investors such as Andreessen Horowitz (one of the largest NFT market investor for startups), Coaute Management LLC, which closed the largest deal from 2021 funding \$305 million to the company Dapper Labs, behind Cryptokitties and NBA Top Shot. Other large investors would be Benchmark, Animoca Brands, Breyer Capital, Sequoia Capital, Coinbase Ventures, Tezos Foundation, and many others (Baloyan, 2021).

Furthermore, NFT marketplace OpenSea received more than \$100 million in funding and many others received deals in millions of Euros. All these important investments lay a strong foundation for future development and market adoption. The interest from large investment firms is not arbitrary. The exponential growth of the market has attracted large fundings seeking for maximising profit in a hyped market. And funding is not limited to one type of industry, companies from diverse sectors have already jumped into the space, as shown in *Fig. 05*.



*Fig. 05. Industries that have jumped into the metaverse.*  
Source (Newzoo, 2021)

This proves the affirmation of major research papers in the blockchain and web3.0 space, which position NFTs somewhere between commodities, securities, and IP rights.

## 2.3.5 Relevance of NFTs in the Metaverse

In spaces like the different metaverses, where more and more industries are diving in, it is now clear the impact NFTs can have in these environments. Their characteristics and applicabilities in multiple industries can serve as an excellent tool to provide the desired experiences in the emerging virtual worlds (Marr, 2022a).

# 3. Discover

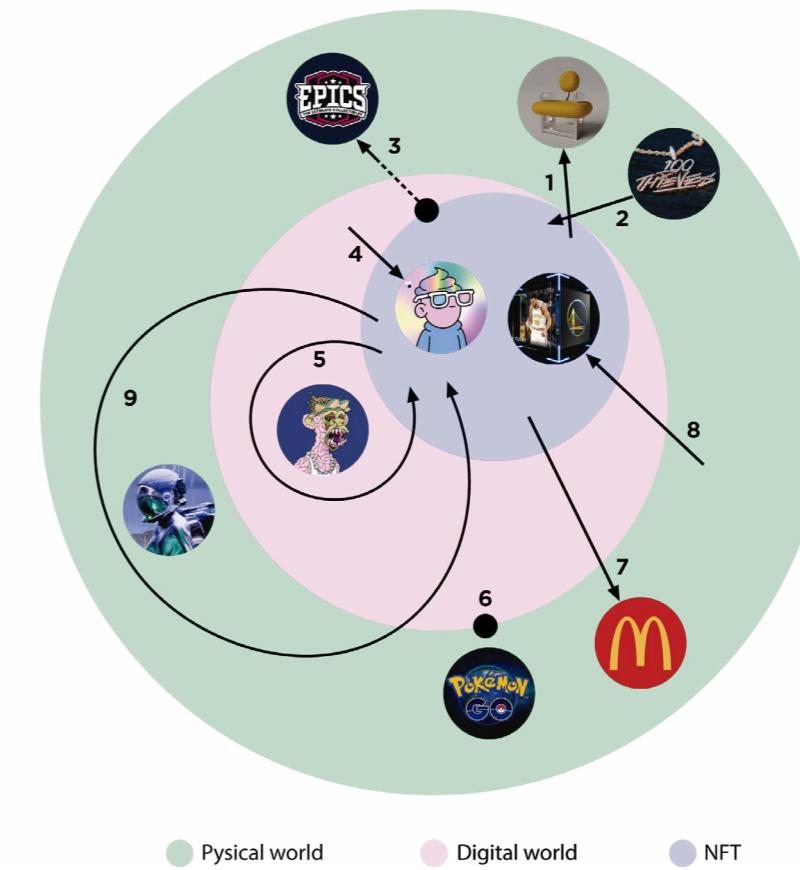
This chapter is divided into **3 main sections**, all aimed to **shed light into the NFT environment** through different angles: current state and applications, trends and future applications perceived by consumers and industries (which includes comparison between them), and user identification and problem detection. By the end of the chapter, the reader will be familiar with the NFT space in all facets and understand which are the main users' concerns.

## 3.1 Environments & their Relationships with NFTs

This chapter is the first of the three main sections previously introduced. It presents the study I conveyed in relation to the different applications of NFTs. The **goal** is to provide an overview of the existing relationships between the environments and how, where and what NFTs are applied. This is done with the creation of a diagram that helps visualise the interactions. In the end, a brief conclusion on which interaction would be more interesting to focus on is given.

### 3.1.1 The Environments where NFT are Applied

Although NFTs belong inherently to the digital space, for the purpose of studying their applications and differences in relation to other environments, I have assigned their own space, with frontier with the digital and physical environments. The model I created of the different environments (**NFT**, **digital** and **physical**), containing different use cases of NFTs for the purpose of the study, can be seen in *Fig. 06*.



*Fig. 06. Environments and their relationships with NFTs*

## 3.1.2 Applications of NFTs. How, Where & Types

By observing the different types of NFTs, their qualities and use cases, I have made a distinction between **nine different interactions**, which will be explained next. As a highlight, due to NFTs always belonging 1st to the digital environment, a specific case will be presented covering this interaction (case number 4), and then omitted for every case. All interactions described focus on meaningful relations between the environments, meaning that the relationship adds to the properties of the NFT and therefore defines them in a way.

Now, an explanation of each interaction is provided, with an example that helps understanding the implications these interactions have.

### From NFT to Physical (1)

The relationship between these 2 environments result in NFTs with **direct applications in the physical world**. An example of NFTs belonging to this category would be CreaChairs (*Fig. 07*), a collection of chairs created by the interior design studio Thehighkey (*Thehighkey, 2022b*, *Thehighkey, 2022a*). These NFTs are not only created as a piece of digital furniture that can be used in any digital environment, but are also meant to be produced. They are auctioned in sets of 200 to cover the costs of production. This way, when the chairs are fabricated they already have an owner and all costs are covered, resulting in a new way of crowdsourced design methodology.



*Fig. 07. CreaChair. Source (Thehighkey, 2022b)*

### From Physical to NFT (2)

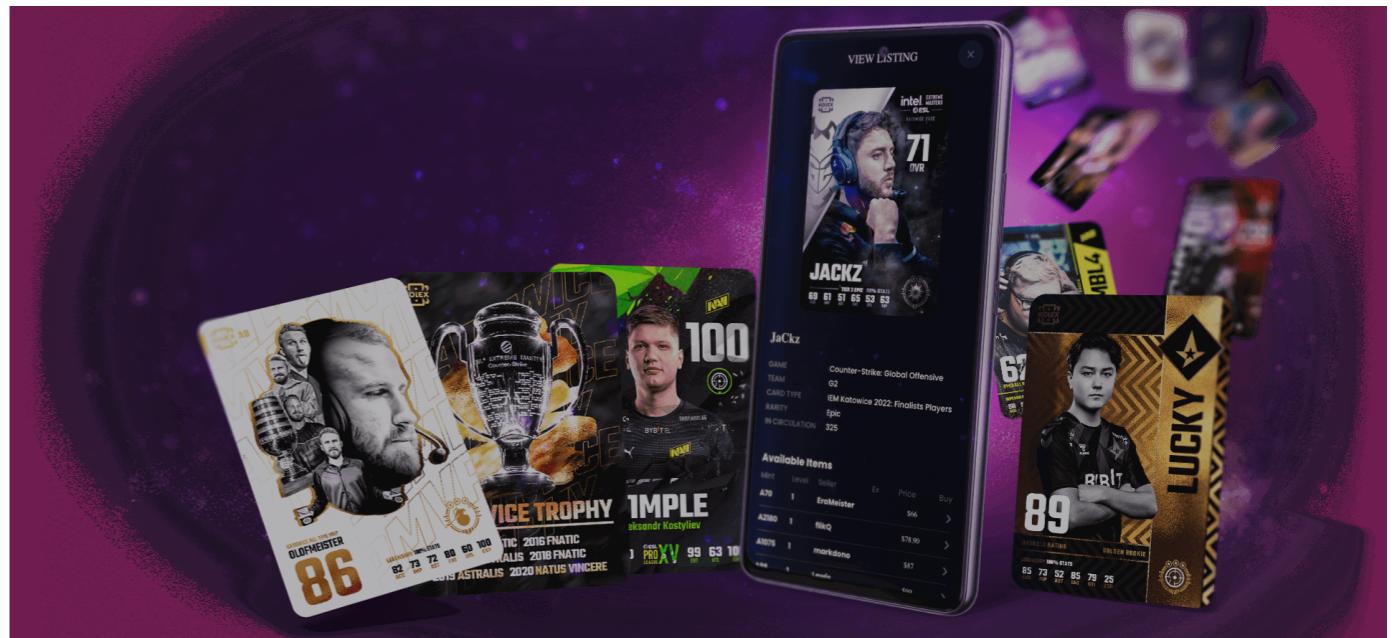
In this category stand the **NFTs created from a physical model** and whose properties and value depend on those of the physical model. They are digital twins. An example of a relationship of this kind would be the 100 Thieves' chain. The physical chain was a trophy given by 100 Thieves' CEO Nadeshot to his League of Legends team after winning the 2021 LCS Championship. The chain was then turned into 300,000 animated NFTs (*Fig. 08*) and given out to fans for free, as a commemorative asset (*Switzer, 2022*).



*Fig. 08. 100 Thieves. Necklace NFT. Source (Switzer, 2022)*

### From NFT-Digital Border to Physical (3)

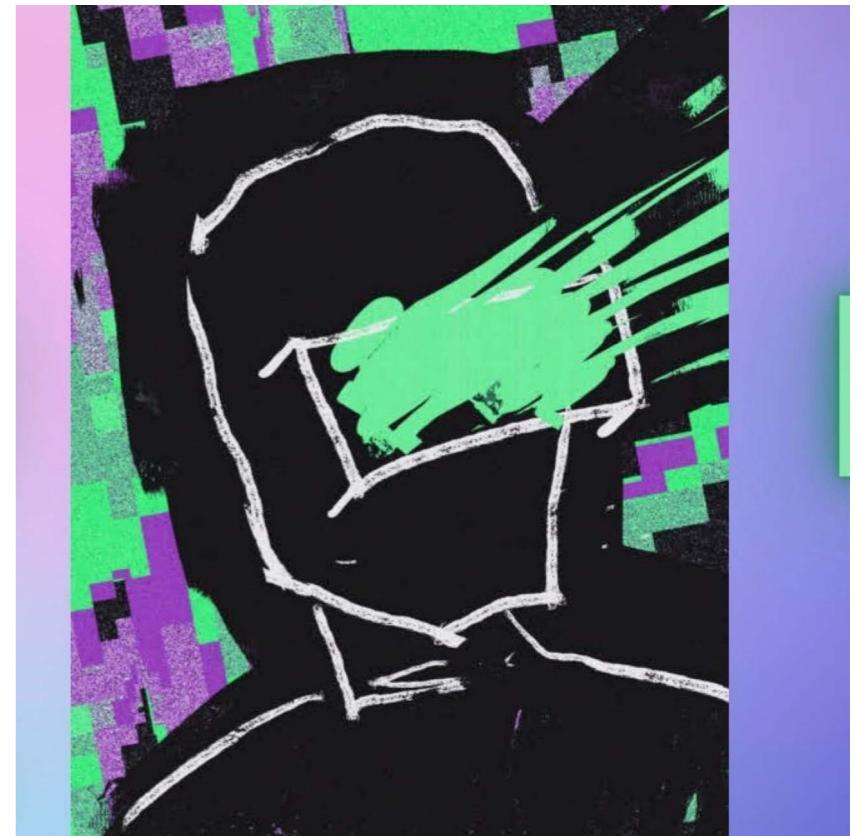
Also digital twins, but in this case the **physical asset is the representation of the NFT**, which completely changes the properties of the NFT. These assets are situated in the NFT-digital border because of their slight applications in the digital world (mostly tradability). An example of this relationship between environments is embodied with the Epics collectible cards (*Fig. 09*). The cards have a physical and digital (NFT) side. They combine the thrill of collecting physical items with the possibilities NFTs bring, such as upgradability and redeemability. For example, one can combine duplicates to have a better card, which will also grant physical rewards (*Kolex, 2022*).



*Fig. 09. Epics collectible cards NFT. Source (Kolex, 2022)*

### From Digital to NFT (4)

**Most common relationship.** It is present in every case. The most common example of NFTs that only possess this relationship is digital art turned to NFT. It is the simplest of the interactions and based on ownership and tradability. One example is Don't Panic piece, by digital artist XCOPY (*Fig. 10*) (*XCOPY, 2022*).



*Fig. 10. XCOPY. Don't Panic. Source (XCOPY, 2022)*

## Loop Digital-NFT (5)

This relationship brings additional properties to NFTs thanks to the regressive character. **NFTs have the possibility of evolving** when interacting between environments. An example of this would be the Bored Ape Yacht Club (BAYC) with the mutant properties. BAYC NFTs are images of monkeys with several traits. With a BAYC NFT and the addition of another NFT called “serum” (**Fig. 11**), you can create another NFT: A mutation from the 1st one. The serum disappears and you have the original image and the new one. An example can be seen in **Fig. 12**.



**Fig. 11.** BAYC mutant serum.  
Source (Langston, 2022)



**Fig. 12.** Mutant BAYC. Source (Ravi, 2021)

## Digital-Physical Border (6)

Any Augmented Reality (AR) game application. They combine **virtual elements superposed over a real environment**, which brings new ways of experiencing both environments. An example is Pokemon Go, a game where players can interact with virtual monsters in their neighbourhood (**Fig. 13**).



**Fig. 13.** Pokemon GO scenario. Source (Pokemon GO, 2022)

## From NFT to Digital to Physical (7)

When the three environments combine, the most powerful interactions emerge. In this case, an **NFT brings capabilities to the physical world** like services while also having utility in the digital. An example of this would be McDonald's service in the metaverse. The fast-food chain aims for a mixed experience, where the users in the metaverse can go to their virtual restaurants and order food that will be delivered then to their physical homes, all with the use of NFTs (Dean, 2022).

## From Physical to Digital to NFT (8)

Similar to the digital twin examples mentioned previously. However, in this case, the relationship with the digital environment can be more meaningful, where users can experience the NFTs rather than just own them or trade them. An example would be the NBA Top Shot collection (**Fig. 14**), which consists of stellar moments of the NBA history turned into NFTs. The properties come from the physical historical moment, and it can be displayed digitally while also owned and traded.



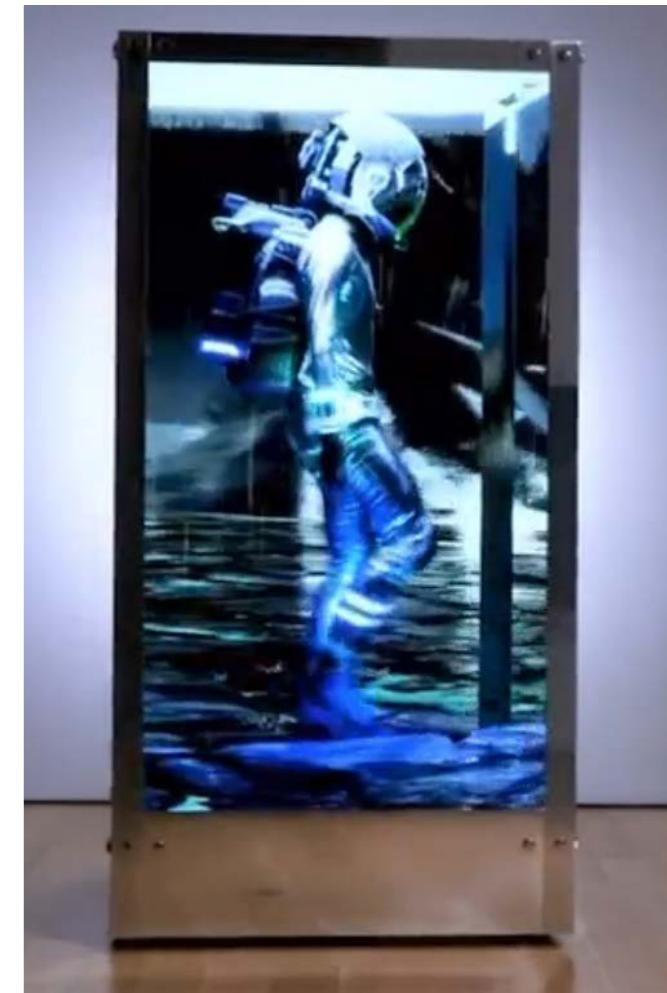
**Fig. 14.** NBA Top Shot. Magic Johnson. Source (NBA Top Shot, 2022)

## Loop NFT-Digital-Physical (9)

There are very few examples where these interactions happen. Human ONE from Beeple (**Fig. 15**) would be the example that embodies the **most complex of the interactions** between the 3 spaces. The physical sculpture for HUMAN ONE is an always on kinetic 16K video sculpture that changes over 24 hours according to the time of day. The video will also change over time as the story unfolds (HUMAN ONE, n.d.).

## Main Insight

The **constant evolution** of an NFT while also being **part of the physical world** and enriching every interaction would be the ultimate goal of every NFT use. Nowadays, more and more NFT collections and new creations are trying to involve interactions with the physical world thanks to utility NFTs and as a response to critiques. Therefore, it is of special interest to focus the attention on this specific relationship of environments.



**Fig. 15.** Beeple's HUMAN ONE. Source (Beeple, 2022)

## 3.2 Market Research & Analysis

The content of this chapter forms the second big section of the discovery phase, aimed to determine the trends and future applications by the hand of consumers and industries. More concretely, this chapter **showcases the results of user and industry** focused questionnaires and finishes with a set of main takeaways when both surveys are compared. These are the main trends for communities and target group sizing.

### 3.2.1 NFTs From a Consumer Perspective

In this section the main **objective** is the identification of the target group (in terms of gender, age group and professional situation), and their interests related to NFTs, followed by the future trends seen from a consumer perspective.

To do so, the company conducted an online quantitative survey in May 2022, focused on the knowledge users have about NFTs, their uses and trends. The raw data of this survey was provided by Newzoo. **My contribution** to the knowledge in this section includes the analysis of the questionnaire, more specifically all the result explanations, insights, graphs and conclusions presented. Although this research is not focused on the physical environment, it does give clues about how people engage with NFTs and how they visualise future scenarios. The method followed, results and a brief discussion of the research conducted are presented next.

#### Method

The structure of the questionnaire:

- **Section 1:** Demographic profiles
- **Section 2:** Gaming behaviour
- **Section 3:** Key concepts. Awareness, knowledge and intentions
- **Section 4:** Focus: Play to earn
- **Section 5:** Focus: Ownership
- **Section 6:** Classification

Not all the sections were of interest for the project, therefore, only questions in some of the sections were selected. These sections are:

- **Section 1:** Demographic profiles (user demographics)
- **Section 3:** Key concepts. Awareness, knowledge and intentions (concepts such as metaverse, cryptocurrency and blockchain)
- **Section 5:** Focus: Ownership (use and trends of NFTs)
- **Section 6:** Classification (user's income, working situation)

To see the specific questions selected see **Appendix 03**. Consumer Research Question Selection. The survey was created and distributed online by Newzoo, which also gathered the raw data results, weighted them to represent the overall population accordingly, and delivered it to me for the analysis.

Almost 1800 participants spread over the US and Germany participated in the research. For ease of later comparison with the industry research, and a clearer overview of the results I clustered the participants in 3 different age groups: between 18-25, between 26-35 and between 36-50. With these age groups I expected to record how different generations perceive NFTs and related topics. Germany will be considered as representative for European countries, as the cultural similarities are close enough.

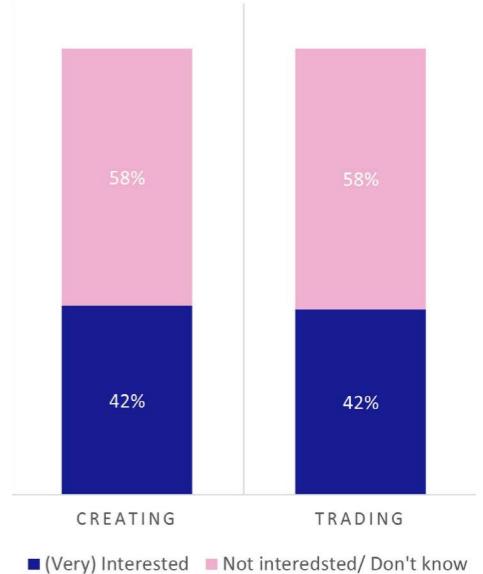
The analysis was conducted using comparisons between results and associating them to a specific gender and age group, with the purpose of obtaining a relevant overview of the matters identified (what, how, who, when).

## Results & Discussion

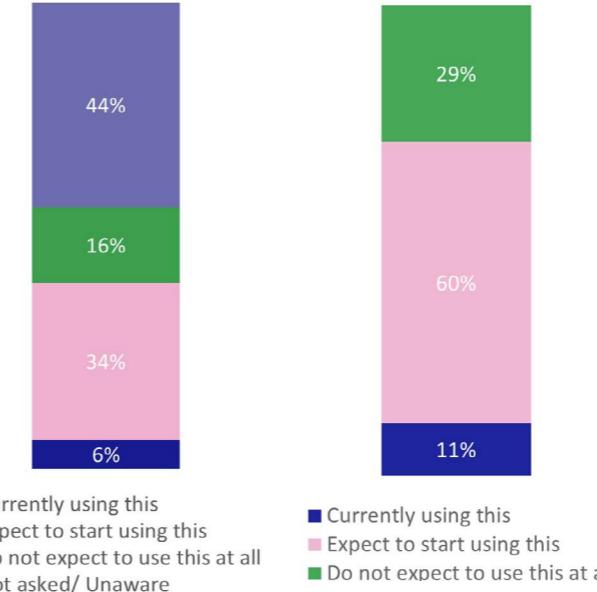
The **most important outcomes** will be presented and discussed. To see an extensive overview of all topics, see **Appendix 04**.

### Main insight. Balance between creators and traders

As for the user interaction the main outcome of the survey is that the **interest in creating** NFTs is the **same as trading** them: 42%, as shown in **Fig. 16**. This result is of significant importance as it reflects balance in the space. The equilibrium between creators and traders brings new opportunities for technical development while also ensuring a healthy ecosystem for economic growth and stability.



**Fig. 16.** Interest in NFTs. Creating VS. Trading



**Fig. 17.** General population

**Fig. 18.** Aware population

### Early adopters. Few, mostly male and full-time workers

In general, the population that is aware of what NFTs are is 56% (**Fig. 17**). When referring only to the aware population, **Fig. 18** illustrates that early adopters are few (11%), but a big increment is expected in the upcoming years from the aware population.

Out of the total number of participants, the **male audience dominates** the space in several aspects, such as knowledge (2/3 experts is male), usage and future interest (1.6 times more usage and interest than females).

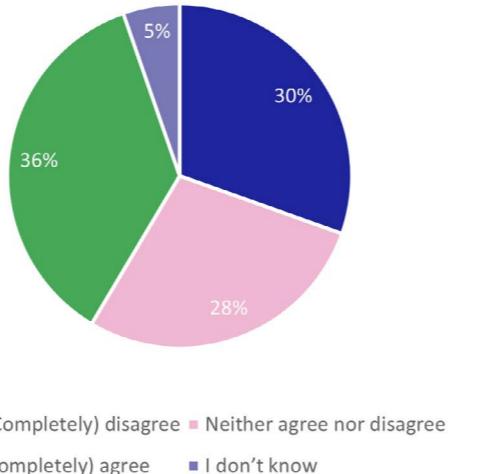
When focusing on the **age groups**, the younger group (18-25) claims to be the most expert (1.6 times more than the rest) with a focus on the present and the current opportunities, Millennials (26-35) are the most constantly active, and optimistic, and the older generations (36-50) are more future-oriented and optimistic about what NFTs can bring.

**Occupation:** the early and future adopters are mainly full-time employees, however, an increase in the rest of occupational situations (self-employed, part-time employee, student...) will occur in the future.

In **Chapter 3.2.3** a further discussion of the most relevant group for the project will be discussed, with input from the industry research.

## Trends in communities. Hype and future vision

- There is too much **hype** around NFTs. Male older generations are the most critical
- High **importance** expected from NFTs regarding digital ownership in the mid-long term.
- **Blending physical and digital:** There is majority of positive feedback although neutrality is quite high (**Fig. 20**)



**Fig. 19.** Perception of NFTs out of the digital environment

## 3.2.2 NFTs From a Industry Perspective

After obtaining knowledge from the consumers, I **aimed** to gather information about the industries' perspective on the same topics: importance for communities and main trends, specifically how blending physical and digital environments is perceived. This relates to the finding in the first section (**Chapter 3.1**) and aims to establish a strong connection between results. Moreover, instead of a focus on the users, the focus shifts to the industries.

To achieve this goal I developed a questionnaire, which collects qualitative data from different industries and focuses on answering the following research questions:

1. **How do the different industries perceive NFTs' (and related concepts such as blockchain, digital identity and ownership, and metaverse) trends now and in the future?**
2. **How is the inclusion of NFTs in the physical environment perceived, regarding usefulness and added value, and is it a good idea to use them to bridge physical and digital realities?**

The method followed, results, and a brief discussion of the research conducted are presented next.

Besides the information gathered from Newzoo's survey, another questionnaire was developed, in this case focused on people from different industries that benefit or might take benefit in the future from the NFT space and capabilities. In the following chapter, the different industries targeted will be described, as well as the method and the results obtained.

An in-depth analysis and discussion of the industry and consumer research will follow, in **Chapter 3.2.3**. Therefore, the survey is targeted to a specific audience for the sake of a future comparison with the consumer insights. It must be said that the survey is anonymous, so no information is gathered related to gender and age group, as it is not relevant in this case.

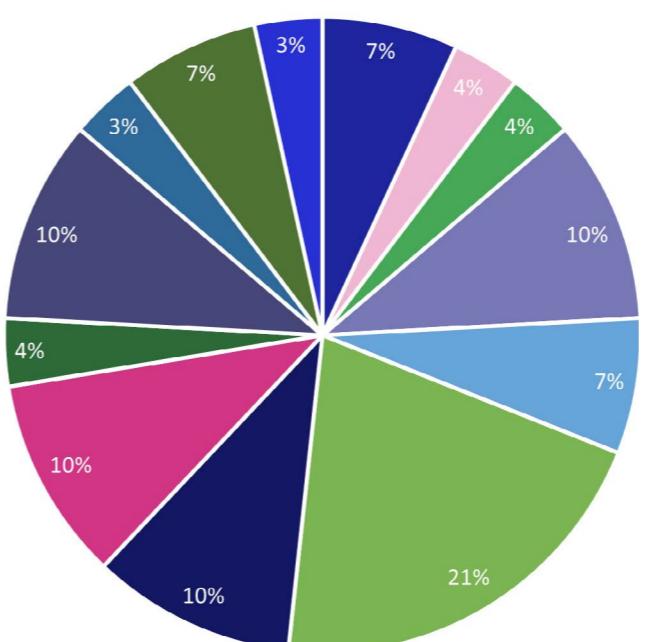
## Method

The research is thought to gather **qualitative data samples**, this is, between 20-40 to reach saturation. In this case, data saturation was reached with 28 respondents. Data saturation is the point in which no relevant information is added when acquiring more samples, as all relevant concepts have been identified. It is majorly used to conclude qualitative research (*Hennink & Kaiser, 2022*), (*Gugiu et al., 2020*).

To create the questionnaire I used Cmix, an internal professional tool used in Newzoo specifically aimed to create surveys. Cmix gives the creator all the capabilities needed. The survey followed the specified structure:

- **Section 1:** Demographic profiles (industry, role, country)
- **Section 2:** Key concepts (metaverse, blockchain, NFTs)
- **Section 3:** Focus: Digital ownership and authenticity
- **Section 4:** Focus: NFTs (general, in industries, applications in environments)

For the complete questionnaire, see **Appendix 05**. Industry Research Question Overview. Once created, it was distributed through Whatsapp.



**Fig. 20.** Industry research. Industry participation

The survey is anonymous and no information is gathered related to gender and age group, as it is not relevant in this case. The age range of the participants must be within the working age (>16). The markets targeted are European countries (9) and the USA. The consistency with the participants of the research conducted by Newzoo will enable meaningful comparison of the results.

The **industries** targeted in this questionnaire are the following (**Fig. 20**). For a simple analysis, I have clustered the industries in 2 different groups: entertainment (E) and business (B).

1. Arts & Culture (E)
2. Automotive (B)
3. Consumer Electronics (B)
4. Entertainment & Collectibles (E)
5. Fashion & Beauty (B)
6. Finance & Consulting (B)
7. Game Development, Tech & Services (E)
8. Hardware & Components (B)
9. Media & Agencies (B)
10. Music (E)
11. Sports (E)
12. Tech Giant (E)
13. Transport, Travel & Tourism (E)
14. Government & NGOs (B)

The **analysis** was also conducted using comparisons between results with the purpose of obtaining a relevant overview of the matters identified (what, how, who).

- Automotive
- Consumer Electronics
- Fashion & Beauty
- Finance & Consulting
- Game Development
- Game Tech & Services
- Hardware & Components
- Media & Agencies
- Tech Giant
- Other
- Sports
- Tech Giant
- Art and culture

## Results & Discussion

The **most important outcomes** will be presented. The following sub paragraphs answer each of the research questions. To see an extensive overview of all topics, see **Appendix 06**.

### The industries care about NFTs.

#### Mass adoption believed in the mid-far future

In this subsection the **answer** to the following **research question** is provided:

**How do the different industries perceive NFTs' (and related concepts such as blockchain, digital identity and ownership, and metaverse) trends now and in the future?**

In the first place, **NFTs are and will be of high importance for industries**. Entertainment industries receive nowadays the most benefit and lead the ecosystem in the mid-term. Besides, the most relevant NFTs for communities (of vital importance for companies and brands) in the near-mid future will be those related to gaming, followed by credentials.

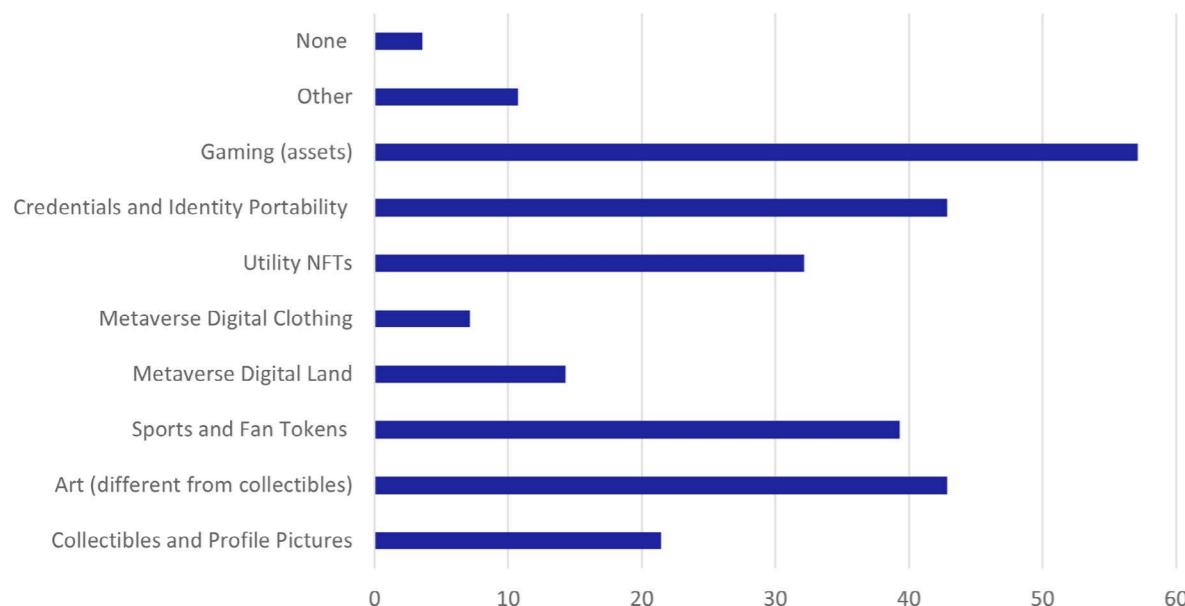


Fig. 21. Industry research. Types of NFT believed to be most relevant for community building in the future

In general, all applicable to the entertainment industries score the highest (Fig. 21). Special attention must be paid to utility NFTs. Although they do not score the highest for community building they are of extreme relevance for industries thanks to their applicability to real-life scenarios, as presented in **Chapter 3.1**.

However, in 10 years time it is expected that NFTs will become mainstream and all industries will benefit from them (Fig. 22 and Fig. 23). Governments & NGOs will specially receive great benefits in the long term.

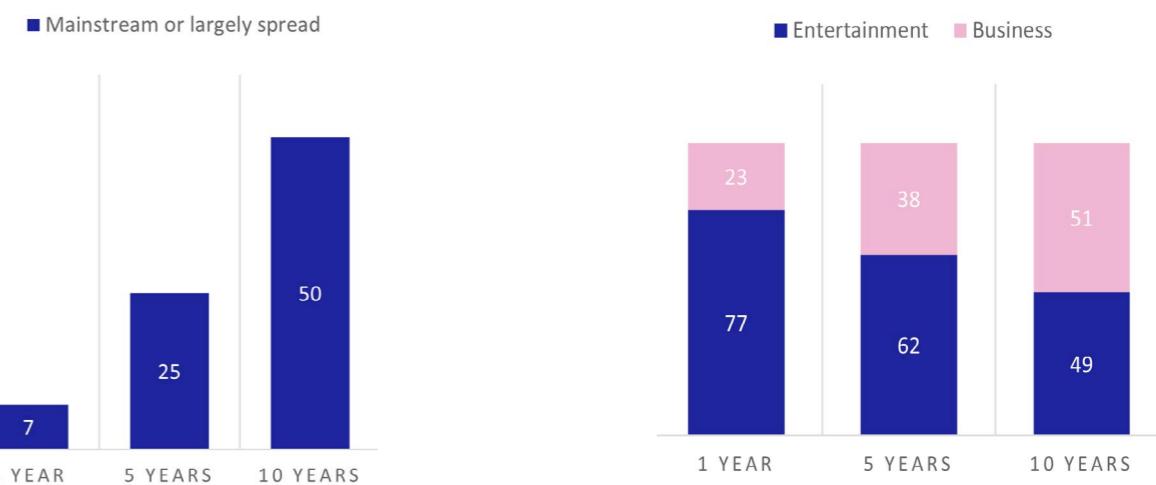


Fig. 22. Industry research. How widely will NFTs spread?

Fig. 23. Industry research. Industries that will receive most benefit from NFTs

### Trends in communities. Blending physical and digital environments is the future

In this subsection the **answer** to the following **research question** is provided:

**How is the inclusion of NFTs in the physical environment perceived, regarding usefulness and added value, and is it a good idea to use them to bridge physical and digital realities?**

There is **general consensus** in the importance and relevance of digital ownership and authenticity for the digital space, in both cases rating more than 60%. Furthermore, not only the relevance is rated positively, but also the usefulness when being used to bridge physical and digital worlds. (Fig. 24)

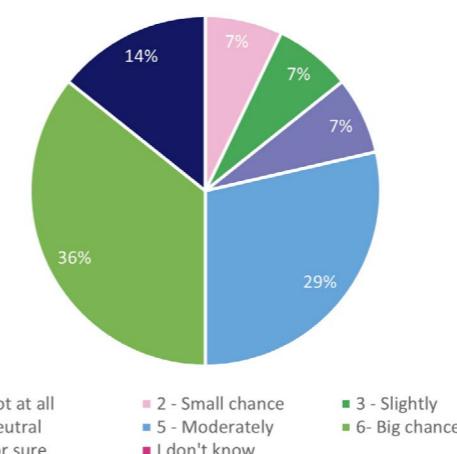


Fig. 24. Industry research. Bridging physical and digital worlds

Moreover, **bridging physical and digital environments** is also **desired** as there is value created for both (Fig. 25). To achieve this goal, Augmented Reality (AR) and blockchain are the preferred technologies by the industry. Additionally, a product that enhances the current interactions with NFTs would have a high level of acceptance.

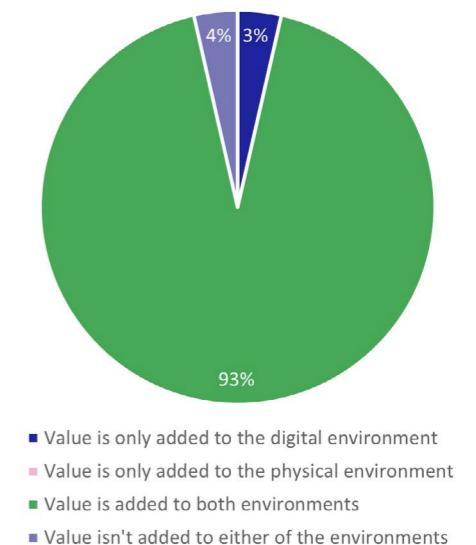


Fig. 25. Industry research. Added value of bridging physical and digital worlds

Finally, NFTs are **strongly reliant on communities**. NFTs will be more relevant in digital communities (**Fig. 26**) than physical ones (**Fig 27**). Their overall importance in human relationships is expected to grow in the far future between 8 and 14 times depending on the environment.

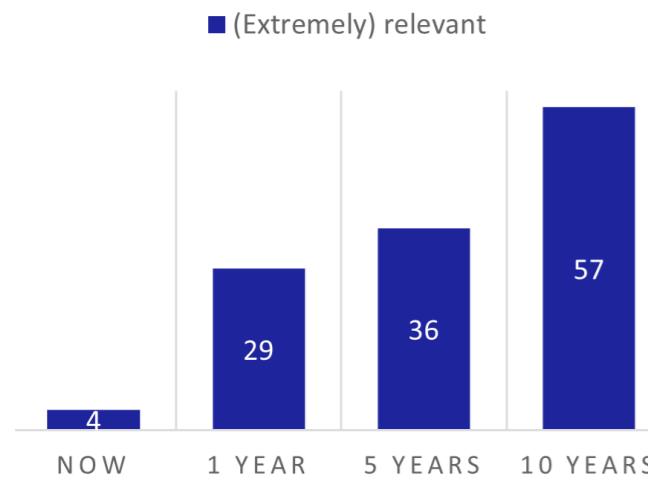


Fig. 26. Industry research. Relevance of NFTs in **digital** world

### 3.2.3 Synergies between Consumers & Industry

In this chapter the results of the two surveys are combined and discussed. The **purpose** of this section is to provide a summarised overview of all the results obtained from the questionnaires regarding trends in communities and target group sizing. The **overall conclusions** are that NFTs are thought to be widely adopted, where the inclusion of the physical world plays an important role. The chapter concludes with the need for further investigation about the target users, as the information gathered with the conducted research is still of high level.

#### Trends in Communities. Adoption of NFTs in the Future, including the Physical World

Although both surveys do not share the exact same content, there is a lot of overlap in the conclusions, as well as complementary information. **In the first place**, the focus on European and US markets shows in both surveys a high interest from consumers of all age groups, in the near future. The knowledge of younger generations is higher, as well as the level of engagement with blockchain technology, NFTs and Metaverse. Users that engage with NFTs do it

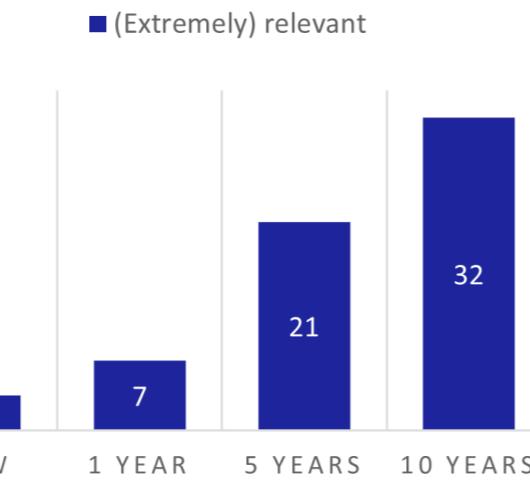


Fig. 27. Industry research. Relevance of NFTs in **physical** world

also with the communities in most of the cases. The space is growing at a very rapid pace and all members are active, which helps in building a strong community and enables dynamism and rapid improvements.

**Secondly**, the engagement is quite niche in the present but it is foreseen to become mainstream in the mid future (5-10 years). Here, the early adopters group will be already experienced workers in their industries and will have the knowledge needed to be considered experts in these matters. The entertainment industries are foreseen to receive the most benefit from NFTs in the short term, but reach parity with the business industries when mass adoption takes place. In this panorama Governments and NGOs will be tremendously benefited from NFTs' properties.

**Thirdly**, communities seem to be more relevant in the virtual space than in the physical. On the other hand, it is widely believed that merging both realities will result in benefit for both, and therefore, the interest in this to happen is also very high. The technologies most suitable for that to happen point towards Augmented Reality (AR), due to its capability of merging both worlds, and blockchain technology, by the hand of NFTs and their intrinsic characteristics (digital

ownership, digital authenticity, and adaptability to multiple scenarios and use cases). This result is complementary to the main insight from **Chapter 3.1**

### Target Group Sizing. The Early & Future Adopters

In the industry and consumer research it is visible that the future predicted for NFTs is the general adoption. NFTs are expected to become mainstream. For this reason, it is convenient to narrow the focus of the design to the users that will make this happen, that is, the early adopters and people who are expecting to use the technology in the **near future** (in 2-4 years). In the following **Fig. 28** it is shown that this cluster represents 71% of the aware population.

Translating this data to rough numbers, the online population of Europe (694.78 million) (*Statista, 2022a*) and US (307.2 million) (*Kemp, 2022*) is approximately 1 billion. Consequently, 400.8 million people could potentially be involved with NFTs in the near future for the selected markets. These are clearly very broad estimations but they are helpful to narrow down and have a more clear overview of the possible future panorama.

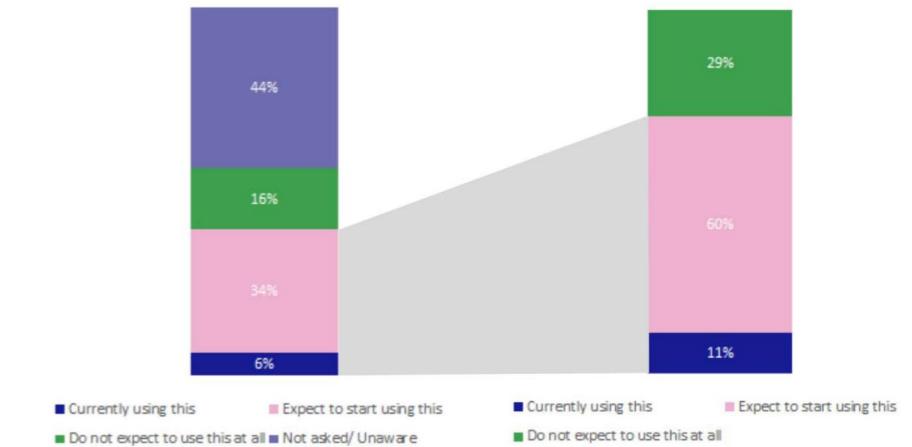


Fig. 28. Aware population compared to the total

#### Early adopters

The early adopters (**Fig. 29**) are a niche group (11%) majorly represented by **Millennials** (26-35 years old). GenZ is surprisingly the smallest group using NFTs currently, and claim to be most experts. Males compared to females are in general twice in number of experts, 1.6 times more proactive in future use, 1.5 times more active trading and more than double active creators. Gender representation of this group is largely male. As for their occupation, the vast majority of the early adopters are full time employees.

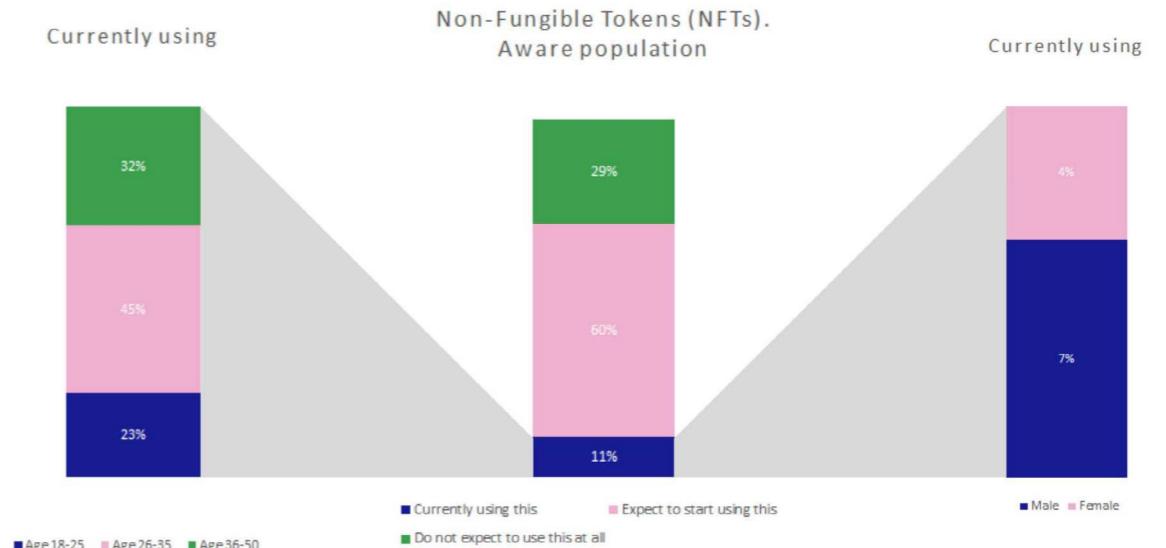


Fig. 29. Early adopters

## Future adopters

Moving on to the future adopters, the panorama is **somewhat similar**. Again, there is a larger male representation, however, there will be a strong future impact from GenX, followed by GenZ (**Fig. 30**). GenX is more focused on the future and is the most optimistic about NFT implementations (benefit for economy and digital ownership), followed by Millennials. On the other hand, GenZ is more focused on the moment. They have the most knowledge out of all the groups and are the most active sporadically. Finally, these users will mostly be full time employees, but there is a noticeable increase in people willing to enter the space with other economical situations.

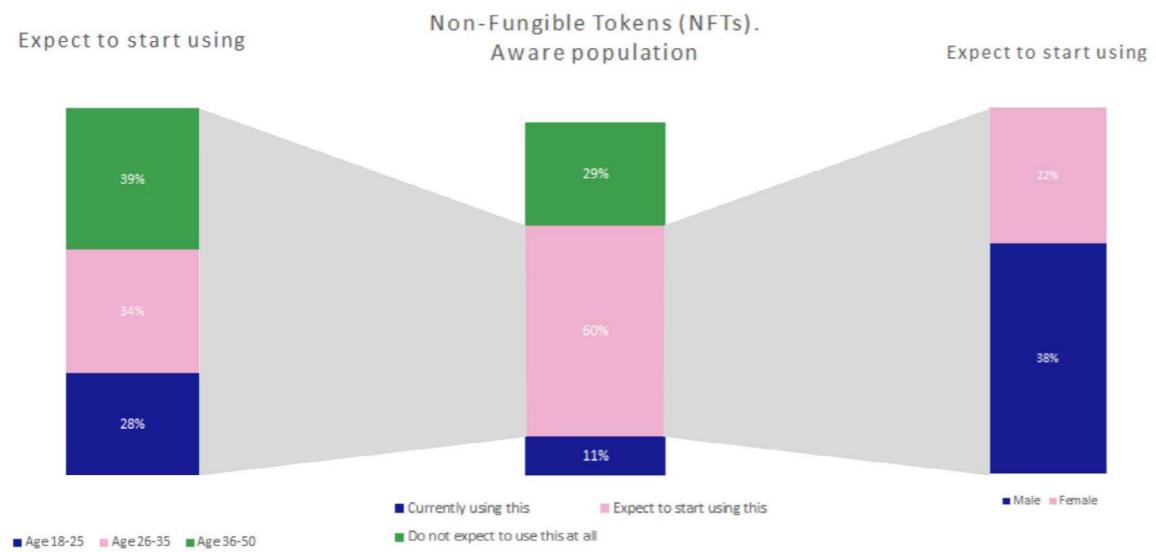


Fig. 30. Future adopters

## Conclusion

To sum up, **Millennials** have been identified as the **most important group** due to their notorious presence in the early adopters group and their expected representation in the future adopters. Gen X is expected to also enter the space strongly in the near future contributing with their long term vision. This will have a positive impact for mass adoption. Moreover, GenZ is also expected to join the future adopters group and contribute with their knowledge, which will impact positively in the future expertise needs.

Nevertheless, the group sizing is still quite large. It is necessary to narrow down and fine tune the user profiles. Ultimately, NFTs are still very niche and many problems need to be solved. Hence, it is convenient to focus on the early users and deeply understand their desires and needs, with the bigger picture in mind. For this, in-depth interviews were made, described in the following chapter.

## 3.3 Getting to Know the Users & their Problems

The **goal** of this chapter consists of obtaining in-depth knowledge of the early adopters and detect what are their struggles and needs. With these insights I pretend to gather valuable information that helps refine the target group in a more precise manner and target its main issue. By the end of the chapter, I will have identified and chosen the target group within different profiles, determined and discerned by relevance between specific conflicts concerning buying, owning and selling NFTs.

The method, analysis, results and insights, target group and problem identification, and conclusions are presented next.

### 3.3.1 Method

The results from the Industry and Consumer research mark out the early adopters as the most relevant group to design for. They have the highest interest, knowledge, predisposition and potential to help the technology mature and evolve.

To gather more information about them I conducted semi structured interviews, which helped to understand how they interacted with NFTs, and learn from that process where the struggles were and how design could improve the overall experience. The interview guide was flexibly adapted to the interviewee, and shifted towards topics relevant for each of the respondents. For a full overview of the questions see **Appendix 07**. I conducted 4 interviews with NFT users, of approximately 45 minutes each.

## Interviewees

The interviews were anonymous, as the name is of no relevance for the desired outcome. The interviewees were **4 males** within the identified most relevant age group (ages 26-35). As explored in the questionnaires, users do not fall in one closed category. Even though age groups and gender are more or less defined, from the industry side it is visible that the users can come from different backgrounds, which is translated into different interests. This was visible in the interviews, where each of the different interviewees had a different approach to NFTs. Thus, it was relevant to make the **distinction between profiles** considering the different approaches. These profiles are:

1. Profit seeker
2. Learner & curious
3. Art collector
4. Creator/ Developer/ entertainment focused

## Focus of the Interviews. User Challenges

The **focus of the interviews** is on the process of buying, owning and selling NFTs. The process of selling is considered to be similar in terms of security and knowledge, thus it is omitted. The reason why the focus is the one mentioned is explained next.

In **Chapter 2.3** I identified several **challenges** for NFTs. The technological and regulation issues are challenges out of the industrial design spectrum, however, the challenges concerning their use involve users, which enters the domain of industrial design. Here, the challenges identified were in the **security and knowledge** aspects. Security suffers from scams and hacking while the complexity of the technology is the reason why people are reluctant to enter the space. Without the knowledge, users are prone to scams. Furthermore, these two problems **do not manifest the same way** in the whole process of buying, owning and showing NFTs.

Moreover, the previous Consumer research also shows that early adopters can equally be creators or sellers. In the creative aspect, solutions are being developed to ease the initial stages of NFTs where industries are developing platforms that help the creation of NFTs without the technical knowledge. An example of this is the “game maker platform” developed by Sandbox, where creators only interact with a 3D environment, and the technicalities of creating an NFT are done automatically (**Fig. 31**). In the commercial aspect, solutions take place to help owners list their NFTs in different markets with relative ease and security. Nevertheless, there is very little focus on what happens in the **in-between time**, when users **own** an NFT.

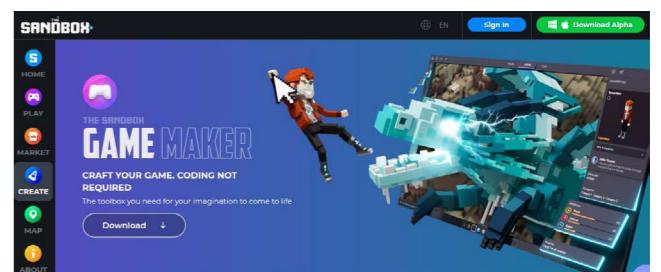


Fig. 31. Sandbox game maker. Source (The Sandbox, 2022)

### 3.3.2 Analysis

The information from the interviews was recorded in the form of notes. The content was analysed manually by reading the comments and extracting general conclusions. Therefore, the reasoning process was inductive, starting from statements and moving to general statements.

### 3.3.3 Results & Discussion. Problem & User Identification

In this section the main results of the interviews are presented in a combined manner, with a brief discussion. By the end of the chapter, I will have an overview of the major activities the users convey with NFTs and the problems associated to them.

The structure of the section is divided in 3:

1. **Acquiring** NFTs
2. **Owning** NFTs
3. **Summary**

The results are all focused on detecting the problems of the users. To see the specific insights

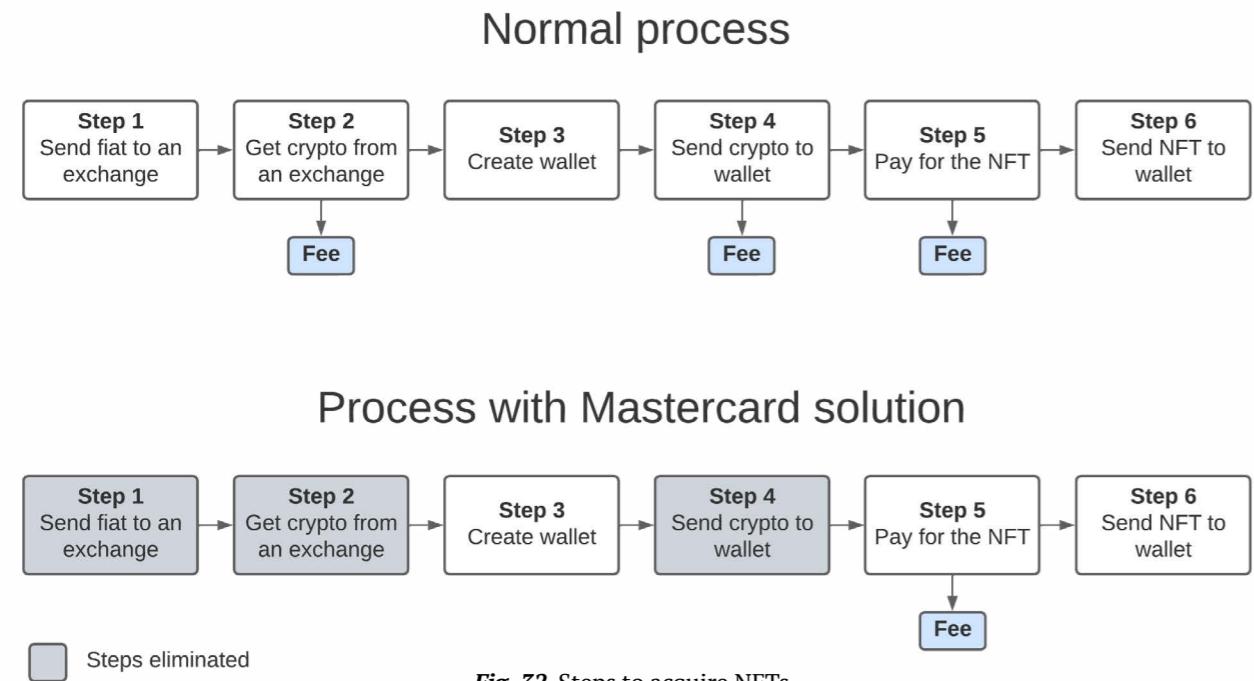
for each profile see *Appendix 08*.

The information presented is either extracted from the interviews and presented as quotes, gathered after a personal analysis and comparison between the different interviews, or extracted from extra literature research. When presenting a finding I will make clear where the information comes from. I performed the identification of the target users and problems by observation, reasoning and comparison of the main results, as well as the use of external research.

#### Acquiring NFTs. A Process Full of Steps and Fees

One of the questions of the interview targeted this matter specifically (*Appendix 07*). The information and affirmations presented are a combination of the feedback of the interviews and personal external research, where I experienced personally the whole process.

The process of acquiring NFTs is tedious and full of fees. However, solutions are already being implemented that could have a big impact. Here, Mastercard offers paying for NFTs without the need of cryptocurrencies, which eliminates several steps and fees (Dhamodharan, 2022). The following *Fig. 32* shows the current state and how the panorama changes with Mastercard's solution: from 6 to 3 steps, including the elimination of 2 fees.



*Fig. 32.* Steps to acquire NFTs

#### Owning NFTs. Showing-off as the Primal Activity

This section deepens in the moment of owning NFTs. Here I dive deep in the **exploration of the users' activities**. I will make a distinction between 3 major steps:

1. The fact of **owning**
2. The **use**
3. Practical **demonstration** and **feedback** from the users

At the end of the section, a summary of the main key points is provided.

##### Step 1. The fact of owning

Owning only involves action when they are utility NFTs or when trading. As stated by the interviewees:

**"The best part of NFTs is owning them"**  
(Creator/ developer/ entertainment focused)

**"I don't do anything with the NFTs. Only when I can redeem them for physical goods or interactions I use them"**  
(Profit seeker)

Referring to the main insight of *Chapter 3.1*, the utility NFTs have the potential to become one of the most important types, as they have more inherited value due to their applicability in the physical world. This must become a common ground in order for NFTs to become mainstream, as it is envisioned in the results from *Chapter 3.2*.

##### Step 2. The use

When asked how they used the NFTs (in the case they do), the interviewees stated:

**"... to use them you have to show them"**  
(Art collector)

**"Showing your NFTs is not common, only when you have a cool collection. However I think it is a critical step for the NFTs to become largely adopted"**  
(Creator/ developer/ entertainment focused)

**"Showing off is a big part of owning them"**  
(Profit seeker)

Moreover, in the Industry research, some respondents also gave their opinion about this topic:

**"People like to show off. Fashion, automobile brands know this well"**  
(CEO, Media and agencies)

**"Showing that you have it is very big part of the reason to get it"**  
(CEO, Game development)

Therefore, it is clear that the process of showcasing NFTs is majorly about pride and that this is the main reason why users show their NFTs to others, in addition to showcasing them for selling purposes. As one of the interviewees mentions, this is highly visible in the extensive use of NFTs as profile pictures in social media.

**"I think social media exposure is critical. There is where everyone can see the NFTs you have. Although I would love to be able to do the same in the physical world, for example, showing them in my room would be cool"**  
(Learner & curious)

An example can be seen in *Fig. 33*, a collection of NFT profile pictures from platforms like twitter (hexagonal profile pictures confirm it is an NFT) and Instagram. When referring to NFTs, all users expressed the importance of communities and the values connected to them: pride, support and engagement.

**"My reasons to buy an NFT would be to obtain profit or belong to a community"**  
(Profit seeker)

**"I entered the NFT community because I was curious. Now I stay because I want to support creators and belong to a certain group. I have a lot of friends that do the same. We support each other."**  
(Learner and curious)

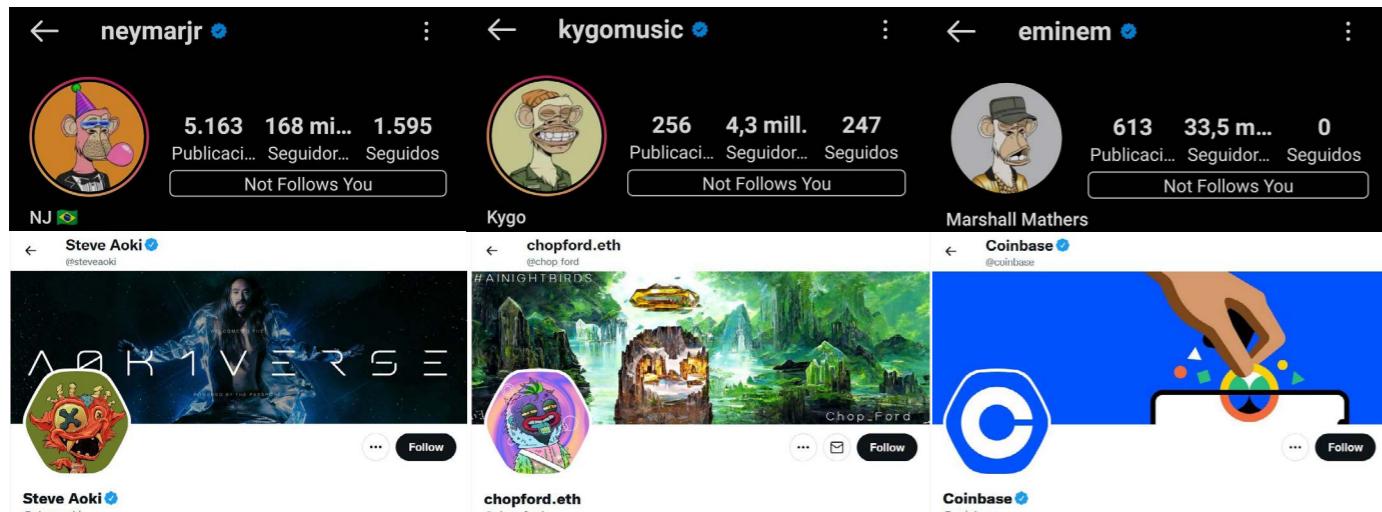


Fig. 33. Social media NFT profile pictures. Sources: Instagram and Twitter

### Step 3. Practical demonstration and feedback from the users

The interview then deepened into the **showcasing topic** as it seemed the most relevant aspect of owning NFTs. To get the users more involved and better identify the possible issues, I asked them to execute a **practical exercise**: show their NFTs on the web and mobile. When this was not possible (due to technical difficulties such as not having an app installed in the phone), they were asked to describe how to do so in each case.

Afterwards, I asked the participants to make a **comparison** of both possibilities, which forced them to look for pros and cons. For the users that only described the use of one platform, I asked them to make the comparison in case they used more than one marketplace. In addition, I also performed an external literature and practical research focused on obtaining insights about the pros and cons of all possible visualisation methods. Therefore, in this section I will make a distinction between:

1. Information gathered from **users**
2. **Personal** exploration

#### 1. User feedback.

**Centralisation is desired, where mobile plays a big role**

**“Showcasing is easy in the first case. When more platforms are involved the process becomes more annoying. However, I always prefer the web. Connecting my wallet to another app in the phone feel more insecure”**  
(Profit seeker)

**“I can’t even see them properly on the web. In the phone I am not sure if I would be able to do it”**

(Creator/ developer/ entertainment focused)

**“I like mobile better, with the wallet I have everything centralised in one platform. I think it is the best”**  
(Art collector)

**“I think I would show you my profile picture on Twitter, so it’s easier the mobile. For the rest of NFTs I would have a big problem as many cannot be used as profile pictures”**  
(Learner and curious)

In the cases where **mobile** was chosen, the users described it as the best option due to its **centralisation and ease of access**. In these cases the users owned just one type of NFT: images. Here, a specific platform can have an optimised visualisation (like a wallet for example), but when involving more platforms and types of NFTs, the opinion changes.

The **web browser** was chosen as the easiest option when the users involved more **types of NFTs or security** aspects. In these cases, the steps described for mobile were more tedious: A wallet app, marketplace app, and connection permissions (insecure) are needed. In **Fig. 33** a comparison between all steps can be seen for visualisation in a mobile device in the last case. This figure showcases what would be the first time interaction. To make sure that the steps were as described by the interviewees, I also did the practical exercise myself and corroborated them.

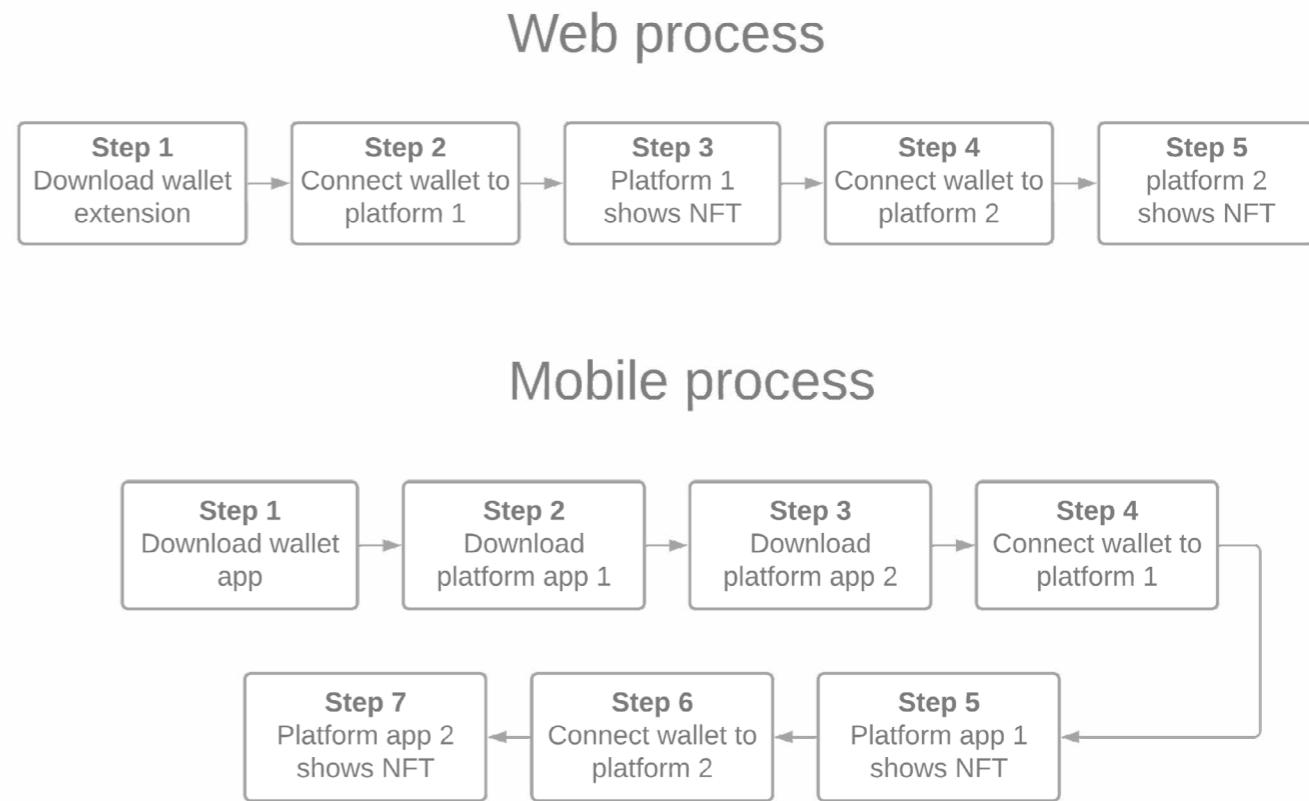


Fig. 33. Web VS. Mobile. Showcasing NFTs from different platforms and types

It must be said, however, that if this process is desired to be done more than one time, the number of steps in each case is reduced to 4. Nevertheless, the mobile will always result in more inconvenience due to the need to install more and more apps.

The conclusion from the user feedback is that in an environment where NFT types and marketplaces are surging (+50, official, without counting webpages where NFTs are also sold), (Cryptowisser, 2022) the inconvenience to use mobile devices for NFT visualisation grows to unsustainable limits, in a panorama where there is no centralisation. However, when the centralisation is achieved (like in the case of image NFTs), mobile is the desired option.

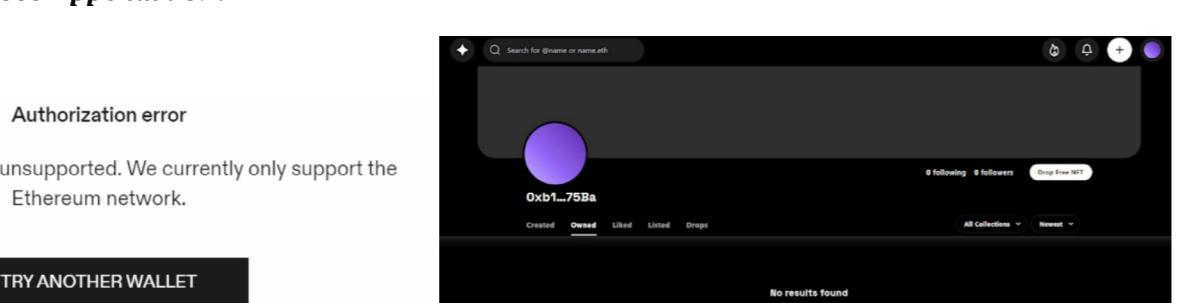
## 2. Personal literature research on types of visualisation.

There is no solution optimal solution.

The **visualisation methods** and their pros and cons are identified through literature research and personal experience (trials).

Before diving into the exploration it is necessary to clarify what **NFT standards** are, as they are key elements in the visualisation of NFTs. NFT standards describe how to build Non-Fungible Tokens on a particular blockchain protocol (Tarud, 2022). Therefore, the standard defines the structure (for more about NFT structures see **Appendix 01**). The most commonly used is ERC-721 implements an API function meaning that it is easy to communicate and interact with the smart contract thanks to the use of functions (Tarcan, 2022).

Another standard is the **ERC-1155**. It is a multi token standard. It can do what the previous ERC-721 can and adding functionalities of cryptocurrencies, all integrated in one. Its benefits come by the hand of batch transactions of NFTs mixed with currencies (Douglas, 2022). This standard is extremely useful in the gaming industry where money and object trading are very common. The main difference with the ERC-1155 standard is that it allows for batch transfer, while the ERC-721 only allows the transfer of one NFT at a time. This saves a lot of power and avoids fees. The benefits of this standard are causing its popularity to surge. For more about NFT standards, see **Appendix 09**.



**Fig. 34.** Visualisation. Blockchain unsupported. Source (Gallery, 2022)

**Fig. 35.** Visualisation. Standard compatibility. Source (Showtime, 2022)

NFTs are mainly visualised:

1. In **native platforms** (in-game). Optimised for visualisation. The biggest limitations are that they can only be visualised inside the game and you need wallet connection (security concerns)
2. Through a **marketplace**. Best optimization for visualisation of all. The biggest limitation is that listing or compatibility (type, standard, blockchain) is needed. An example of this can be seen in **Fig. 34**. In addition, trading permissions are also needed, which create security concerns
3. **Wallets**. Most secure. Not optimised for visualisation but acceptance of multiple types, standards and blockchains
4. Online **social media** sites. Very limited compatibility (blockchain, type and standard). **Fig. 35** shows how a social media environment doesn't display existing NFTs due to standard compatibility.

For a more in-depth explanation of the strengths and limitations of each option, see **Appendix 10**.

## Summary

When owning and using an NFT, the most relevant aspect is **showing off**, conducted through visualisation of NFTs. Showing off is important and desired by the users and specified as a core consequence of owning something. Nevertheless, the **visualisation** process (instrument to make this happen) lacks a proper medium to do so. Here, mobile is identified as ideal, in combination with a centralised platform dedicated exclusively to optimise the visualisation.

## 3.3.4 Target Group Identification. Developers & their Vision

This section reasons the **refinement of the target group** through the selection of one of the 4 user groups created. The identification is made by observation, reasoning and comparison of the main results.

When observing and comparing the feedback from the different users (See **Appendix 08** for a complete overview), 2 of them pay special attention to the visualisation of NFTs: art collector and creator/ developer/ entertainment focused. Nevertheless, the art collector is majorly focused on NFTs of image types, which already has an optimised platform for mobile that covers its main activities.

On the other hand, the profile of the game developer is very interesting. These users hold a complete vision of the NFT panorama, and are less dependent on the market trends. They believe in the potential of the technology, have deep knowledge and the ability to create valuable use cases with their future-oriented vision. That is the reason why, this is the target group selected to design for. In the following Chapter 4.1 Target Group Definition, the target group will be presented in a precise and complete manner.

## 3.3.5 Users Face a Problem. Visualisation as Main Technical Constraint

The **goal** of this section is to identify the **main problem** for the users. To do so I gather all the main concerns and desires of users presented in the main results. These are collected through observation of the feedback from the interviews (inductive process).

When owning NFTs and not using them, owners showcase them (in some cases). Although this is not very common, it is still a very important aspect of the experience of having a NFT. However, technical constraints prevent the users from doing it in a proper way in some situations, or impossibility in others. Therefore, the attention will be placed in helping the users obtain the desired **experience when showcasing** their NFTs. In the following **Chapter 4.2** the problem will be stated in a precise and concise manner.

## 3.4 Limitations

In this chapter I present the general limitations in the research conducted for the discovery phase, present even with the combination of the 3 exploring directions (current state and applications of NFTs, trends and future applications perceived by consumers and industries, and user and problem identification), ones covering the lacks of others.

**In the first place**, the study was done in a very particular moment in time, when the NFT market had only surged but didn't have any corrections typically seen in older markets. Hypothetically, the insights obtained could have been different after 2 or 3 cycles, where more patterns could be extracted and the maturity of the technology is higher. Nevertheless, the combination of methods ensure an empirical study from different angles and can be assumed valid.

Secondly, time limitations and the fact that the market explored is still niche, made it complicated to acquire a vast number of respondents, especially in the interviews. Although saturation was achieved in cases where it was necessary, it might be dependent on the regions where the research reached. The results therefore, might be dependent on the regions where the research reached. In the case of the interviews, it is possible that the definition of more profiles could have taken place with more participants. Nevertheless, for the purpose of the project it is considered acceptable.

## 3.5 Conclusions

The **goal** of this chapter was to gather valuable information about the NFT environment through different angles: current state and applications of NFTs, trends and future applications perceived by consumers and industries, user and problem identification. By the end of the chapter, the reader will be familiar with the NFT space in all facets and understand which are the main users' concerns.

Former information reveals the unanimous belief of **NFTs becoming mainstream** fostered initially by the entertainment industries, and the important role utility NFTs and bridging physical and digital worlds in for this to happen.

Although the mass adoption of NFTs is envisioned, it is necessary to design first focused on solving the possible roadblocks the technology might encounter before this becomes a reality. There are several **roadblocks** for this to happen, related to the technology, use and regulations. In the field of user-centred industrial design, the main struggle is associated with the **experience of showing off the NFTs**. By tackling this problem with a special focus on the main drivers of the change, **early adopters** (more specifically the creators/developers/entertainment focused), I intended to set the ground for future development of NFTs and their mass adoption.

The results of the discovery phase led to a **redefinition of the scope** presented in the project brief. The legitimacy aspect was not directly identified as an issue by the users, therefore, the scope was reduced to the visualisation aspect only.

To sum up, I present now in **Table 01** my **personal contributions** to the project in the different fields of desirability and feasibility, where applicable.

Desirability	Feasibility	Viability
Environments and their relations with NFTs	<i>Not applicable</i>	<i>Not applicable</i>
Consumer analysis		
Industry research		
Synergies between consumers and industry		
Target group sizing and identification		
Problem detection		

Table 01. Discovery chapter. Personal contributions

## 4. Define

In this chapter I cover all the definitions and requirements needed to move forward to the design phase. More concretely, I specify the definition of the target group and main problem, (already covered in the previous chapter), provide an exploration of the current solutions with their pros and cons, and present the proposed solution with the values they add.

The **structure** of the chapter will be divided in 3:

- Target group definition, problem definition, and current solutions.** The methodology used in this cluster is the Problem Definition Canvas
- List of requirements**
- Proposed solution and exploration of values.** The methodologies used in this cluster are customer journey maps, product overview, and Value Proposition Canvas

## 4.1 Target Group Definition & Stakeholders

This chapter is the first part of the cluster using the **Problem Definition Canvas** methodology. There are several methods to define a problem, however this method is **user-centred**, emphasising who the end user is and how it feels. The following **Fig. 36** shows all the aspects covered by this method.

The canvas will be covered in separate sections. The first column (**context and customers**) will be defined in this chapter. The following chapter will include the problem and the emotional impact. Finally, the alternatives and their pros and cons will be covered.

The information required for the context is gathered from **Chapter 1** and **Chapter 2**. Therefore, the context in which the project is framed is:

<b>CONTEXT</b> When does the problem occur?	<b>PROBLEM</b> What is the root cause of the problem?	<b>ALTERNATIVES</b> What do customers do now to fix the problem?
<b>CUSTOMERS</b> Who has the problem most often?	<b>EMOTIONAL IMPACT</b> How does the customer feel?  <b>QUANTIFIABLE IMPACT</b> What is the measurable impact (include units)?	<b>ALTERNATIVE SHORTCOMINGS</b> What are the disadvantages of the alternatives?

Fig. 36. Problem definition canvas. Source (Bayes, 2019)

## 4.1.1 Context

In the metaverse and its opportunities, the entertainment industry plays a significant role, where gaming is the main driver. Here, social activities have gained more and more relevance diffusing the line between physical and digital. In this scope, **casual meetings** will be the specific context in which the project is framed, where it is more likely and recurrent for the problem to occur.

## 4.1.2 Target users. The Creators/ Developers/ Entertainment Focused

Moving on to the users, the specific information gathered and analysed comes from **Chapter 3.2** and **Chapter 3.4**. Therefore,

The target group is constituted by the early adopters, more specifically the **creators/ developers/entertainment focused**. This group is the most likely to have the problem due to their involvement with all types of NFTs and platforms. Furthermore, it is also the group that **can bring more benefit** to the NFT environment if the problem is solved, as they hold a complete vision of the NFT panorama, and are less dependent on the market trends. They believe in the potential of the technology, have deep knowledge and the ability to create valuable use cases with their future-oriented vision. The group is majorly defined by male **Millennials** (26-35 years old), mostly full-time workers.

As an **estimation**, this profile will be considered to be 1/4 of the NFT early adopters. Referring again to the estimation made beforehand, early adopters in the targeted markets would correspond to 60.1 million, being the target group roughly **15 million users**. As previously mentioned this is an estimation made to have an overall picture. Nevertheless, it can be concluded that although the market is still niche, the potential of it becoming a billion-dollar business is very high.

## 4.1.3 Stakeholder Analysis

The stakeholder analysis identifies the main groups that can affect the development of the project, along with their concerns and goals. An analysis of the main actors can be done by answering the following three questions (Freeman, 1994):

1. **Who are they?**
2. **What do they want?**
3. **How will they try to get it?**

From the context of the metaverse, Newzoo has identified a large number of stakeholders. The overview can be seen in **Appendix 11**. Out of the total, I selected only the stakeholders that play an important role in the context described, and placed them in terms of interest and impact in a stakeholder matrix (Fig. 37). Interest measures how engaged a certain person or group can be. The impact measures the power each stakeholder has, and how that power could influence the result of the project.

The stakeholders and their impact and interest are:

**Metaverse gateways.** Their interest is high, as they can benefit from the exposure the desired solution can have. However, they do not have much impact. They do not offer any critical element for the solution to become a reality.

**NFT PFP Collections.** They might have neutral interests. There are already platforms optimised for these types of NFTs, but none of them include an immersion in the real world. Their impact is very low, as they do not offer any value to the solution.

**Social and meeting hubs.** Their interest is very high, as NFTs rely heavily on social communities. They could receive big benefits of this solution by implementing similar features in their platforms or establishing partnerships. Their impact, however, is not very high for the time being, although it can potentially increase with the adaptation of the solution to their platforms.

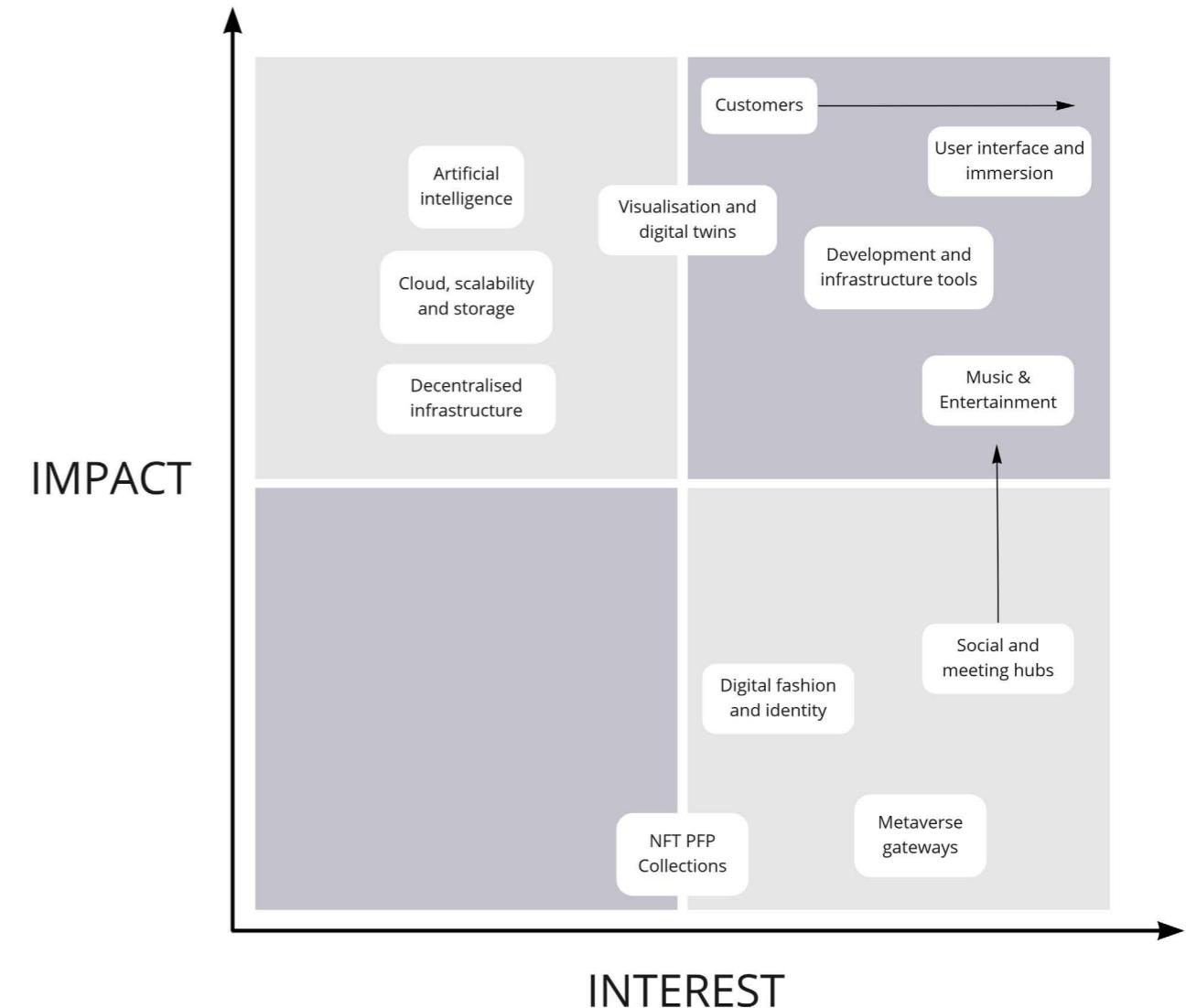


Fig. 37. Stakeholder matrix

**Music & Entertainment.** Special interest due to the NFT applications in their field. Their impact is quite high too, as they are the leading industries of the ecosystem. Their involvement impacts directly the quantity and quality of the content to visualise. These groups are in charge of appealing and hosting the early users.

**Digital fashion and identity.** Interest in all activities related to the metaverse that bring exposure to this new current and way of conceiving fashion. They can benefit from the visualisation opportunities the design solution brings, although their impact to the project is relatively small, as they are part of a bigger collective of 3D NFT creators (gaming, utility, fashion, collectives, etc.)

**User interface and immersion.** Industries related to human-computer interactions, especially app development and metaverses. Meta and Oculus would be examples of these. Their interest and impact are the highest from all stakeholders.

The solution helps bridging physical and digital worlds thanks to their technology. Their interests are aligned with community engagement and bringing new opportunities to physical and digital worlds by closing the gap between them.

**Visualisation and digital twins.** Companies like Unity, Unreal Engine and Quixel. Their impact is remarkably high as they are the lead companies in terms of visualisation. Also, they incorporate solutions to bring physical elements to the digital world (3D scanning) and vice versa (AR, VR). This aspect is of immense relevance in the design solution.

**Development and infrastructure tools.** Companies that are closely related to visualisation and digital twins. They collaborate to deliver engaging platforms aimed to develop user-focused applications. Therefore, their impact on the current solution is severe. Their interest is too, due to the repercussions the design might have in the future. A mass adoption would have a

positive impact in their relevance, and thus, their business. In this case, the interest is higher than in the visualisation and digital twins industries, as the benefits of getting involved are bigger in terms of user adoption. These are industries that receive benefits when more users get to adopt their tools.

**Artificial intelligence.** Very high impact due to the applications and implications it has in digital visualisation and platforms. Their interests however, are far beyond this specific solution. They have a broader view, solving technological problems such as enabling AR, VR for common use. Therefore, their interest is low when speaking particularly about the proposed solution.

**Decentralised infrastructure.** Blockchains majorly. They have a very high impact in terms of how the new protocols and underlying technology work. Thus, they can drastically affect how NFTs behave, are stored and function. Their interest, however, is very low for this particular design. Its development will not affect their functionalities, it is the design solution that has to adapt to their decisions.

**Cloud, scalability and storage.** Very similar to decentralised infrastructure. These companies serve as a tool for decentralisation to evolve. They provide methods for decentralisation to grow and improve. Therefore, they have similar relevance in terms of interest but slightly bigger impact, as they are directly involved in the process of storing and identifying NFTs.

**Customers.** Highest impact in the solution as it is focused on solving a problem they have. Nevertheless, their interest is not extremely high. This is because the design solution solves a problem that nowadays is niche due to the applications of NFTs. However it is envisioned to become of major interest for consumers as the NFT space evolves towards mass adoption.

## 4.2 Desired Experience & Problem Definition

The chapter **focuses** on the second column of the Problem Definition Canvas (Fig. 36). Consequently, **three different sections** are included: the desired experience, the problem and what is the root that causes it, and the emotional impact it brings to the users.

The information presented in **Chapter 3.4** reveals the relevance of showcasing NFTs for users. Although this is not a very common practice nowadays, it is still a very important aspect of the experience of having a NFT. Therefore, the desired experience can be defined as:

### 4.2.1 What users want. Showing off

Users want to **show off** the owned NFTs in an engaging way, which triggers a feeling of pride. More about showing off and its relationship with pride can be seen in **Chapter 5.1.1**.

Nevertheless, technical constraints prevent the users from doing it in a proper way in some situations, or completely impossibility in others. The visualisation of NFTs lacks a unified platform that is entirely dedicated to this purpose. From both a technological and user interaction standpoint there are opportunities to improve ease-of-use and maximise the level of engagement of the consumer interface. Therefore, the problem can be stated as follows:

### 4.2.2 Problem

**Users cannot undergo the desired experience of showing off their NFTs in some cases due to technical constraints in the visualisation.**

The implications of solving this problem are quite important. Although the problem is quite niche nowadays, it will become a critical roadblock in the future if NFTs are expected to become mainstream. Thus, designing a solution

focused on **improving the current state for visualisation** of NFTs will be of extreme relevance also in the future. It is impossible to solve all technological barriers within the scope of this project. Some will remain and are expected to be solved as blockchain and NFT technology evolves. Early adopters will be more willing and able to invest time in overtaking the remaining barriers. Therefore this project aims to broaden the **use of 3D NFTs** among early adopters first, laying groundwork for other larger target groups and business cases as the underlying technology matures.

The problem identified has already been tackled by others, however the solutions proposed focus only on one or two of the critical aspects (blockchain, type, standard). In the following **Chapter 4.3** these solutions are explored and analysed.

## 4.2.3 Emotional Impact

The emotional response of the users to their problem is presented in detail in **Chapter 6.1**, where a comparison with the final solution in these terms is presented.

## 4.3 Current Solutions to the Problem

In this chapter I present the outcome of the third column of the Problem Definition Canvas (Fig. 36). The **goal** is to identify which are the alternatives that try to tackle the problem, how they do so, their positive aspects and limitations.

The information presented is the result of literature research. In the end of the chapter, a conclusion is presented, where I determine which are the relevant aspects my solution should cover.

As a **general remark**, all the solutions focus on trying to solve the problem by facing the technical limitations in visualisation. Although each alternative stands out in a particular way, they all lack the ability to solve the problem in a complete way.

### Frames

The most common solution. Focused on showcasing the NFTs in a large size and/or high quality while also displaying the metadata. The **metadata** in general terms is data that provides information about other data. In NFTs, it is a piece of information that describes the NFT's essential properties (NFT School, 2022), (Pastel, 2021). To know more about the metadata, see **Appendix 12**. This solution works great for images, videos and GIF NFTs. They cover a wide range of blockchains and standards, but lack format coverage (3D or music).

Examples of these frames would be LAGO frame (Fig. 38) focused on enhancing the authenticity of NFTs and pride (Lago Digital, 2022), Infinite Objects (Fig. 39) focused on enhancing the authenticity and uniqueness of the NFTs (Infinite Objects, 2022), or Danvas (Fig. 40) focused on the quality of the images, reaching "museum quality displays" (Danvas, 2022).



Fig. 38. LAGO frame. Source (Lago Digital, 2022)



Fig. 39. Infinite Objects frame. Source (Infinite Objects, 2022)



Fig. 40. Danvas frame. Source (Danvas, 2022)

## Wearables

These solutions focus on showcasing NFTs everywhere you go. They lack big size but gain in mobility and location exposure. The problem with these solutions is the same as with the frames, they lack format coverage.

Examples of these solutions would be TAG Heuer's new watch (Fig. 41), and NFT Necklace (Fig. 42) with a special focus on enhancing pride and high resolution display (NFT's Necklace, 2022).



Fig. 41. Heuer's NFT watch. Source (Levin, 2022)



Fig. 42. NFT's necklace. Source (NFT's Necklace, 2022)

### 4.3.1 Conclusions

All the solutions presented have unique and positive aspects. An ideal solution would combine all these aspects into one product, in addition to solving the extra problems presented. Therefore, I will aim to design a solution that enhances the **values of NFTs** (authenticity and uniqueness) and the feeling associated with the desired experience (**pride**), while providing an adequate resolution for the visualisation of NFTs combined with the advantages of the mobility and exposure of **wearables**. All this while providing the capability of **visualising** multiple NFTs at the same time, regardless their type or standard with an integration in the **physical world**.

## 4.4 Product Requirements

In this section I present the requirements needed for the desired solution introduced above to become a reality. The way I have executed this task is making a **List of Requirements**, that I have divided into the following categories: **technical requirements** (feasibility), **user qualities** (desirability) and **economic requirements** (viability). The requirements are framed within the specified context.

### Technical Requirements

- 1. Connectivity.** The solution must have access to NFTs in order to visualise them. Therefore, it should be able either to gather the NFTs by itself (internet connectivity), or be able to communicate with a device that is capable of it
- 2. Mass production possible.** All components should be able to be adapted to mass production
- 3. Durability.** Minimum life expectancy of 5 years of all the components
- 4. Portability.** Users must be able to comfortably carry the product with them. This is translated in a compact size (maximum 7cmx15cm in the largest sides) and lightweight (maximum 250g)

**5. Environmentally friendly.** Referring to avoid e-waste (1% of the maximum weight, 2.5g), and recyclability (minimum 90% of the whole product should be recyclable)

**6. Safety.** The product should not be a risk for the user's health in any way: no skin, muscular, brain, respiratory, eye or ear threats of any kind. Allergies and ingestion issues are not contemplated. A note in the final device should inform the users not to ingest it and the material composition

**7. Resistance to different environments.** Exterior use intended. Temperature operating range: -15 to 40°C. Water and dust resistant (IP54), corrosion resistant

**8. Visualisation possible for all types of NFTs.** Images, GIFs, videos, 3D and music should be able to be displayed

**9. Acceptance of all types of standards.** ERC-721 and ERC-1155

**10. Acceptance of all blockchains.** Limited to NFT blockchains

**11. Technical upgradability and adaptability to a fast changing environment.** It should be possible to include new blockchains and standards

**12. High security levels.** Technical impossibility of fulfilling money or exchange requests

**13. Blending physical and digital worlds.** Must be an integration of both environments in the visualisation

**14. Optimised visualisation.** Minimum resolution display HD (1,920 x 1,080 pixels)

**15. Centralisation.** One unique platform for visualisation

## User Qualities

- Pride.** Should be the emotion that evokes to users. Measured with a Product Emotion Test
- NFT essence: ownership, authenticity.** Should convey these qualities in any way. For example shape or capabilities. Depending on how it is conveyed, the validation would vary
- Adaptability to any type of user (uniqueness, self-expression, communities).** Flexible design. Users must be able to customise the product at least in one way. For example colour, shape or additional features
- Usability.** Simple to interact with. Users must learn how to use the product in 3 or less tries. Measured with usability test
- Seamless interaction.** No awkward transitions, interruptions, or indications of disparity. Measured with engagement test
- Desirability.** How attractive it could be for early adopters. Must follow the general aesthetics of products used by the target group. Measured following the guidelines of a study of the look and feel

## Economic Requirements

- Competitive price.** Less than 80% of the cost of its cheaper competitor. This is an estimate sale price of 80€
- Technology simplicity.** Avoid complex technological solutions that create a heavy impact on the price

### 4.4.1 Values of the Desired Solution

In this section I present the values the desired carries and illustrate how it targets the different users' dimensions (pains and gains). For that, I use the **Value Proposition Canvas**, which helps visualise the relationships between the desired solution and the users in a friendly, yet clear way. By the end of the chapter I provide a brief conclusion concerning these values.

## Value Proposition Canvas

The value proposition canvas is a tool to visualise, design and test how value is created for customers (Strategyzer, 2020). It consists of two main elements. The **consumer profile** and the **value map**. In the following *Fig. 43* I present how the desired solution deals with the pains and gains of the users. All the entries of the Value Proposition Canvas come from the interviews, questionnaires, comparisons, literature review, deductions and research conducted up to this point. An explanation of the different parts of the Value Proposition Canvas is presented next.

### Customer profile

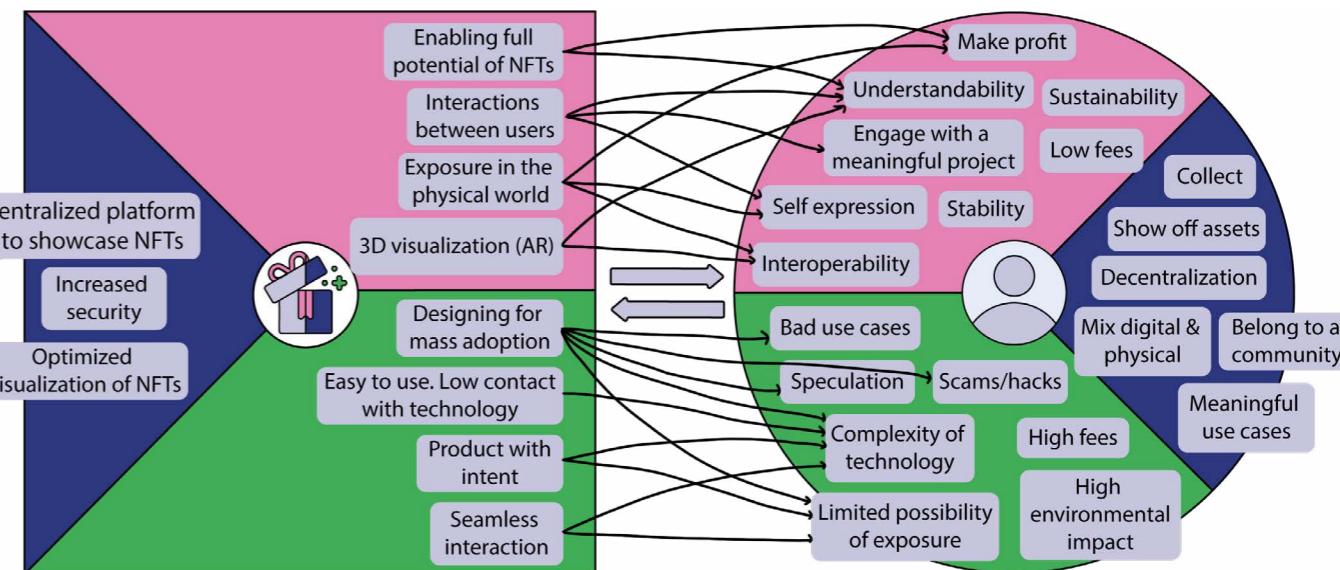
Identifies the desires of the users, what are those elements that limit the user to gather the desires and which would be the benefits of fulfilling the desires. In *Fig. 43* these areas are colour coded as followed:

- Job to be done** (blue). What the customers want
- Gains** (pink). Positive outcomes hoped to achieve
- Pains** (green). What annoys the customers to get the job done

### Value map

Identifies what the solution gives to the users, and how it helps relieve the pains and fulfil the gains. In *Fig. 43* these areas are colour coded as followed:

- Products and services** (blue).
- Pain relievers** (green). How they minimise pains customers care about
- Gain creators** (pink). How they produce outcomes and maximise benefit that customers desire



*Fig. 43. Value Proposition Canvas. Desired solution*

## Conclusion

The desired solution would cover a broad spectrum of both pains and gains of the users, targeting specific elements from multiple directions. A solution of these characteristics grants high pain relief for the users and applicability. Thus, its value and impact should be taken into consideration. The following chapter will deepen in materialising this high-value idea.

## 4.5 Proposed Solution

In this chapter I will present and describe the solution proposed that would meet the requirements and desires mentioned in previous chapters. With the use of user journey maps and overview breakdown of the main components and their relationships with the user (interaction, experience, service), I will describe how the solution aims to deliver the desired experience: **show off the owned NFTs in a physical context in a seamless way, triggering a pride feeling in the user, in an engaging way for users and viewers**. Therefore, the chapter is decided in 2 sections:

- Explanation of the design solution.** Parts and relationship with the user
- Fulfilment of the desired experience**

All decisions made regarding design, interaction and technology will be motivated and explained in the upcoming **Chapter 5**.

### 4.5.1 Design Solution. Combination of Physical and Digital Products

The proposed design solution uses a combination of a **physical and digital product (app)**. Each of the parts has a main driver and purpose. The **physical product** embodies most of the user qualities desired, with a main focus on the **emotion pride**. The **digital product** (app) can be divided into front end and back end. The front end's main driver is the **engagement** of the users, with the use of an appealing interface. The backend's main driver is the **ease of use**. The creation of a logic that provides an effortless interaction with NFTs. In *Fig. 44* the different parts of the solution and their relationships and connections with the users can be seen. For each one of them I will describe the contribution to the experience and values, and interactions with the user.

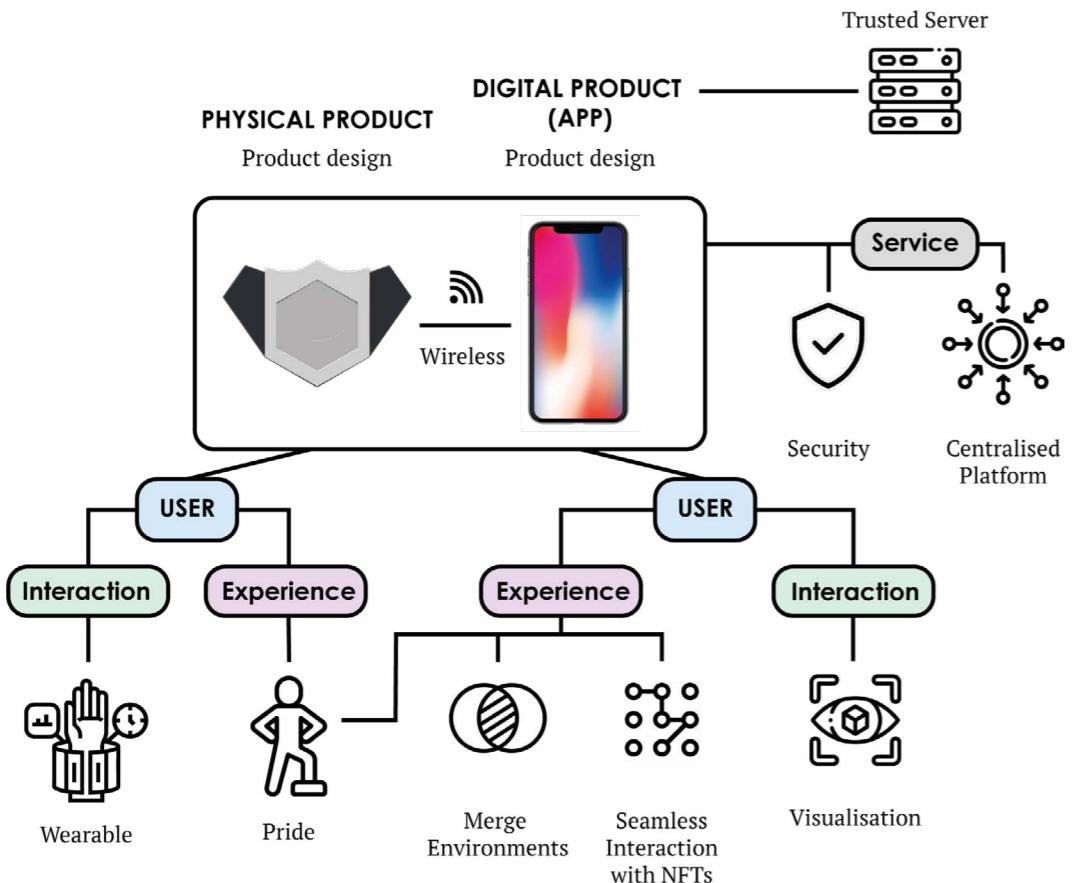


Fig. 44. Overview of the proposed solution

## Physical Product. Emotion Driver

The **emotion expression** of the product is its core function towards the user. Besides, it is envisioned to be a core element in the whole experience as the initialiser of the experience.

### Contribution to the experience and values. Embody pride and self expression

The physical product has as its primary function to **embody** most of the **user qualities**, most importantly the emotion pride. It is the part of the design solutions the user will use to express themselves. From the Value Proposition Canvas (Fig. 43), it focuses on:

1. **Safeguard anonymity**
2. **Increase security** against hacks/ scams. Close communication
3. **Ease of use**. Seamless interaction
4. **Self expression**, ownership and community building

### Interaction with the user. Wearable

The product is envisioned as a wearable (from desired solution and requirements). The design is meant to have the **flexibility of adapting** to the users' likings. Therefore, it is envisioned to be able to be worn as an accessory (e.g. necklace, bracelet, keychain, ...). It is also the starter of the experience. In the utility aspect, the physical product is meant to serve as a key. If the product is missing, the visualisation process becomes less seamless and more tedious. Its utility highlights the essence of NFTs (ownership and authenticity). More about this can be seen in *Chapter 5.1.3*.

### Digital Product (App). Ease of Use and Appeal for the Users

The main functions of the app towards the user are to provide a platform that is **easy to use** and **engaging** when **visualising** NFTs. This is done by its 2 main parts: back end and front end. Before diving into the explanation of the contribution to the experience and the interaction with the user it is necessary to explain why the use of an app in the first place.

### Why use an App? The benefits of smartphones

The requirements stated above specify the need to have access to NFTs, while providing an immersive experience blending physical and digital but staying technologically simple (*Chapter 4.4*). This combination of factors is very complicated to achieve when a physical product is involved, as the combination of physical and digital environments require state of the art technology (which is not simple). However, there is a product already widely adopted that meets these requirements and can be incorporated in the design solution: smartphones.

Smartphones have become part of our daily lives and have evolved to a point where they have become portable computers. There are many benefits of including them in the design solution. Smartphones are technologically advanced. They have access to the internet, high resolution cameras and display screens optimised for visualisation, and are programmable. Therefore, instead of designing one physical product which is technically complex I will focus on designing a mobile app that can benefit from the capabilities of these devices.

### Contribution to the experience and values. Ease of use and Engaging

The app has as its primary functions to provide an easy relationship with the NFTs (back end), while also presenting the visualisation in an engaging way (front end). These experiences are the result of the service the app provides. The service consists of a centralised platform for all types of NFTs, standards and blockchains. It also ensures a high level of security. More about these services can be seen in *Chapter 5*. The app is the core of the product, where all the interactions with the blockchain and NFTs take place. It embodies most of the technical aspects.

From the Value Proposition Canvas (Fig. 43), it focuses on:

1. **Optimised for visualisation**. Virtually any type of NFT
2. **Immersive visualisation**. AR, technology relevant for the entertainment industry and the metaverse. Enables NFT interaction with the physical world, therefore, creates room for new and valuable use cases
3. **Simplification of technology**. Makes NFTs more accessible
4. **Centralised** way of visualising NFTs. No limitations with blockchains, or standards
5. **High level security**. No connection with wallet needed or permissions of any kind
6. **Upgradable**

### Interaction with the user. Visualisation

A simple and intuitive interface will guide the user through the necessary steps to achieve visualisation. The user provides input with the use of buttons and tactile feedback, commonly used in apps for mobile. The ultimate goal of the interaction user-app is the display of NFTs in a physical context. More about this interaction and steps can be seen in the following *Chapter 5.2.3*.

## 4.5.2 Fulfilment of the Desired Experience

In this chapter I **visualise and explain** the whole realisation of the **experience** with the help of the design. From the initial context and constraints, moving to how the users interact with the product and finally showcase the NFTs. All the steps of the interaction are explained with the help of a consumer journey map, which focuses on the user experience surrounding a particular product or service as the user goes through the process of accomplishing a particular goal. This consumer journey map can be seen in *Fig. 45*.

In the following paragraphs, I provide an explanation of the major steps of the experience. These explanations follow the order left-right of *Fig. 45*. Each step corresponds to each of the illustrations visible in that figure.

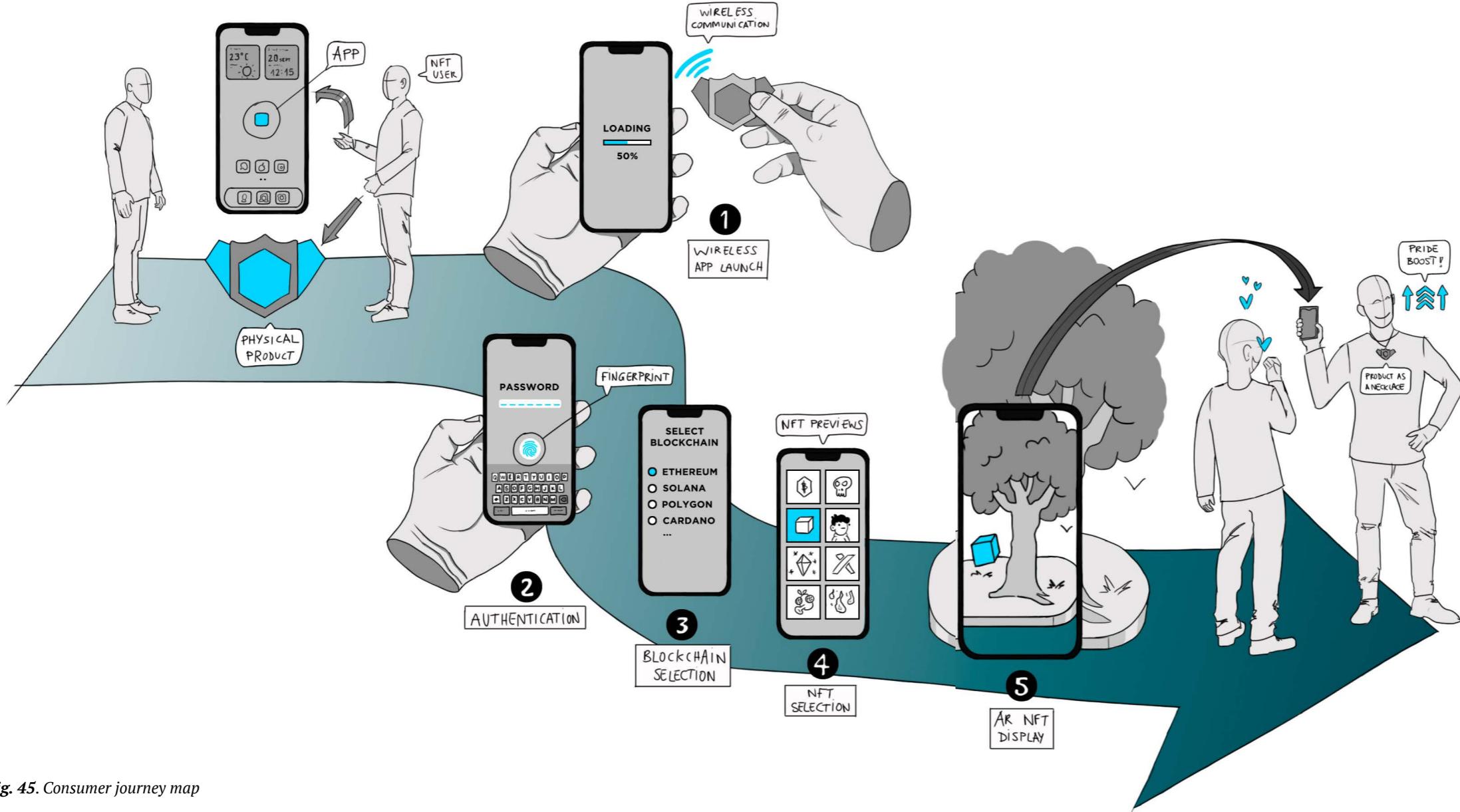


Fig. 45. Consumer journey map

#### Initialisation of the experience. Context

The experience is set in the context of a **casual meeting**. The major agents involved are the NFT owner and the viewer. For the experience to happen, certain requisites must be met. Either of the 2 agents must carry a **smartphone** with the **app** designed installed. The smartphone must have access to the internet and be ready for a wireless connection. The specifics of this wireless connection are covered in the following **Chapter 5.1.2**. Furthermore, the NFT owner must carry the **physical product**, which will contain the key personal information needed to find the NFTs. More about this personal information can be seen in **Chapter 5.1.2**. The product can be carried in any of the ways explained in the previous chapter (wearable). Lastly, the physical product must be also ready for a **wireless connection**.

With all these elements the experience is ready to start. This step is illustrated in **Fig. 45** at the top left corner.

#### Step 1. Wireless app launch

The user initialises the experience establishing a wireless connection between the phone and the physical product. The physical product sends all the personal data stored to the smartphone. Within this data is also the **automatic launch** of the app. Therefore, the product participates actively in the flow of the experience. This step is very relevant because it provides security. The connection of the 2 elements is necessary for the whole experience to be fulfilled.

#### Step 2. Authentication

After the personal data is identified, the following step is to authenticate the user. With the use of a **password or biometric unlock** this can be easily done. This process verifies that the user can only access the owned NFTs.

#### Step 3. Blockchain selection

This is the most important step and what differentiates the solution from the existing ones. The selection of all possible blockchains makes the platform a **centralised** medium to display all types of NFTs.

#### Step 4. NFT selection

Only the NFTs belonging to the selected blockchains are showcased. The blockchain selection already acts like a filter to help manage the NFTs owned. The NFT selection is done through a screen that shows **previews** of the NFTs.

#### Step 5. Augmented Reality display

Once the NFT is selected it is then displayed in AR within a physical context with the use of the cameras and the technology of the **smartphone**. This step helps bridging physical and digital worlds and opens new opportunities for interactions and utilities for NFTs.

#### Final step. Experience achieved

After the showcasing of the NFTs the **user** feels an increment or experience **pride** at a certain grade. Meanwhile, the **viewer** should be engaged about how the visualisation takes place. This engagement can be described as a **"wow moment"**. After this point, several situations can derive, such as the viewer being interested in NFTs and entering the space, use of the NFT for a special purpose (redeemability), or evolution of the NFT after being part of the physical world with new applications and characteristics.

In **Chapter 6.3** I present this solution VS. the best current solution for visualisation, with an explanation of the improvements.

## 4.6 Conclusions

The proposed solution meets the vision and objectives presented in the initial chapter. The definition of the context, target group, desired experience, problem, and requirements have framed the core of the proposed solution. The values pinpoint the solution as highly relevant for the current and future NFT scenario. Moreover, the combination of a physical product with an app merges the benefits of a customizable product that embodies user emotion (pride) with the ease of use and engagement offered by the app design. This design solution shapes a meaningful and desirable solution for the users.

In the following chapters an in-depth explanation of the design process and motivated decisions is provided. Each product, physical and digital is tackled separately.

To conclude, I present now in **Table 02**. Define chapter. Personal contributions my personal contributions to the project in the different fields of desirability and feasibility, and viability where applicable.

Desirability	Feasibility	Viability
Target group definition	Requirements. Technical	Requirements. Economic
Stakeholders analysis		
Desired experience definition		
Problem definition		
Requirements. User qualities		
Value Proposition Canvas		
Consumer journey map		

**Table 02.** Define chapter. Personal contributions

# 5. Develop & Deliver

In this chapter I describe the different **parts of the proposed design** solution in detail: physical product and app (front end and back end). Each part is presented separately. The previous chapter explains how the product meets the expected experience, and gives an overview of the interactions with the user. The **goal** of this chapter is to explain the design process and motivated decisions that led to a final design, and illustrate the interactions of the different parts with the user in a detailed manner.

The approach followed consists of targeting each part of the solution and explaining it in-depth, this is:

1. **The design process.** Focused on the **user values** and what the product must convey or deliver to the users
2. The different parts, how they work and prototypes. Main focus on the **technology aspect**
3. How they interact with the user. Focused on the **user interactions**

The chapter finalises with a comparison between the current state for visualisation of NFTs in the physical world and the proposed solution. The methods used to obtain the desired outcomes, the results and discussion are presented for each section.

## 5.1 Physical Product

This chapter will cover the whole design process, motivated decisions that lead to the final design of the physical product and detailed interactions with the user. In the proposed design solution, the **role of the physical product** (**Fig 46**) is mainly to convey **emotion**, more specifically evoke pride. This aspect is intensively explained in the **Chapter 5.1.1**.

Consequently, the product is in charge of carrying most of the user values. It is the main medium for the users to **express their identity**, it enables a seamless interaction, and showcases the NFT essence (ownership and authenticity). Furthermore, the physical product is designed for the target group defined as creators/ developers/ entertainment focused. Therefore, the general aesthetics has been adapted to be appealing to this particular group.



**Fig. 46.** Physical product

## 5.1.1 Design Process. A Product that Evokes Pride

In this chapter I demonstrate the **full design process**, from the first **iterations to the final design**. The chapter is divided into **3 main sections**. First, I introduce the first iterations of the design, where I aim to explore different general **design directions** including the secondary user qualities (authenticity, ownership and self expression), with creation freedom and almost no constraints. At the end of this section the selection of a design direction takes place using the Harris Profile method.

After the selection of the desired design direction I convey the **study about pride**. This is the core section of the chapter. The **objective** of this study is to obtain knowledge about how users perceive pride and how it is embodied, all in the context of the entertainment industry. The use of Emotion Design methods like collages and PrEmo will help grasp the essence of the desired emotion. User feedback gathered with the use of questionnaires will help to continue developing the design direction with the incorporation of the emotional value to the last section, the **presentation of the final design**.

### First Iterations. Creative Exploration of Design Directions

The first iterations consist of **15 different design directions** that are either unique or combination of design directions for an improved version. The different design directions are presented and categorised next:

**Bio-usage.** These approaches base their functioning in the use of some biological personal input. See **Fig. 47** (facial recognition), **Fig. 48** (heat recognition), and **Fig. 49** (tactile recognition).

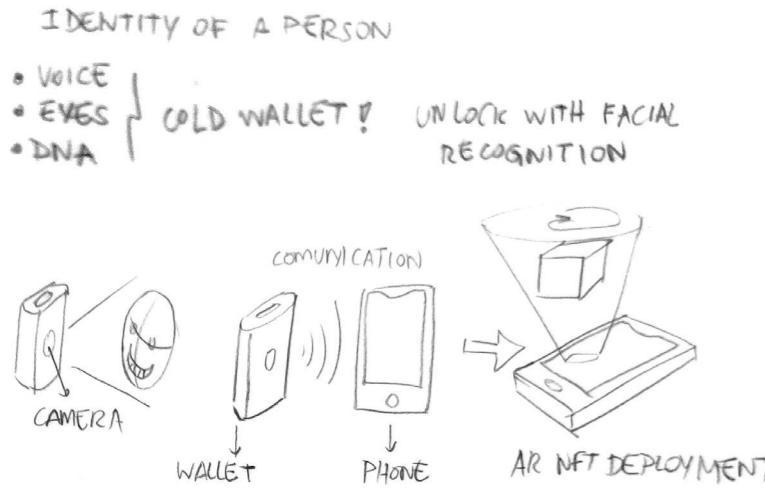


Fig. 47. Design direction. Facial recognition

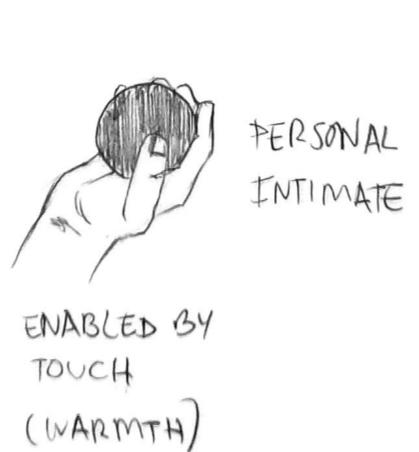


Fig. 48. Design direction. Heat recognition

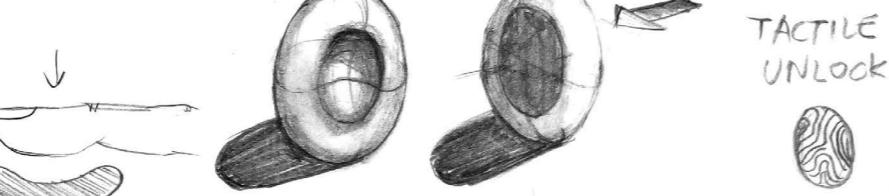


Fig. 49. Design direction. Tactile recognition

**Physical input.** These solutions base their functioning in a physical input like a force or movement. See **Fig. 50** (magnetic force), **Fig. 51** (spinning force), and **Fig. 52** (drawing movement).

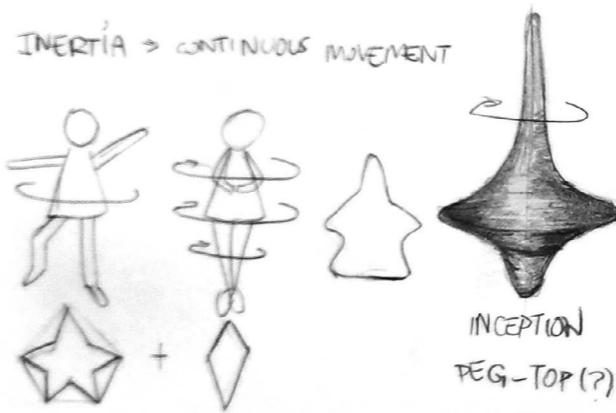


Fig. 51. Design direction. Spinning force

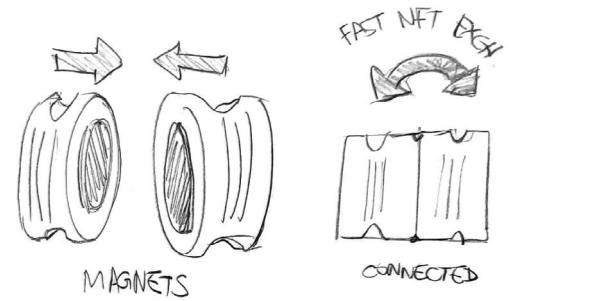


Fig. 50. Design direction. Magnetic force

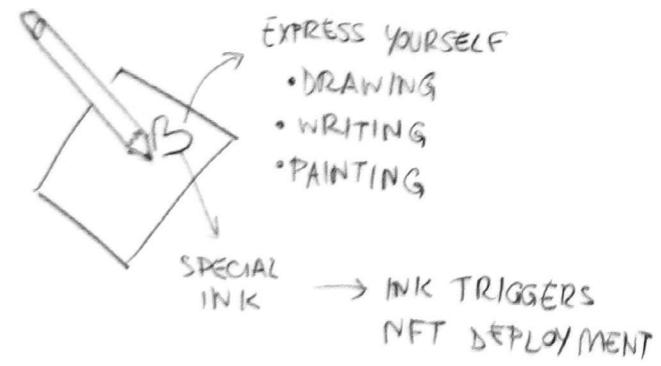


Fig. 52. Design direction. Drawing movement

**Imitation.** These solutions imitate objects that already exist and redesign them for a new purpose. See **Fig. 53** (hologram), **Fig. 54** (Mobius strip), **Fig. 55** (sticker), and **Fig. 56** (mirror).

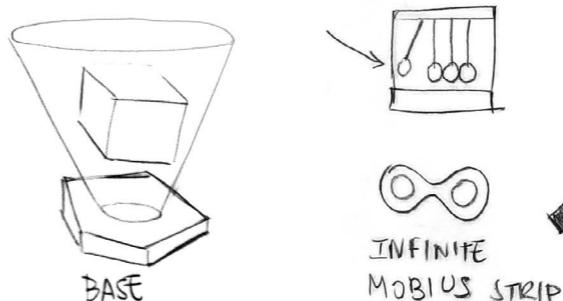


Fig. 53. Design direction. Hologram

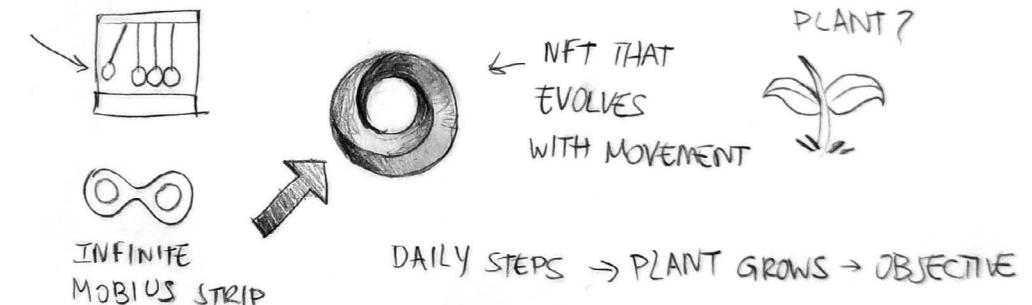


Fig. 54. Design direction. Mobius strip

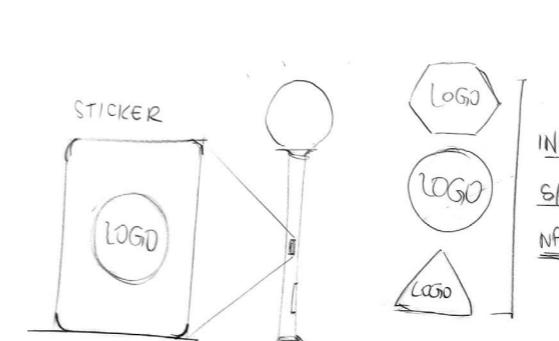


Fig. 55. Design direction. Sticker

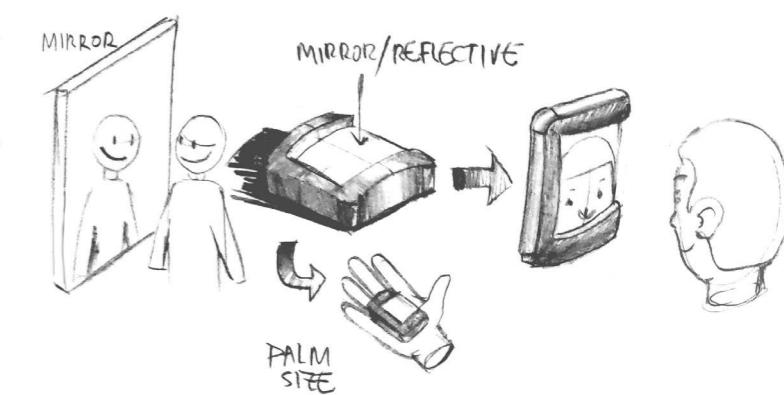
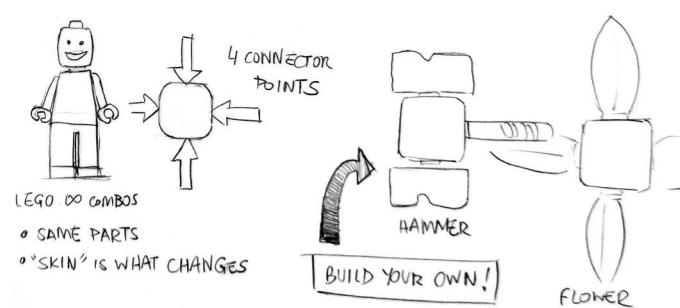
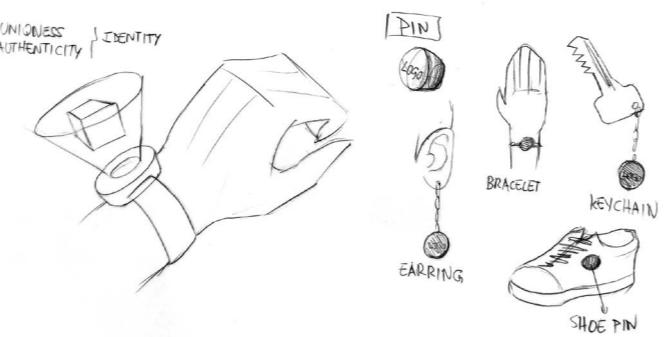


Fig. 56. Design direction. Mirror

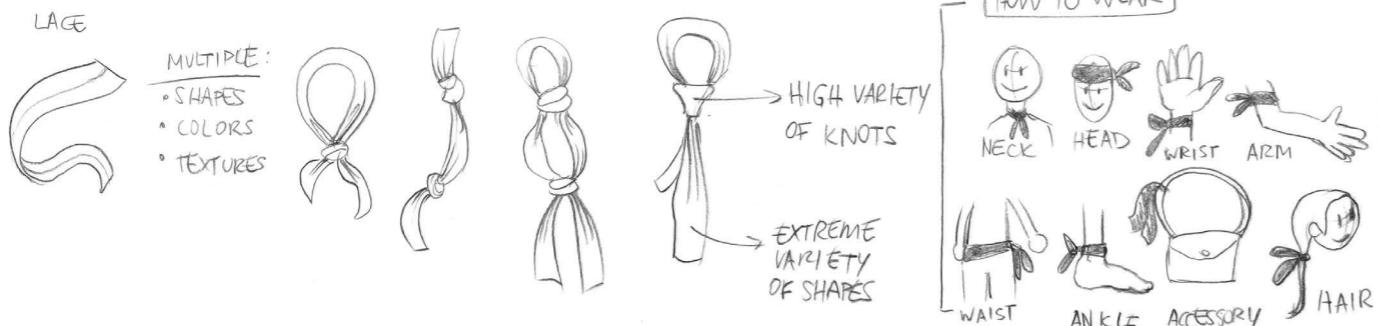
**Customizable.** These design directions are based on the possibility of obtaining different shapes depending on the user. They are conceived to maximise user customizability. See **Fig. 57** (LEGO-like), **Fig. 58** (wearable), and **Fig. 59** (laces).



**Fig. 57.** Design direction. LEGO-like

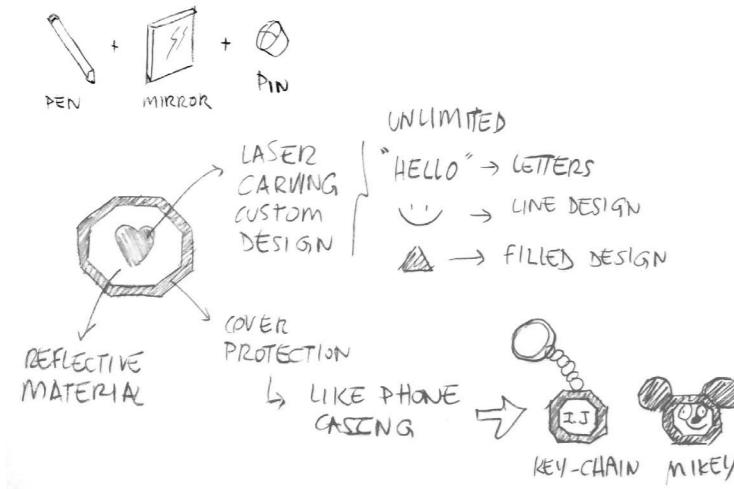


**Fig. 58.** Design direction. Wearable

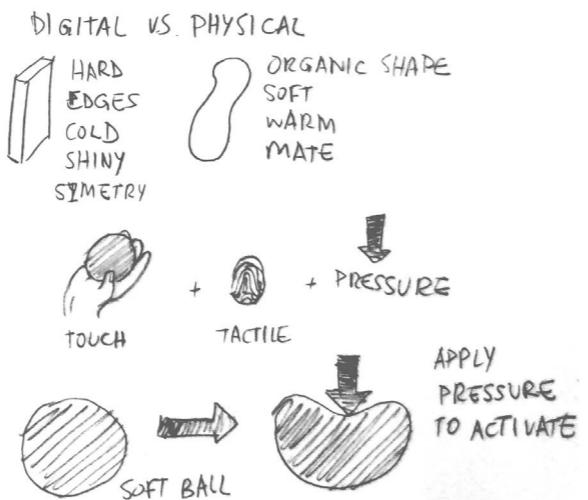


**Fig. 59.** Design direction. Laces

**Customizable.** These design directions are the result of a mix of two or more of the above presented. See **Fig. 60** (pen+mirror+pin), **Fig. 61** (warmth+tactile+pressure).



**Fig. 60.** Design direction. Pen + mirror + pin



**Fig. 61.** Design direction. Warmth + tactile + pressure

### Harris Profile selection. A requirement focused approach

Out of these design directions one was selected using the Harris Profile method. A Harris Profile is a graphic representation used to evaluate designs with a rating method based on **requirements**. It is helpful to choose which designs should continue being explored within a design process (Van Boeijen *et al.*, 2020). The use of this method ensures that some of the requirements are already fulfilled or are taken into consideration for the next steps of the design.

### Method

The different designs were placed next to an empty matrix, consisting of 5 columns (**Fig. 62**). In the first column the requirement is provided. The consecutive columns constitute a range for **rating**. The description of the method establishes that the rating scale must be even to avoid neutral results. This facilitates the selection process. The rating range used goes from negative to positive, as follows: --, -, +, ++. For the rating, the correspondent cell has to be filled in.

The requirements used for the Harris Profile selection were some of the ones presented in the previous **Chapter 4.4**. The requirements in the Harris Profile are organised by order of importance. This is, the most important at the top and the least at the bottom. Thus, the designer will always prioritise designs with more positive scores in the top area.

Out of all the requirements some of the have been included, as an in-depth study will be conducted later due to their relevance and need for user input (such as conveying the emotion pride), or because they are not applicable to the physical product itself (e.g. acceptance of all types of NFT standards). Therefore, the requirements used were the following:

1. **Connectivity** with phone
2. Object should advocate **NFT properties** (ownership and authenticity)
3. **Adaptability** to any type of user (uniqueness). Flexible design
4. **Usability**. Simple to interact with
5. **Technology simplicity**
6. **Desirability**
7. **Mass production possible**
8. **Cheap**
9. **Durability**
10. **Portability**
11. **Environmentally friendly** (avoid e-waste)
12. **Safety**
13. **Resistance** to different environments

REQUIREMENTS	--	-	+	++
Connectivity with phone				
Object should advocate NFT properties (authenticity & ownership)				
Adaptability to any type of user (uniqueness). Flexible design				
Usability. Simple to interact with				
Technology simplicity				
Desirability. How attractive could it be for early adopters				
Mass production possible				
Cheap				
Durability				
Portability				
Environmentally friendly (avoid e-waste)				
Safety				
Resistance to different environments				

**Fig. 62.** Harris Profile method. Rating matrix

## Results and discussion

Out of all the designs, the one who performed best was a mixed solution: **pen+mirror+pin** (Fig. 60). The mix of various design directions improved the score of the individual solutions by adding up strengths, in particular, the pen and the mirror design directions improved the wearable in desirability and enhanced ownership and authenticity. The desirability is improved by making a product more customizable by the user thanks to the addition of laser engraving features, and NFT properties with the integration of a reflective panel in which the user can see himself mirrored. This self-reflection symbolises the uniqueness and possession of one's self. The Fig. 63 shows the score of the chosen design direction using the Harris Profile method. For an overview of the score of all design directions see **Appendix 13**.

REQUIREMENTS	--	-	+	++
Connectivity with phone				
Object should advocate NFT properties (authenticity & ownership)				
Adaptability to any type of user (uniqueness). Flexible design				
Usability. Simple to interact with				
Technology simplicity				
Desirability. How attractive could it be for early adopters				
Mass production possible				
Cheap				
Durability				
Portability				
Environmentally friendly (avoid e-waste)				
Safety				
Resistance to different environments				

Fig. 63. Harris Profile method. Score of the selected design direction

After selecting a design direction, a study to adapt it to users was conducted. Product is intended to evoke pride, a core feeling when showcasing. For this, a **design for emotion** approach helped in determining shape, form, colour, texture and material.

## Design for Emotion. Pride

This section constitutes the **core, most valuable section of the design process**. Pride is expected to be the emotion showcased by the product, thus the relevance of the upcoming paragraphs. The **aim** of this section is to study the emotion pride related to physical qualities, and how it is perceived by the users. Therefore, the section consists of **2 different parts**. First, a study of the feel and look focused on the entertainment industry will reveal what are the different shapes and forms associated with this feeling in the desired context. The results of this study will determine the overall look of the product. Thus, its relevance is notorious. Secondly, a user test

is conducted with the use of questionnaires to select a new design direction, created with the input of the look and feel study.

This new design direction will continue the line of the first selection but will add the user feedback. This results in a product that conforms with the requirements and evokes pride in an effective way for the target group.

All the methodologies, results, discussions and conclusions of the different parts are presented next.

### Feel and look study.

#### Pride in the entertainment industry

In this section I **aim** to understand what are the physical attributes of products associated to the emotion pride. From the user interviews in **Chapter 3.3** the important role showing off plays when showcasing the NFTs is highlighted. It is one of the main actions executed when owning

an NFT. A feeling closely linked to the action of showing off is pride. The knowledge gathered will serve as input for the physical product, aimed to embody this feeling.

### Feel.

#### Pride and its connection to possession and self-esteem

The **objective** of the “feel” study is to identify which is the association the emotion pride has for the target group. Pride is considered to be universally recognisable, meaning that it has the same associations all over the globe. The study conducted reached the same conclusion. For the complete study, see **Appendix 14**.

This **insight** led to the following “look” exploration. The goal of this exploration is to identify in which way that “feel” of pride, related to possession, communities and success, is materialised in the form of shapes, materials, textures and colours. The explorations were made through observations.



Fig. 64. Look. Material, texture and colour collage

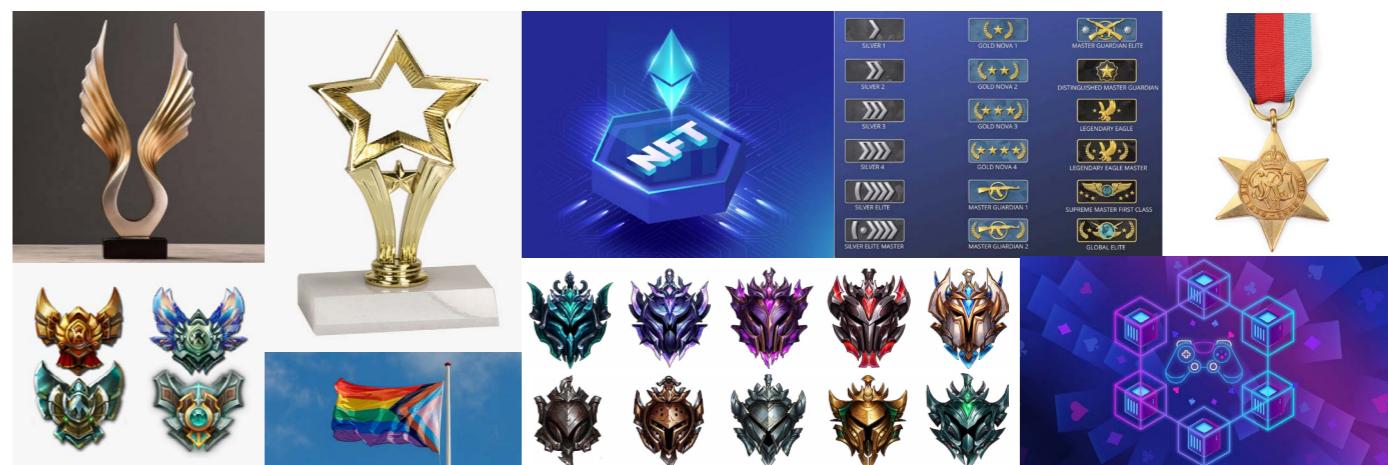


Fig. 64. Look. Shape and form collage

### Look.

#### Material, Texture & Colour

Related to the gaming industry. Predominance of hard mate plastics and shiny metallic finishes, neutral colours such as black and white and cold chromaticism (blues, purples, violets), as well as some vivid and colours. In Fig. 64 an example of these can be seen.

### Look.

#### Shape and Form

In Fig. 65 there a collection of the most common shapes and forms concerning pride in all entertainment industries (and therefore NFTs) is shown. There is high predominance for the angular and spiky shapes, all derivatives from trophies and medals. Most of these shapes embody the expanded posture mentioned previously, with the use of wing-type shapes. In addition, square symbols like flags and commemorative plates are also included.

Finally, the shapes of the **representation of NFTs** have also been taken into consideration in this cluster, as their meaning is also intended to be embodied by the product. NFTs are graphically represented as a hexagon, derived from how a block of the blockchain is represented. See examples of this current NFT representation in **Fig. 66**.

### Conclusion.

#### The best embodiment of pride are trophies

The information collected shows predominance of all those objects that intervene in the recognition of talents or success in competitions. These are: trophies/ medals. Physical qualities that stand out from these objects are shiny materials and expanded shapes (imitating the universal pose of showing off).

#### New design direction. Product emotion test

The **objective** of this section is to collect user feedback on the shapes that best embody the emotion pride. The **relevance** of this finding lies in the identification of a specific shape that embodies a specific feeling for the user. This will derive in the desired emotion to be triggered universally, regardless of the individual user from the target group. The research question that drives this research is:

#### Which shape best embodies the feeling of pride from the user's perspective?

The method, results, and discussion of the study will be presented next.



Fig. 65. Look. NFT representation collage

#### Method

The next iteration of the concept selected was made considering all the exploration made regarding pride. Special emphasis using the shape and form inspirations resulted in 4 different categories of shapes to explore for the embodiment of pride. These are:

1. **Star** shape
2. **“V”/ wing** shape
3. **Rounded** shape
4. **Rectangular/blocky** shape

Accordingly, 14 new variations of the shape were created, as shown in **Fig. 66**.

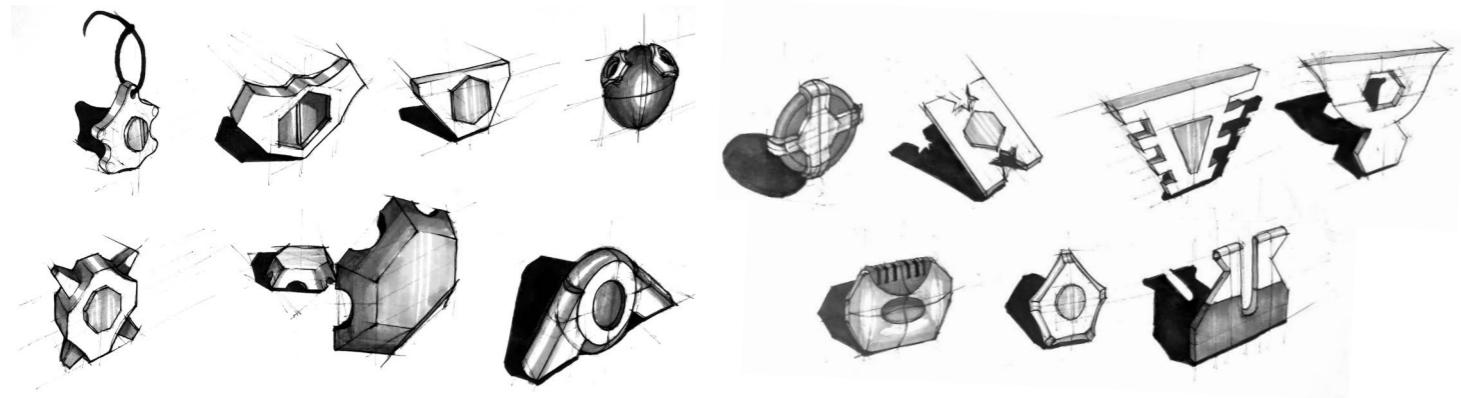


Fig. 66. Design directions based on shape study

For the selection of the new design direction, a research was conducted. In this case, a **questionnaire** was created to evaluate how certain shapes are perceived emotionally. This will help identify which shape better represents the pride feeling from the user's perspective. It was distributed to 15 members of the gaming community, not necessarily owners of NFTs. Pride having a universal meaning indicates that the possession of an NFT was not a requirement needed. This is also the finding from the “feel and look” exploration, where it is shown that pride is associated with the same concepts in the NFT and entertainment industries.

The **questionnaire** consists of an introduction and the presentation of the 14 new design directions. These designs are asked to be rated in terms of the emotion they convey, interpreted by the participants. In the introduction almost all context was omitted (only the topic of the graduation project is mentioned), since the product must manifest a specific emotion independently of the situation. For the complete overview of the questionnaire, see **Appendix 15**.

To measure the emotional response, the **PrEmo method** was used. PrEmo (Product Emotion Measurement Instrument) is a method created and developed in 2002 at TU Delft by Prof. Pieter Desmet. It is a tool that helps designers record emotions from participants when interacting with a product. It uses images that express possible feelings of the users (**Fig. 67**) (*idStudioLab*, 2022), (*PrEmo*, 2022), (*Desmet & Wassink*, 2019).

A future improvement of this tool in 2009 conveyed by David Güiza Caicedo, in collaboration with Prof. Pieter Desmet, added an extra emotion (**Fig. 68**) and reorganised the emotions in 4 different dimensions (**Fig. 68**), which provide a wider range of applications (*Güiza Caicedo & Dr. Desmet*, 2009):

1. **Social context** emotions
2. **Material context** emotions
3. **Expectation-based** emotions
4. **General well-being** emotions

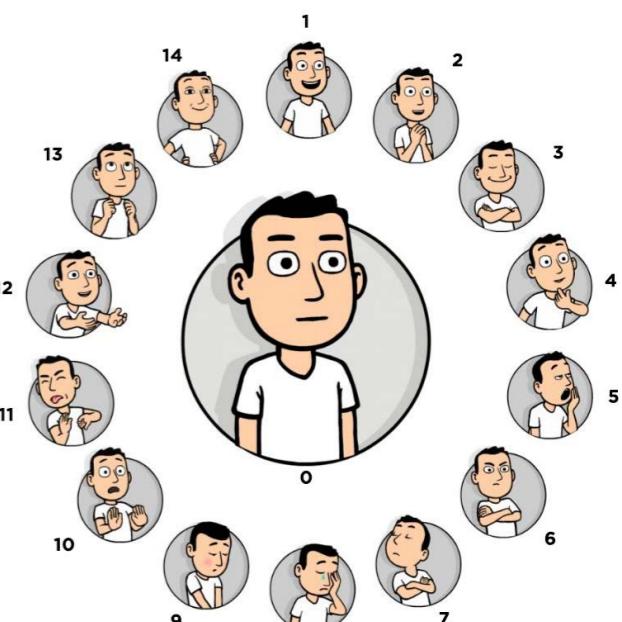


Fig. 68. Improvement of the PrEmo tool.  
Source (*Güiza Caicedo & Dr. Desmet*, 2009)

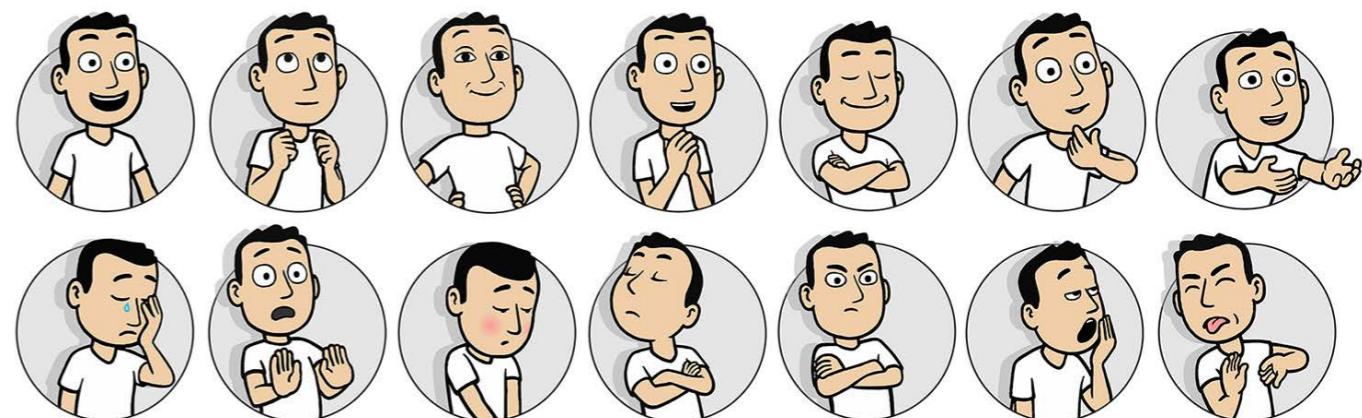


Fig. 67. PrEmo emotions. Source (*Desmet & Wassink*, 2019)

Out of the 4 dimensions, “material context” emotions is the least relevant in this case, for the reasons previously mentioned. Therefore in the remaining 3 categories the desired product should score high in the following emotions:

- Social context emotions: pride & admiration (n14 & n2)
- Expectation-biased emotions: satisfaction (n3)
- General well-being emotions: joy (n1)

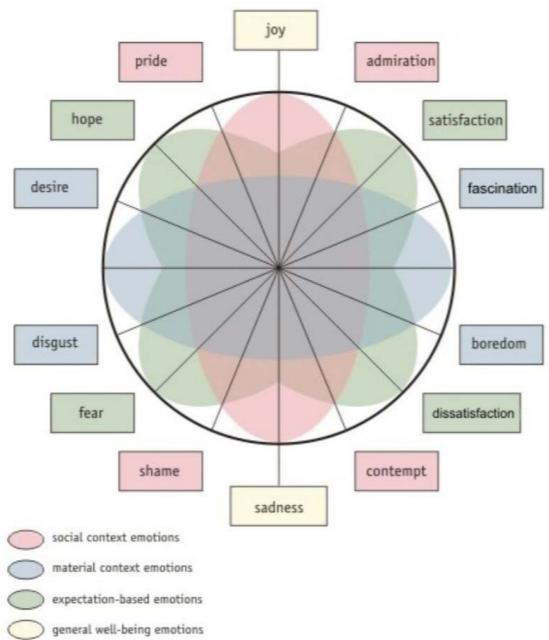
Material context emotions were used to help guide the final decision. Here, fascination (n4) would be the desired emotion.

**Fig. 68** is the figure presented to the participants following the introduction. I added a numeration to the different emotions to help them in the selection process.

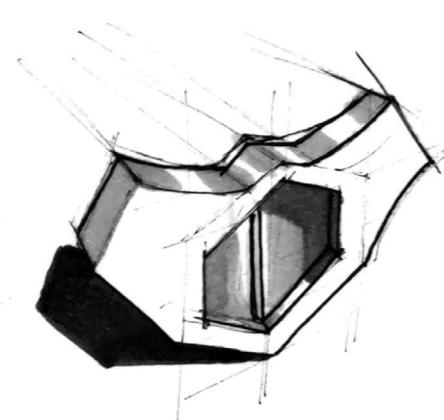
### Results and discussion

With this rating method, the v/winged shape scored the best, with the highest average. The following **Fig. 70** shows the design and the score. For in depth results of the test, see **Appendix 16**.

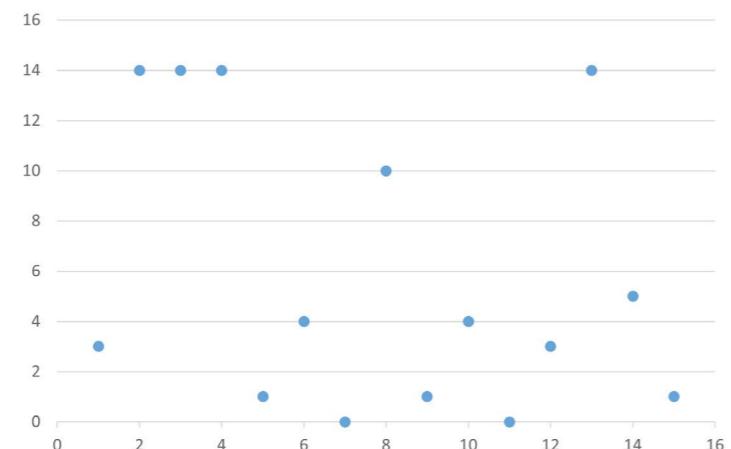
This design direction stands out for its **wing-like features** and the hexagon in the centre, characteristic derived from the pride emotion analysis. From this point, further iterations were made to adapt the design to the other requirements.



**Fig. 68.** Dimensions of the *PrEmo* tool.  
Source (Güiza Caicedo & Dr. Desmet, 2009)



PRODUCT EMOTION TEST.  
DESIGN DIRECTION 2



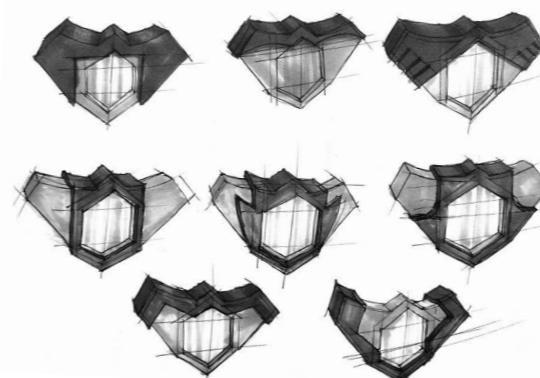
**Fig. 70.** Product emotion user test. Best result

### Final Iterations and Design

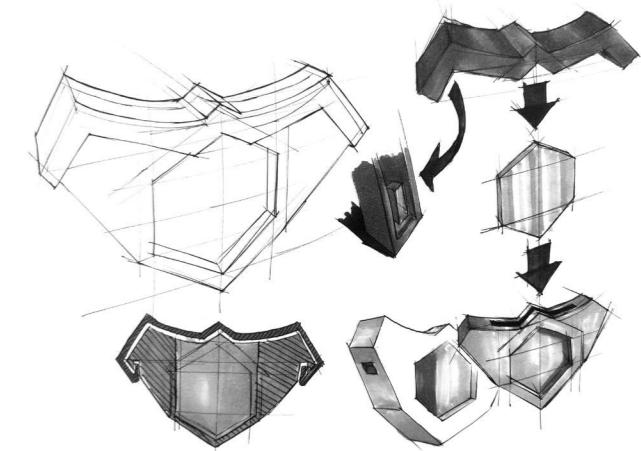
In this section I present the final iterations and the selection of the final design, driven by requirement fulfilment and personal choice.

While iterating, several aspects were taken into consideration:

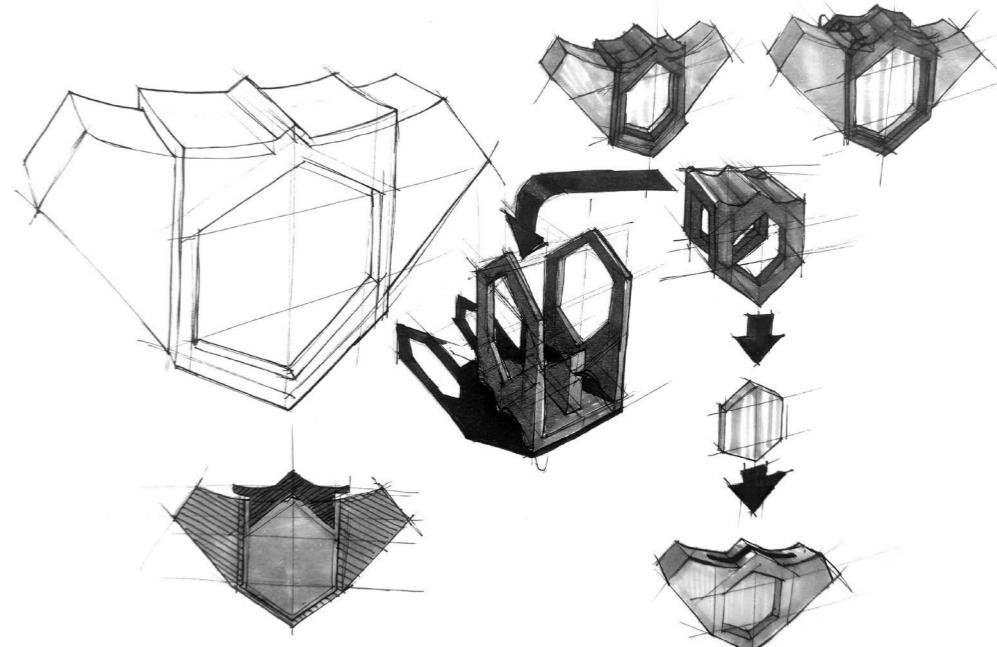
1. **Maintaining the general look** of the selected design with slight modifications
2. **Complexity.** The least parts possible
3. **Manufacturability.** How it could be produced and what parts should have what materials. In this regard, a study of possible materials that could fit the requirements used in the Harris Profile selection
4. **Assembly.** It should be as easy as possible, giving also the option for the users to repair the product in case it stops working, or make modifications (customizable)



**Fig. 71.** Final design iterations



**Fig. 72.** Final concept selection. Concept 1



**Fig. 73.** Final concept selection. Concept 2

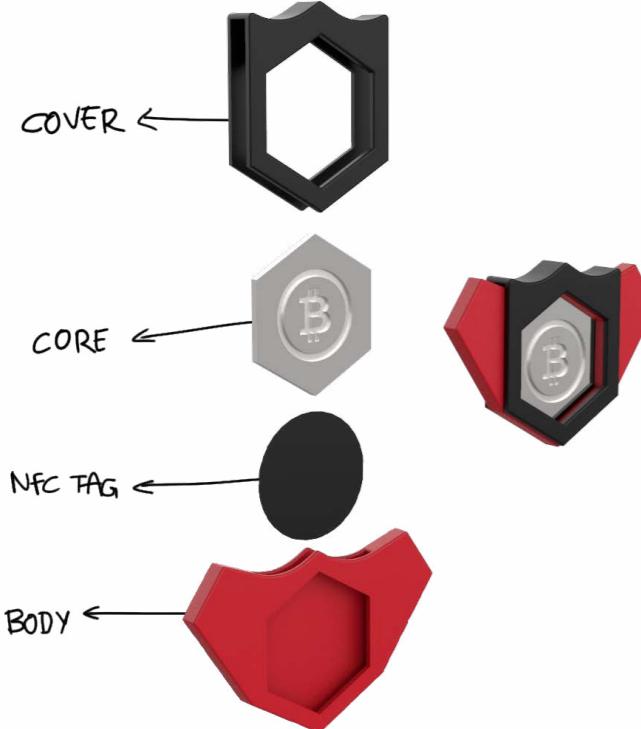
From these considerations 8 new designs were generated, showcased in the following **Fig. 71**.

The final selections shown in **Fig. 72** and **Fig. 73**, stand out for their equilibrated aesthetics in the line of the design direction. I conducted the final decision taking into consideration the requirements and personal taste. Furthermore, the final design corresponds to **Fig. 72**, a decision motivated by the ease in manufacturability. Accordingly, the final solution consists of a combination of motivated decisions based on requirements, design for emotion and user feedback.

## 5.1.2 Technology. Final Design, Components Description & Prototypes

The resulting design combines the flexibility and adaptability of a **wearable** that can be carried as a key chain, necklace, earring, pin, wristband, etc. with customizability characteristics **and emotion** expression. This is the second section of **Chapter 5.1** where I will describe the different parts that form it and motivated decisions concerning the technology, materials and fabrication process selection.

The final design consists of 4 different parts, shown in **Fig. 74**



**Fig. 74.** Final product. Physical product parts breakdown



**Fig. 75.** Physical product. NFC tag. Source (Wankhede, 2022)

### NFC Tag

The NFC (Near-Field Communication) tag enables **connectivity** and seamless interaction with the app. An NFC tag is formed by an antenna, a tiny memory chip and a sticker that keeps everything in place (**Fig 75**). This chip is easily **programmable** and can store data or send commands. In this case, the tag is used to launch the app automatically and store locally the address of the crypto wallet, necessary to identify the NFTs owned by a user. The communication is wireless with the smartphone. The technology used for these data transmission is NFC, due to the facts presented next.

#### Technology selection

The technology choice comes from a **comparison** of the pros and cons of possible technologies that could serve for this purpose. The comparison was made with input from different technological sources describing their traits. These technologies are:

- Bluetooth
- Bluetooth Low Energy
- Infrared
- Radio-Frequency Identification (RFID)
- Microwave
- Satellite
- WIFI

The main **disadvantage** of all the technologies except for RFID is that they need **batteries** to function. This is a big inconvenience due to the amount of **e-waste** that would be produced and costs. Referring to the technical requirements (**Chapter 4.4**), the e-waste should be less than 2.5g. All alone, a button cell weighs 2.3g, therefore the use of batteries is highly discouraged. In case the NFTs become widely adopted this impact can be of high relevance. Moreover, out of all of these, NFC (a form of RFID) stands out from the rest for this particular case due to the following reasons (*Wankhede, 2022*):

1. **NFC tags are programmable.** Each user can add their own information. NFC tags will hold the address of the wallets owned by the user, avoiding the need for memorising them

#### 2. **Multiple commands can be programmed.**

This adds extra flexibility to the design, with the possibility for multiple customizable seamless interactions

#### 3. **The information is stored locally.**

Therefore, one can only access it if they are physically close to the tag

4. **The range** of wireless detection is limited, up to 10cm. This results in close physical proximity to access it, which increases security deeply

#### 5. **No need for batteries.**

NFC tags consist of a small chip with memory and a radio antenna. The only requisite they need to work is an NFC emitter. Here, phones play a very important role, as most have the capability to communicate using NFC. Communication is established when a emitter (phone) creates a magnetic field powerful enough to induct the antenna and power the NFC tag

6. **It is compatible with public-key cryptography.** This is a security method used in contactless credit cards (bank-level security). The power of this method is explained in the following **Chapter 5.2.2**.

The NFC tag needs to be physically separated with a physical barrier such a plastic (ABS) of 2mm minimum from the core to have adequate responsive signal.

#### Fabrication methods

The NFC tags are **mass fabricated** and can be obtained in bulk quantities.

### Core

Reflective metal sheet of hexagonal shape (**Fig. 76**). The shape is chosen for the meaning it has in the NFT space (**Chapter 5.1.1**). The metal sheet has 2 purposes:

1. **Enable customization.** Engraving can be done in the form of text or images to make your product unique and more suitable to your personal likings
2. **Reflective properties.** When faced towards the user, the reflective material acts as a mirror, embodying identity and ownership.

### Material selection

The material used for the core must meet the following requirements:

1. Scratch resistant (higher hardness than Brass)
2. Easy manufacturability
3. Resistant to corrosion
4. Engraving possible
5. Suitable for polishing
6. Low price

The material chosen is **stainless steel 304**. Stainless steel is a metal which is very resistant to weather conditions and scratches. Furthermore, it is recyclable, and can have premium finishes. It can be easily engraved and polished. The only drawback of this material for the application would be its price. Nevertheless, the piece is quite small (less than 3cm x 3cm), its thickness is standard (not too thin, not too thick) and the waste in production is minimal. Therefore the impact of the price in the overall product will be quite insignificant. More about costs in **Chapter 7**. The hexagonal shape enables a distribution in which almost no material is wasted from a rectangular sample.

#### Fabrication methods

The techniques and tools needed to fabricate this piece are of relative low cost and can be adapted to low and high demand. For this particular case, they will be outsourced to other producers. For more information about costs in production and materials, see **Chapter 7**.



**Fig. 76.** Physical product. Core

## Cover

Element whose function is to **keep the NFC tag and metal sheet in place**. It is located on top of the body and fitted with a friction fit. It can also adopt different designs, as seen in the previous **Fig. 77**. Nevertheless, this shape has been chosen for its balance, not too aggressive, yet according to the general aesthetic needed.

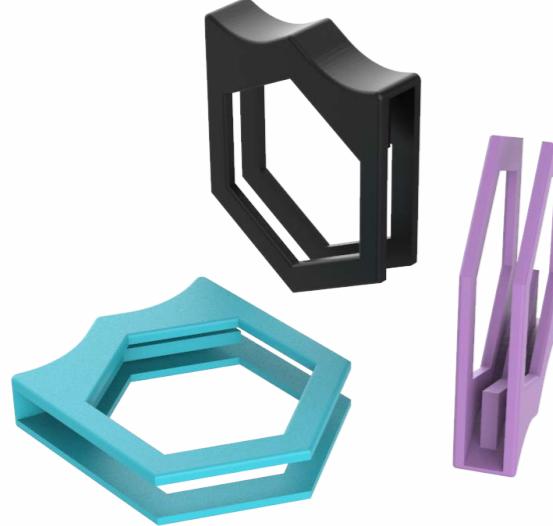


Fig. 77. Physical product. Cover

## Material selection

The technical requirements for the cover are:

1. It must resist outside temperatures (-10, +45)
2. Recyclable
3. Water resistant
4. Scalable with manufacturability method
5. Resistant to impact
6. Light weight

Several materials can meet these requirements. Out of all of them **TPU** is chosen. TPU is a flexible material that will perform excellent in this situation. Due to the connection between the body and the cover being friction fitted, it is convenient to have a deformable material with a slight overdimension. When applying pressure to join both pieces, the flexible material can adapt to the smaller hole, creating reaction forces that will help it stay in place.

The variety of colours available is very high. Its price is very low and it is 100% recyclable, therefore the waste produced is almost null. Finally, it is a material that resists high and low temperatures, as well as behaving properly outdoors and having low weight (Ansys, 2020).

## Fabrication methods

Another advantage of TPU is that it can be **easily adjustable** to production **scalability**. It can be easily 3D printed for small scales and injection moulded for larger scales. The production process in the initial stages of the launch of the product would be 3D printing, in the case the demand is low enough. If the demand is suitable for injection moulding, this would be the process used for fabrication. For more information about costs in production and materials, see **Chapter 7**.

## Body

**Enclosure** for the NFC tag and the core (**Fig. 78**). Its shape, material, texture, colour and form are the result of a study conducted on the users about product emotion. The body does not involve any external fastening methods to accommodate the elements mentioned. The NFC tag is located in the centre and covered by the metal sheet, which slides inside the body through a slot (**Fig. 79**). Moreover, the metal sheet is kept in place inside the slot thanks to the cover.

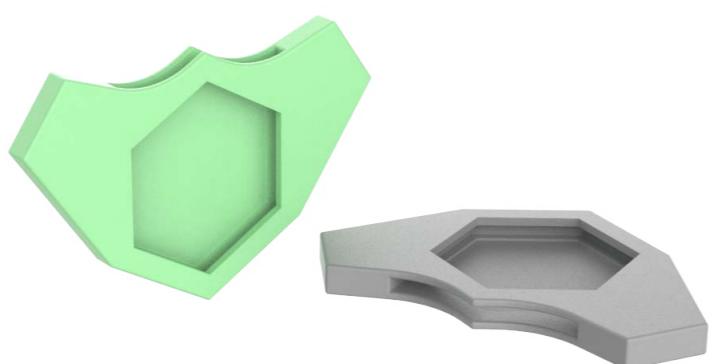


Fig. 78. Physical product. Body

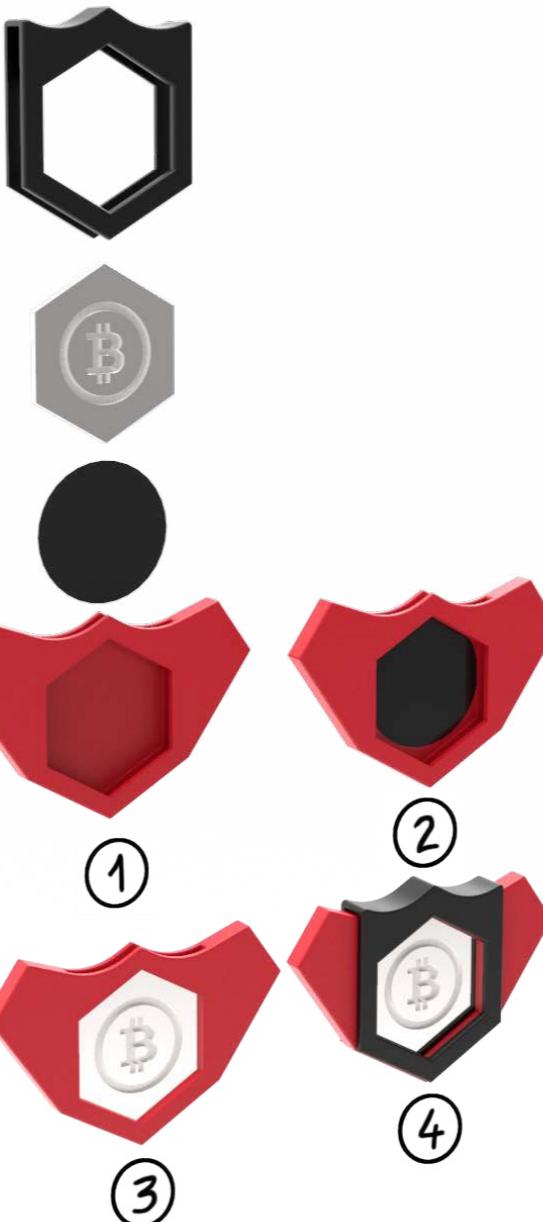


Fig. 79. Physical product. Assembly steps

## Material selection

The technical requirements for the body are the same as for the cover. However, the material selection here has been different. Instead of TPU, **ABS** is chosen. This material is highly used in the gaming industry for components such as mice, laptops, keyboards and other devices. It can have different finishes, such as matte and polished, and the variety of colours available is very high. Like TPU, its price is also low and it is 100% recyclable, therefore the waste produced is almost null. It also resists high and low temperatures, as well as behaving properly outdoors and having low weight. As there are no other demanding physical properties that need to be met, it is an excellent material for this application (Ansys, 2020).

## Fabrication methods

The fabrication methods of ABS are very similar to TPU. **It can be adapted** from small scale production to mass production (3D printing to injection moulding). The production method will be adjusted with the demand. For more information about costs in production and materials, see **Chapter 7**.

## Prototype

The creation of a prototype (**Fig. 80**) was of use for the **final validation test**. For the test, no material requirements were needed. Therefore, the prototype was 3D printed using PLA. Moreover, the creation of a prototype served to have a grasp of the real size, shape and assembly tolerances to deliver a product ready for production. For more details about the validation tests where the prototype was used, see **Chapter 6**.

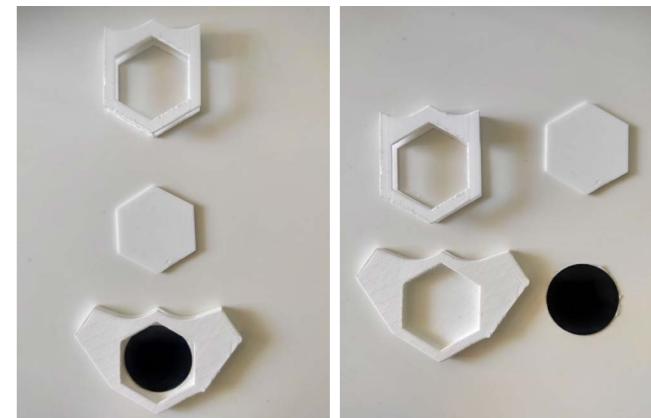
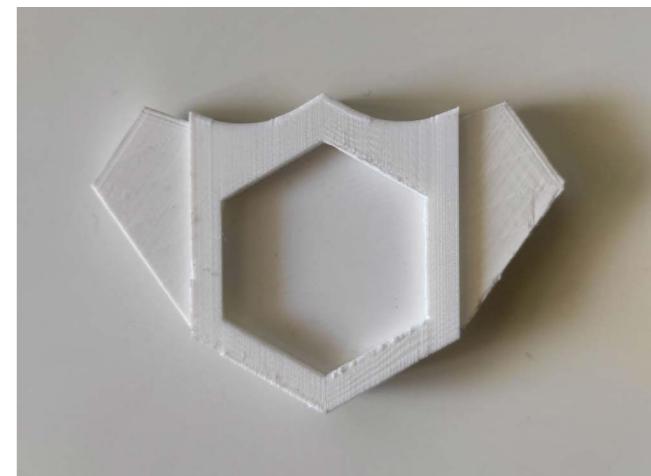


Fig. 80. Physical product. Prototype

## 5.1.3 User Interaction

The **goal** of this chapter is to describe in which ways the user can interact with the physical product in order to **explain** the reasons why the physical product exists in the first place, apart from its technical functionality (start the interaction and security).

As described previously, the physical product is aimed to embody a certain feeling (pride) and meanings (authenticity and ownership), which serve as self-expression for communities and individuals. Previous exploration shows that in the NFT space it is very important to be identified as a member of a group and showcasing this aspect is desirable for the users. To enhance and promote this attitude, the physical product aims for as much **personalisation** as possible with several characteristics such as colour, shapes and wearability. The users can influence the overall look of the product by these **3 means**. The following **Fig. 81** shows in which ways the users can influence the design and adapt it to their personal taste.

### Colour

Colour plays a very important role when conveying non-verbal meanings. There are fields of study (colour psychology) which try to link certain colours to emotions and understand how they influence our well being. Thanks to the materials selected for the different parts of the product, having a colour variation is simple and cheap, which allows the users to personalise the product in this aspect and adapt it to their personal likings.

### Shapes

A second aspect that has high relevance in conveying meaning are shapes and symbols. These elements have been widely used in history to classify and identify groups, categories and emotions through non-verbal communication. The use of shapes that convey meaning have helped humanity evolve and progress in unimaginable ways. The best example of these are the letters we use for writing. Therefore, by allowing users to use these powerful tools of self expression, they can undoubtedly personalise the product to embody any relevant aspect desired. By doing so, they influence the meaning of ownership and authenticity perceived towards the product.



Fig. 81. Physical product. Possible user customisation

The customisation is possible with the use of **engraving** technology on the stainless steel core. Examples of these can be seen in the previous **Fig. 81**.

### Wearability

Finally, the third way in which users can interact with the physical product is wearability. Fashion is also another core pillar way in which people and communities express who they are, what they like and where they belong. Throughout history, clothing has been widely used as a way of categorising and identifying groups. Therefore, it seemed relevant that users could also influence the way they engage with the product in this way. Thus, the design is thought to be adaptable to be worn in multiple different ways. **Fig. 81** shows 4 different possibilities (pin, key chain, necklace and bracelet), however others are possible.

## 5.2 Digital Product

This chapter will cover the whole **design process**, motivated decisions that lead to the final design of the app and detailed interactions with the user. In the proposed design solution, the **role** of the app is mainly to offer an **engaging experience** through an **easy process**. The app is the main medium to solve technical aspects related to visualisation and NFTs.

## 5.2.1 Design Process. Ease of Use in an Engaging Platform

The app is developed with Unity, specialised software for game development, that has multiple tools for app development, including the utilisation of **Augmented Reality**. For the app to deliver the desired experiences, it must meet certain requisites.

1. **Verify** you are the owner of a certain wallet. Identification and Authentication
2. **Access** the content of your wallet, this is, retrieve the NFTs.
3. **Display** the content in Augmented Reality

## 5.2.2 Technology. Final Design, Components Description Prototype

The **goal** of this chapter is to identify and explain from a technological point of view the different **parts** that form the app: the front end and the back end. In the structured approach, I provide a description of the part, the technologies involved and how it works and the prototypes created. All the methods used for the selection of a technology will be presented and explained. The results will follow.

### Back End. The Architecture for an Ease of Use

The **goal** of the back end is to provide an **experience service** for the app that is pleasant for the user. It is focused on **ease of use**. The back end is in charge of the technical functioning of the app, and combines all the automated processes that happen without the user's knowledge. To help visualise these automations, I have created an architecture flow chart (**Fig. 82**) that describes all the steps that happen during the experience (from start to end) in a sequential order. The order and logic followed correspond to that presented in **Chapter 5.2.1**.

#### Step 1. Identification and authentication

In the first place, it must be able to identify your wallet address. This is done with the help of the **physical product**. Further explanation of the interaction is provided in **Chapter 5.2.3**.

Next, it must authenticate you as the owner of that wallet without connecting to it and/or exposing your physical identity, all in a safe way. The challenge here lies in proving that you are the owner of a given address. This is possible thanks to the nature of wallet addresses, which are based on public-key technology.

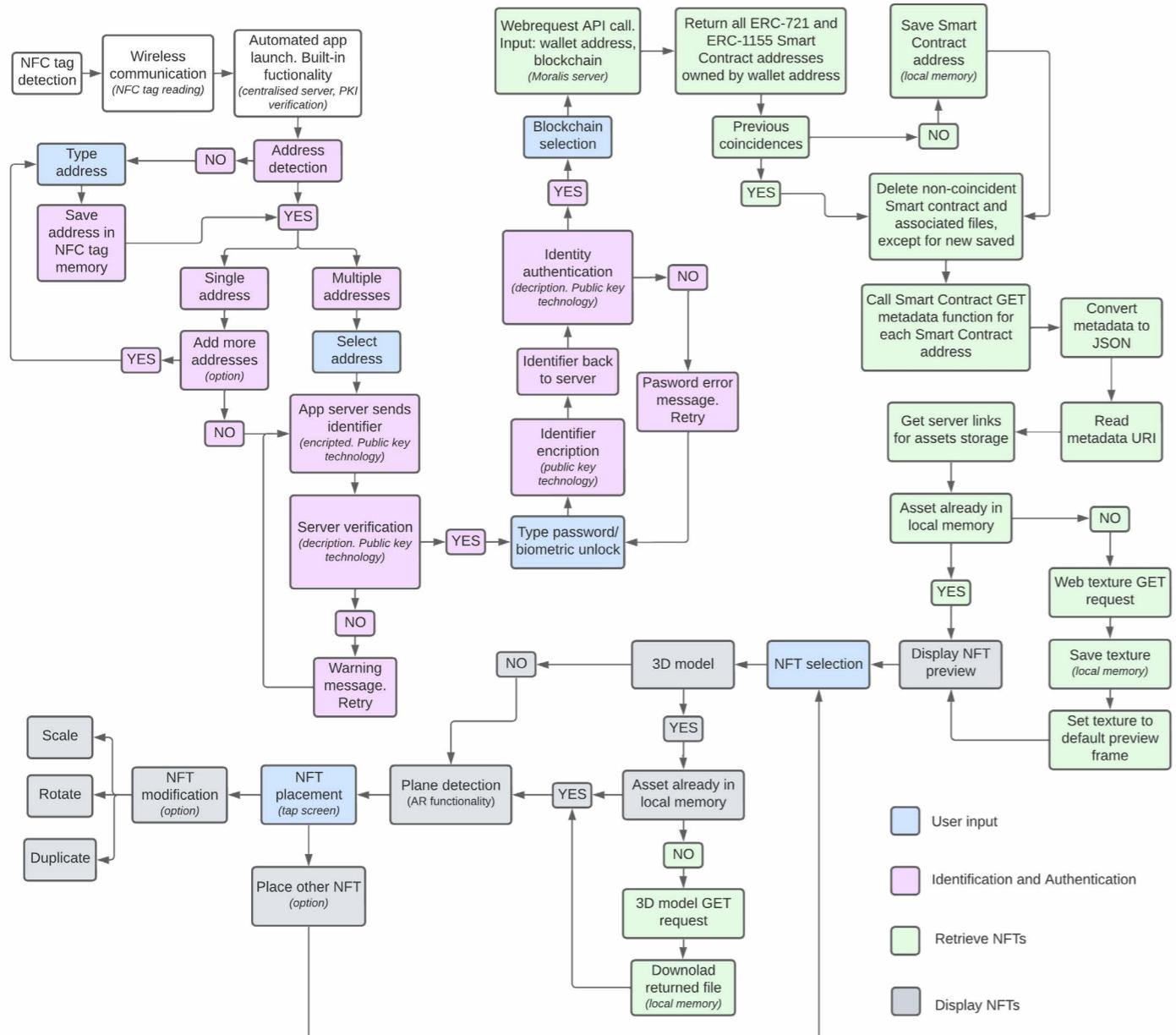


Fig. 82. Digital product. Architecture flow chart

## Public-key technology

These methods are widely used to verify identities online, and have multiple applications, such as digital signatures. Before explaining how the method works it is important to define private and public keys, as well as addresses.

- **Private key.** Only known by the owner
- **Public key.** Known by everyone

Both are generated by mathematical asymmetrical algorithms that ensure that they cannot be exploited using brute force. The most common algorithms used to generate keys are:

- Rivest–Shamir–Adleman (RSA)
- Elliptic curve cryptography (ECC)
- Digital signature algorithm (DSA)

It uses hash function cryptography. A hash function, also called “hash” is a fixed-length character string that corresponds to any arbitrary size data (DocuSign, 2022).

The use and combination is explained in Fig. 83.

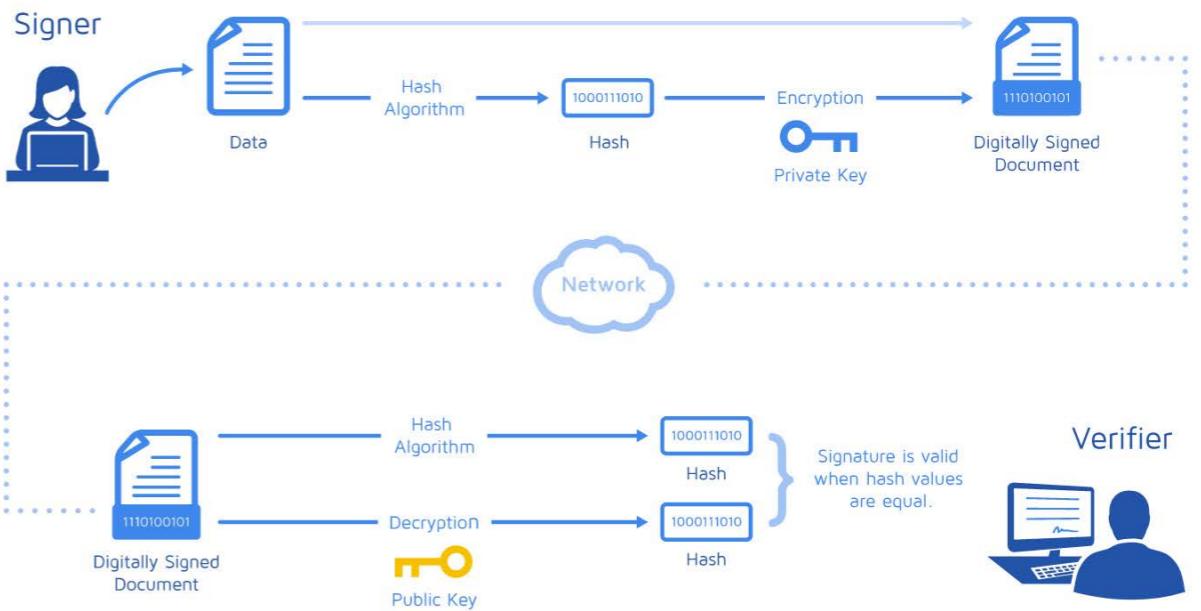


Fig. 83. Digital signatures working principles. Source (DocuSign, 2022)

## Certificates and Digital Signatures

As defined by the Cybersecurity & Infrastructure Security Agency (CISA) from the United States:

**“A digital signature—a type of electronic signature—is a mathematical algorithm routinely used to validate the authenticity and integrity of a message (e.g., an email, a credit card transaction, or a digital document). Digital signatures create a virtual fingerprint that is unique to a person or entity and are used to identify users and protect information in digital messages or documents. In emails, the email content itself becomes part of the digital signature. Digital signatures are significantly more secure than other forms of electronic signatures.”** (CISA, 2009)

They are widely used to sign digital documents and certificates, as they confirm the identity of the entities involved in the transactions.

How it would work in the App (Fig. 82):

1. **App server** (centralised and with a public address verified by a PKI) sends identifier to user (encrypted with private key)
2. **User decrypts** the identifier using server’s public key (identity verification of the sender)
3. **User types private key**, or uses fingerprint, and encrypts identifier
4. **Server decrypts** identifier with user’s public key and compares it with the identifier sent initially (identity verification of the user)

Therefore, it is a valid feasible secure method of identity verification without the need of connecting a wallet and giving permissions. This method is a game changer when applied in this case, as it gives the necessary access to a user’s wallet content with bank-level rating security and 0 risk of money or asset loss. Once the digital identity of the user is verified while the physical still remaining anonymous, it is a matter of retrieving what is stored inside. This use and process is validated by a cybersecurity expert in Chapter 6.2.

## Step 2. Retrieve NFTs

One of the benefits of blockchain is decentralisation, as previously mentioned, which empowers users by keeping them anonymous while providing transparency. All content within a wallet is visible by everyone. Every transaction and token is traceable through wallet addresses, yet, the identity of the people behind those wallets remains unknown. Therefore, with a given address it is possible to know which NFTs it holds. Instead of hard-coding these *READ* instructions to the blockchain, there are easier methods to retrieve this information using free **API services** from any of the many blockchain search engines or services that exist. For example, Moralis.

Moralis provides powerful services for Web3 dapp development, including free APIs. Others could be Etherscan, Polygonscan or Opensea's APIs. All of these can be used depending on the information one needs to obtain. The positive aspect about Moralis is that it has full integration with Unity, which makes it ideal for the proposed solution. Therefore, a simple API request script would be the only thing needed to obtain the NFT information, concretely the smart contract address and the token ID of each of the NFTs, concepts previously introduced in **Chapter 2.3**. This script wasn't developed due to expertise constraints. Nevertheless, it is completely feasible as confirmed from TU Delft, VR Zone lab (**Chapter 6.2**). The information needed for the API to work is:

- Wallet address
- Blockchain
- API key

The information received from the API is:

- Smart contract
- Token Id
- Contract standard
- Token uri (where the metadata is stored)
- Metadata
- Amount of NFTs of the given token Id
- Name of the NFT
- Other information

As explained in **Chapter 4.3**, the metadata holds all the necessary information that defines the NFT. Thus, it is possible to extract the textures (in case of images), or the 3D model files, in case of the 3D NFTs via other Web-Request scripts.

However, because the API script was not developed, the script created works as **proof of concept**, where the blockchain, smart contract address and token Id are the input parameters, included manually. Find the scripts for this in **Appendix 17**. Previous **Fig. 82** shows the logic followed.

## Step 3. Display NFTs in AR

Once the relevant data of each NFT is retrieved, the final step consists of displaying the NFTs. To do so **2 elements** become of vital importance: the **preview image** and the **model** itself. As part of the definition of the ERC-721 and ERC-1155 standards, a preview image has to be provided for the NFT to be visually identifiable. In the case of image NFTs the preview image coincides with the image of the NFT itself, however for music, videos and 3D objects it varies.

To obtain the preview image, you have to follow the **link provided in the metadata** that points to where this image is stored. This can be easily done with a built-in function in Unity called "Texture Request" with which you can obtain an image from any given server. The action can be completed referring to the "image url" variable in the metadata. Once obtained, it can be displayed as a preview and texture of a button in the UI. In the case of image NFTs this process obtains also the model.

Retrieving the model when it is different from an image consists of a similar step. A GET request is also made to the server hosting the model, which is a different link than the preview image, and refers to the variable "animation url" in the metadata. This process downloads the model and stores it in the local memory, to have it accessible for other uses. Then, this model can be displayed at runtime (while the app is being used). This method is very powerful, as it gives you access to assets that are not part of the app. The code I developed for this application can be seen in **Appendix 17**.

Finally, the button corresponding to a certain preview image can be associated with the instruction of downloading and displaying that particular NFT. With this step, only the NFTs that want to be displayed are downloaded, which speeds up the process. An example of how the NFTs can be displayed in AR can be seen in **Fig. 84**, and **Fig. 85**. In this case, I did not develop any code, but future **validation sessions** with experts confirmed that the process explained was correct and feasible (**Chapter 6.2**)



**Fig. 84.** NFT display. Image



**Fig. 85.** NFT display. 3D

## Front end. Engaging User Interface

The front end is the **visible part of the app**. It consists of all the **navigation and visualisation tools** the user needs to interact with the app. Its **main function** is to deliver an **engaging experience** in visualisation. The front end is the window for the user to communicate with the back end. All the different entry points, where the user must communicate with the back end (user input) are highlighted in blue in **Fig. 82**. The app interface is also designed using Unity software, which allows a complete integration of interactive UI elements.

The different screens for these entry points are stated next. In the following **Chapter 5.2.2** they are presented with the use of a user flow diagram (**Fig. 86**).

### (1) Login Screen

It is the screen where the user **authenticates** itself. It is the first mandatory screen for all scenarios. Includes a password login, biometric unlock, add new wallet and exit buttons. This screen logs automatically after launching the app and it already contains the information of the user's wallet address in case one has been introduced.

### (2) Add new wallet screen

This screen is only visible when the user wants to add a new wallet or in the case of the first interaction, when no wallet has been added. It records a **new entry** for the app, and therefore, it has NFC writing capabilities. Includes a text entry and back buttons.

### (3) Wallet selection screen

Only visible when the user has more than one wallet registered. It provides the **initial filter** for NFT search, as each wallet can include only specific blockchains. Includes one separate button for each wallet detected, a button to add a new wallet and an exit option.

### (4) Select blockchain screen

It is the **second mandatory screen**. Within a certain wallet, several blockchains are possible. Therefore, this screen serves as a second filter to fetch the NFTs. Includes a button for each possible blockchain corresponding to the wallet selected and a return button.

### (5) Select NFT screen

In this screen the **final filtering** takes place. All the NFTs of the selected blockchain, contained in the selected wallet are displayed in a grid that shows a preview of each one of them. Includes one button per NFT preview and a return button.

### (6) NFT placement screen

This screen is in charge of capturing and monitoring the physical environment with the use of cameras and displaying the NFT selected within this context. It is the graphical interface for the **AR experience**. Includes buttons to rotate, scale, duplicate, add other NFTs and return to the previous screen.

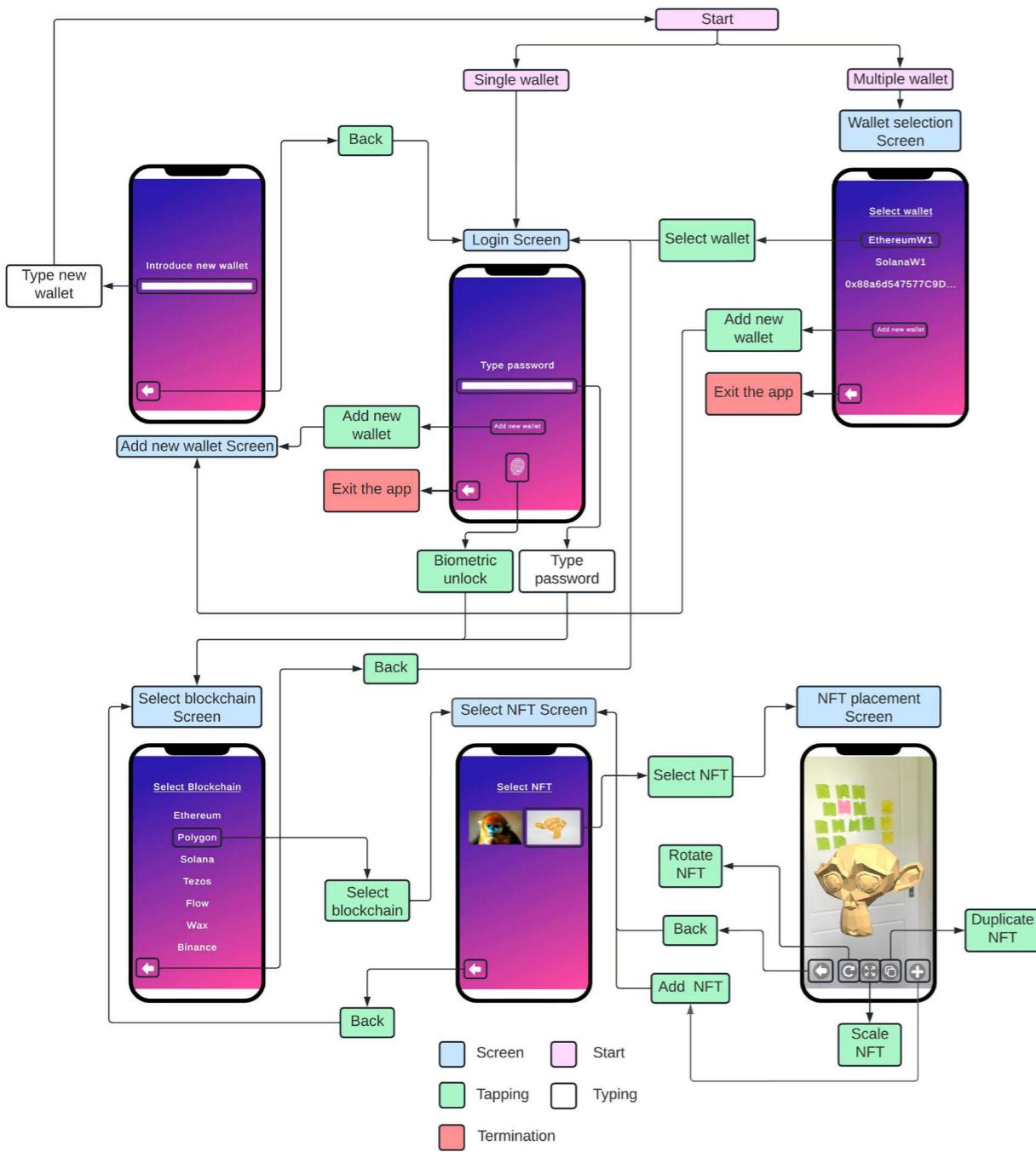


Fig. 86. App. User flow chart

## 5.2.3 User Interaction

In this section I **describe the actions** the user can perform in each of the screens described with the use of a user flow chart (Fig. 86). The objective is to showcase all the different options and actions the user can perform to have a clear overview of all the functionalities of the app.

The app was designed for modern smartphones, therefore, all the interactions with the app are through **tactile input**. The gestures commonly used for mobile tactile interfaces can be seen in Fig. 87 (Wroblewski, 2010).

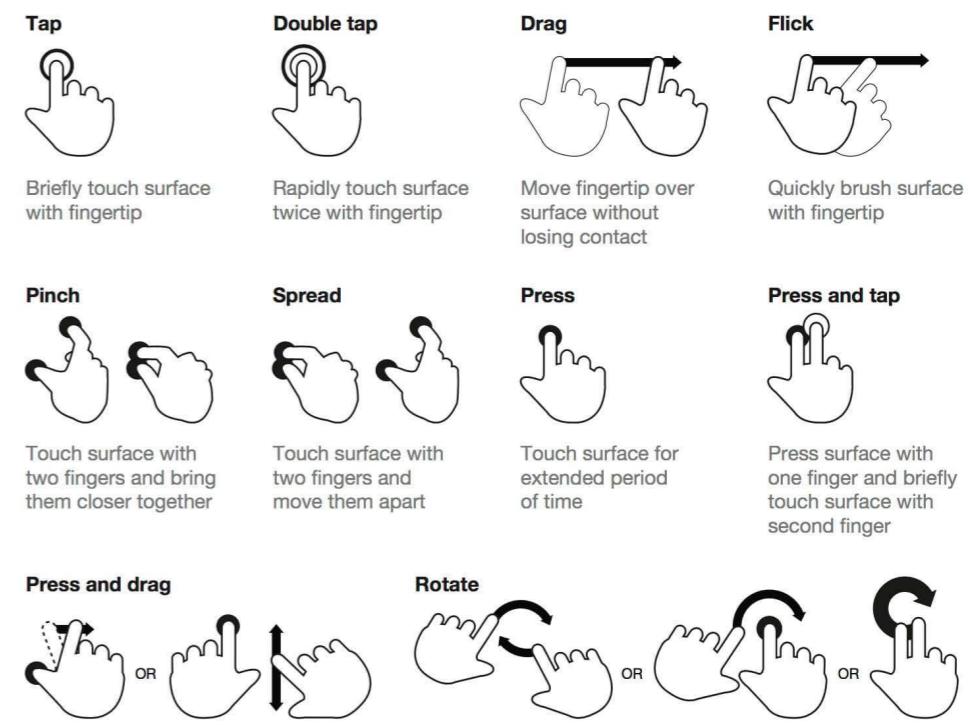


Fig. 87. Gestures for mobile tactile interfaces. Credit (Wroblewski, 2010)

## Identification & Authentication

The interaction starts when the physical product launches the app and sends the relevant information for the identification of the wallets. Already here **3 different scenarios** can happen:

1. **First interaction with the product**, in which no personal information is transferred
2. The user has **one wallet** only
3. The user has **more than one wallet**

In the first and second scenarios, the initial screen after the app is launched is the login screen. If there is no wallet detected, only the buttons to exit (bottom left) or “add new wallet” will be interactive. When tapped (Fig. 87), “add new wallet” screen loads. Here the user must manually include the address of the desired wallet and a password. As in every screen, the bottom left button will return to the previous screen until eventually exiting the application.

If the user has already included a wallet address previously, the login screen is also the first to appear. Nevertheless, in this case the other functionalities are available. The user can either

type manually the password corresponding to that wallet or use the biometric unlock situated in the bottom of the screen, at thumb reach. This type of unlock is much faster and secure than typing the password, and it is becoming more and more popular in use within the apps.

In the third scenario, the “wallet selection” screen is the first to load. The user must choose between the identified wallets by touching the selected one, or exit the application. If one of the wallets is selected, the login screen is displayed to authenticate the ownership. In roughly 2 seconds, the wallet and user are identified and authenticated with these processes.

## Retrieve NFTs

The only input the user provides to retrieve the NFTs, apart from the information given in the authentication, takes place with the “select blockchain” screen. The user is presented with all the blockchain options and touches the blockchain hosting the NFT desired to be displayed. In case changes to the previous choices want to be made, by touching the return button the previous screen loads. All the other processes of retrieving the NFTs take place automatically to avoid close contact with the technology.

## Display the NFTs

**Two final screens** are in charge of this final step. In the first one, “select NFT” screen, the user visualises a preview of each NFT, all displayed in a grid format. Then, by only touching on the image preview, the following screen follows. As with all the other screens, a return button can always be touched to change previous steps.

In the final screen is where the user can interact with the NFTs in multiple ways. First, by tapping anywhere on the screen the NFT is displayed within the physical context captured by the cameras. The repositioning can be done by touching on another place of the screen or dragging. Then, multiple actions can be performed by interacting with all the buttons accessible in this screen. Tapping on the rotate and scale buttons permits the user to perform actions on the current NFT displayed. Once each button is pressed, the interaction takes place with the universal gestures used for these purposes (**Fig. 87**)

The duplicate button, when pressed, loads an exact version of the current NFT being displayed, which then can be placed in the screen as described. Finally, the “add NFT” button reloads the “select NFT” screen, which gives the option of choosing other NFTs in the collection and also placing them in combination with the previous displayed.

## 5.3 Conclusions

The goal of **Chapter 5** was to explain the design process and motivated decisions that led to a final design, and illustrate the interactions of the different parts with the user in a detailed manner. All the former information presented meet the expected outcome. Here, detailed information about the different parts and how they work has served as solid ground to understand the whole purpose of the solution, not only in the technical aspects but also the influence and impact they have on the users while interacting with them. Therefore, all major aspects have been covered.

From **Chapter 4.4**, 3 different dimensions were defined (technical, user and economic), each with its own requirements. Going back to these, after the development of the product and decisions made, I can conclude that most of the technical and user quality requirements have been already met. For a complete overview of all the requirements and how they have been met, see **Ap.Table 01 in Appendix 18**.

To conclude, in **Table 03** I present my personal contributions to the project in the different fields of desirability and feasibility, where applicable.

Desirability	Feasibility	Viability
Design for emotion pride (exploration of look and feel)	Material and fabrication process selection	<i>Not applicable</i>
Product emotion test	Technology selection	
Envisioned user interaction	App architecture (back end)	
	App visualisation (front end)	
	Security protocol technology application	

**Table 03.** Develop & Deliver chapter. Personal contributions

# 6. Validation

This chapter **aims to describe** the different activities performed to verify the final solution delivers the experience desired and all the critical technical aspects that have not been prototyped. This will help **validate** some of the requirements that have not been met yet due to the need of user or expert input. The methods followed, results, discussions and conclusions of each verification are described in each section.

## 6.1 Users Test the Design Proposed

The **goal** of this chapter is to understand if the final solution meets the expectations and solves the problem described in **Chapter 4.2**. The **validation from the users** is key to evaluate the design and its ultimate goal: solve a problem. The user validation pinpoints the 2 most important factors (**user experience and technical underlying problem**). The logic behind this is that the solution would not be complete by only validating one aspect. If the desired experience is met but the technical problem is not solved, the solution delivered would be like any other existing. On the other hand, if the user experience is not validated, the design would have failed its purpose.

The methods, results, discussion and conclusions of each test are presented next.

### 6.1.1 Usability Test. Users Verify the Technical Approach

The **goal of the test** is to measure the usability of the product when showcasing NFTs. This will show if the final solution solves the technical underlying limitations that cause the user problem. To do so, I carry out a usability test in which the participants have the goal of visualising certain types of NFTs. These goals are aimed to be met with the following research questions:

1. *Does the product showcase all types of NFTs required? (Images and 3D)*
2. *What are the main differences with the current mobile solutions?*

After that, a **comparison** will be made between the current solutions and the proposed design at the end of the chapter. The method, results, discussion and conclusions are presented next.

### Method

The usability test followed the **guidelines** dictated by Nielsen Norman Group, world leaders in research-based user experience. The guidelines dictate that to test usability for any product, the experiment must keep track of:

- Time spent to complete each task (current and new design)
- Error rate (how many tasks were completed)
- Success rate (if the task was complete)

User satisfaction/ engagement (current and new design). This part will be recorded using a satisfaction scale and PrEmo (Product Emotion Measurement Instrument) visuals presented previously (**Fig. 68**).

Participants were presented with 3 different cases:

1. Showcasing NFTs through in **game platforms/ marketplace** (Opensea)
2. Showcasing NFTs through a **wallet** (Metamask)
3. Showcasing NFTs through **social media** platform (Showtime)

that will have to be completed for 2 types of assets:

1. **Images** (profile pictures/ art)
2. **3D** assets

The 6 cases were tested under the 4 elements of the guidelines mentioned before. The way to proceed was the following: The participants tried and showcase **first the images** in the 3 cases. Each case will be completed when the intended tasks have been completed (if possible) first for the current solution and second for the new proposed design. **Then**, the participants moved on to showcase the **3D assets**.

It must be said, however, that in some cases the process of **showcasing was not possible**; this is, in the case of 3D assets and the media platform (images also). The blocking element was included to expose the participants to real problems in the scope and obtain more valuable insights.

## Preparation

The NFTs were part of the same blockchain, **Polygon**. The reason behind using this blockchain is due to its low fees, compatibility with **Opensea** marketplace and **Metamask** wallet, ease of interaction with Ethereum blockchain (the main blockchain for NFTs), and relevance. The standard of the NFTs was **ERC-1155**, as it is the standard that gives more problems in visualisation but is heavily applied in gaming and will become the new most used standard. Opensea is selected for being one of the (if not the most) biggest and used marketplaces and Metamask being the most famous wallet for Ethereum-based NFTs.

For testing purposes, a new wallet was created in Metamask specifically for the test. A 3D NFT,

an image NFT were included in the account, and **showcasing** them was the **goal** of the test. The interaction starts at the point where participants already have the NFTs inside the wallet, and a previous connection has been made. Usually, first-contact interactions take more steps and time, which isn't the purpose of the test. Therefore, fully connected and **ready-to-work** situations will be monitored to have in-depth and valuable insights.

Moreover, the account password was shared with the participants, to simulate a real scenario in which they are owners of the aforementioned NFTs and have complete control of the process.

The designed product contained the wallet address in the NFC tag and the app needed installed. The app did not have the following elements included: password block, NFT selection option and real security protocols happening. Therefore, the scenarios were manually created. The lack of these elements did not decrease the validity of the experiment for the following reasons:

1. Although in the real interaction there would be a password/ fingerprint interaction, the time it takes for the participants to complete this action was copied from the interaction with the wallet and added at the end
2. The time it takes for the selection was simulated and recorded at the end of the experiment through other apps
3. An estimation of the time it takes for the security protocols to be completed was added in the end

## Participants

Ideally participants would be early adopters that own NFTs of any type (profile pictures, art, music, 3D, utility...), however they are difficult to find. Due to the goal of the test, which is testing usability, the participants were shown how the current tasks take place, as they are simple enough to learn in a very short period of time. Once they were familiar with how to display NFTs, the test began. The number of participants was 10, until saturation was reached.

Participants used for the current solution

scenarios a phone that already contained the wallet and the marketplace apps downloaded, with all the NFTs included in the wallet and the permissions granted for the connectivity between the apps. The wallet did not have the fingerprint fast unlock option available. An internet connection is needed for the experiment to be conducted.

Participants used for the current solution scenarios a phone that already contained the wallet and the marketplace apps downloaded, with all the NFTs included in the wallet and the permissions granted for the connectivity between the apps. The wallet did not have the fingerprint fast unlock option available. An internet connection is needed for the experiment to be conducted.

## Results & Discussion

The results are divided into 2 categories, the visualisation of images and 3D NFTs.

### Images. Same performance as the best

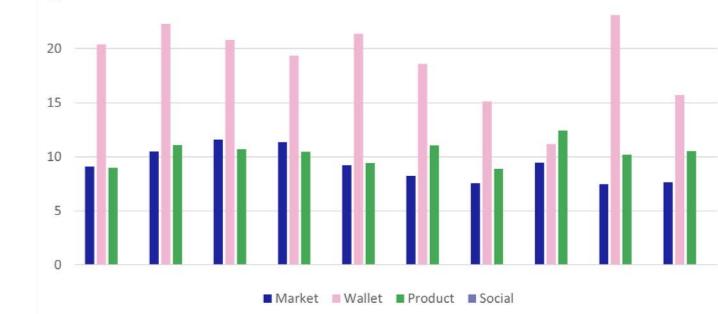
The gathered data shows that the users were able to display the images as fast as the current best method (**Fig. 87**). This result is of high relevance, as the existing methods for displaying NFTs are already optimised for visualisation. This means that the solution presented lives to the best standards of the industry in the moment.

### 3D models. Almost twice as better

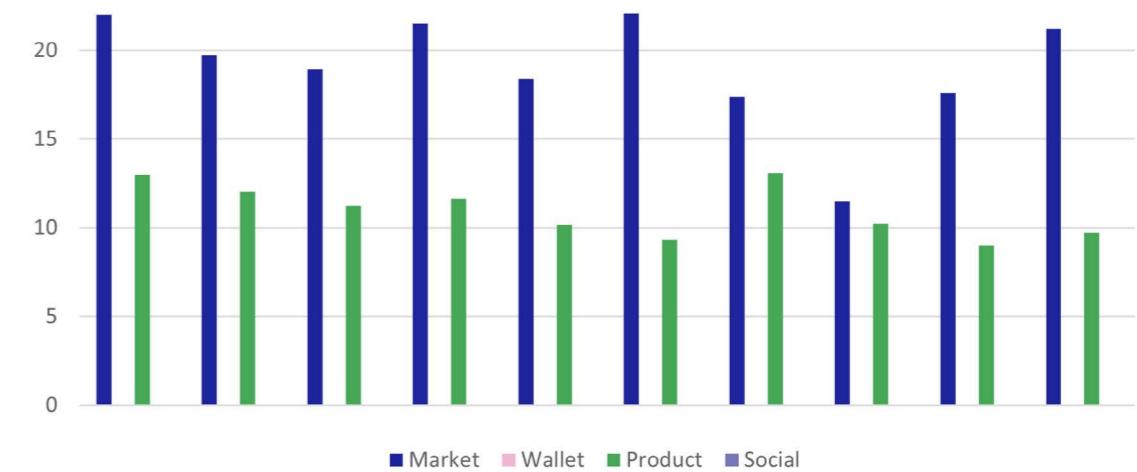
The results in the **display of the 3D NFTs** show a **reduction** of approximately **45%** of the time compared to the fastest method when showcasing 3D NFTs (**Fig. 88**). This result is of high relevance for various reasons. First, the 3D models were the types of NFTs that are lacking major support when visualising. The solution clearly moves a step forward to the inclusion of this type in the category of "easily displayed". Secondly, the solution has proven to be a suitable tool for the upcoming challenges in visualisation with the adaptation of NFTs.

## Conclusion

The design solution has proven to perform **better than any other existing product** in terms of technical inclusion of NFTs. The results obtained position the product at the head of the products that can drive the change of the NFTs, from niche to widely adopted.



**Fig. 87.** Usability test. Time (s) to display image NFTs per platform



**Fig. 88.** Usability test. Time (s) to display 3D NFTs per platform

## 6.1.2 Engagement in Visualisation Test. Users Verify the Final Experience

The **goal** of this test is to **identify the emotions** the users experienced while interacting with the current solutions and the design proposed. In other words, determine if the solution delivers the desired experience and solves the problem. The **purpose** of the identification is to conduct a future **comparison** between the methods and identify if the new experience provided by the final design is the one required and improves the existing one. Translated into a research question:

### 1. Does the final design deliver the emotional experience of pride in an engaging way?

After that, a comparison will be made between the current solutions and the proposed design at the end of the chapter. The method, results, discussion and conclusions are presented next.

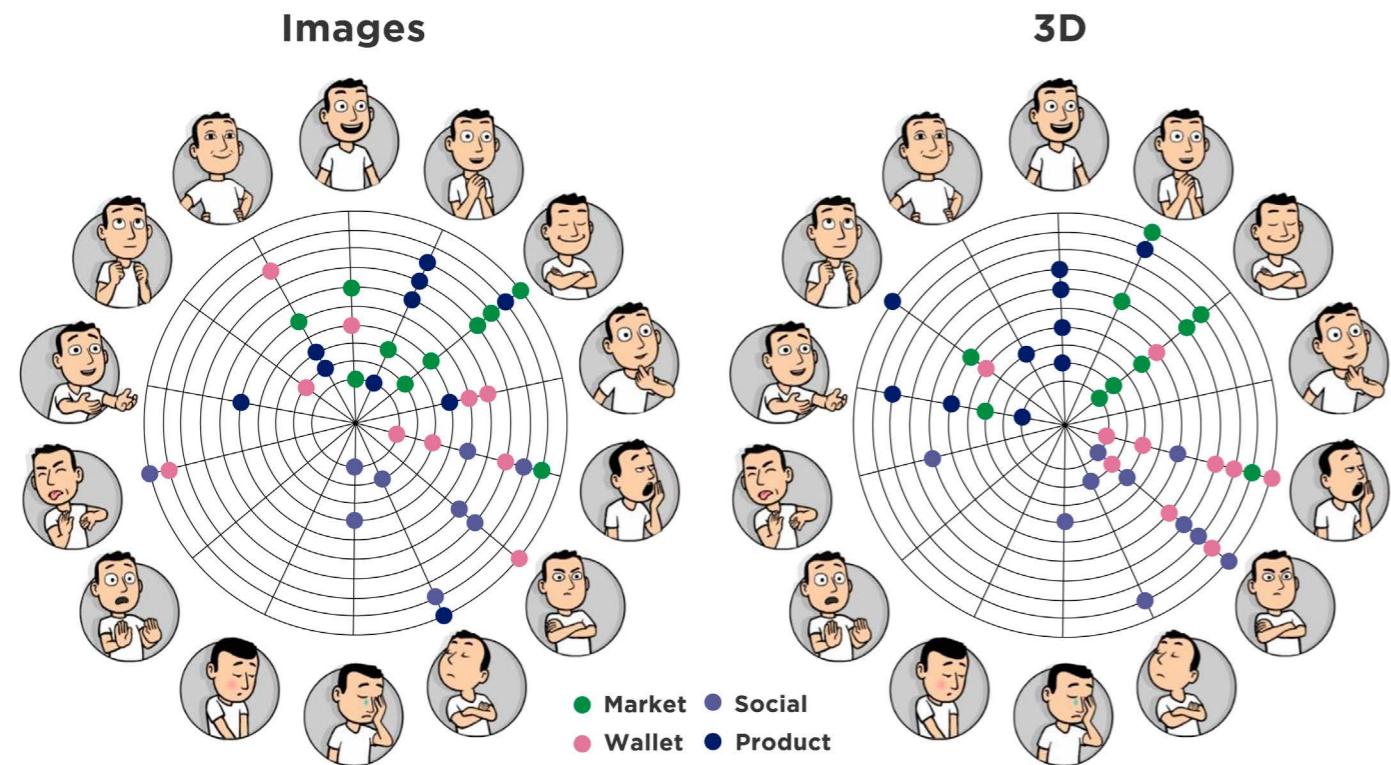


Fig. 89. Engagement in visualisation test. User emotions when engaging with the visualisation of images and 3D NFTs

### Method

For this test, all the input from the previous test was used. In addition, after each type of NFT was visualised (first images, second 3D), the participants were asked to rate the interaction in terms of visualisation using the **PrEmo method**. They were presented with the **Fig. 68** shown previously, after which they rated each of the possible ways of visualisation per type of NFT.

### Results & Discussion

In **Fig. 89** the results are represented in a graphic style, where each of the concentric circles represent a different participant, and the colour coded dots mark the answer per visualisation method. Overall, the product scores very positive, similar to the already optimised Marketplaces.

## 6.1.3 Conclusions & Limitations of the Tests

The tests have several limitations due to the vast and complex environment the NFTs cover in terms of interactions. Although the results already show the benefits of the design proposed, there are aspects that should be improved to have a more precise and real understanding of the users' experience. These limitations are:

- 1 blockchain
- 2 types of NFTs
- 3 1 standard
4. Not all the functionalities of the solutions were implemented (app not fully developed)
5. Use of a prototype. Some of the timing might vary
6. Participants not real owners

In order to obtain more accurate results, future recommendations can be seen in **Chapter 8**.

## 6.2 Expert Validations

The **goal** of this chapter is to **describe** and present the verification of those critical elements that could not be tested or prototyped from the app. All the methods, results, discussions and conclusions are explained when necessary.

As a reminder, the steps required for the app to work are:

1. Identification and Authentication
2. Retrieve NFTs
3. Display the NFTs in Augmented Reality

## 6.2.1 Security Validation. Interview with Cybersecurity Expert

The first step includes security parameters, as explained previously. The security of the solution proposed was validated with an interview session with a cybersecurity expert from GMV (tech company). The company is involved in relevant projects such as maintenance, evolution and follow-up control of Galileo satellites, the European global satellite navigation system (ESA contract).

### Method

Before the **interview**, the expert was presented with the architecture necessary for the authentication phase, as well as a description of the project. The questions asked started from a generic point of view, focused on the underlying technology (public key technology), where the expert explained the concept and how it works. Secondly, the questions derived to security in apps, examples in the banking industry, and how this technology could be applied for apps, in particular the case presented. The interview followed a structure but was flexible to stop in the topics of relevance. For an overview of the questions, see **Appendix 19**.

### Results & Discussion

The most important **insight** from the interview is the confirmation that the use of public key technology for the application presented results in a highly secure solution.

***If you use public key technology in your app it is almost impossible that someone will hack it***

(Cybersecurity expert)

For the complete outcome of the interview, see **Appendix 19**.

## 6.2.2 Gathering and Displaying NFTs. Discussion Session with Developers

For the second and third steps (retrieving and displaying NFTs), another expert validation session took place in the VR Zone at TU Delft (Virtual Reality lab dedicated to building and exploring VR in education and research) where technical aspects concerning programming in unity and its capabilities were discussed.

### Method

The **discussion** covered, **3 main topics**: finding the NFT smart contract addresses from a given wallet address using API calls, obtaining the metadata from a smart contract address and fetching 3D objects online and display them in runtime (without being included as assets of the app, while the app is running). During the session, experts interacted with the existing code. These interactions were meant to help them understand what needed to be solved and the technical steps that had already been taken.

### Results & Discussion

The conclusions from the discussion was that all the **steps** were technically **doable** but require technical skills to program and combine into one code.

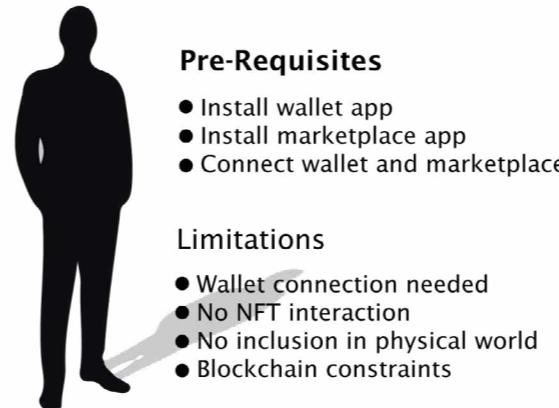
## 6.3 Final Design VS. Current Solution

The **goal** of this section is to illustrate a **comparison** between the best current solution for visualisation and the design proposed. With this comparison I **intend** to showcase what are the **main differences** between both of them and where each solution performs better. I present the comparison with the use of a simplified consumer journey experience, where I describe the steps needed to follow to visualise 2 types of NFTs (images and 3D) in each case. The emotions of the users have been omitted as they weren't recorded for each of the steps. Only the final overall emotion of the experience was recorded, and can be seen in the results of previous **Chapter 6.1**.

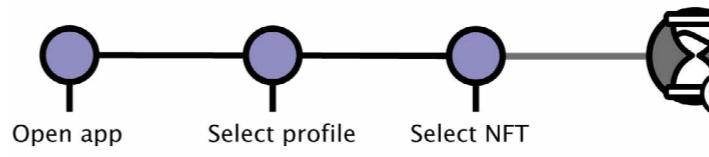
**Fig. 90** describes the prerequisites for each experience to be initialised and the limitations. Then, a comparison in the steps followed, highlighting the differences depending on the design. Finally, a comparison in time shows how each of the solutions performs compared to the other.

The design proposed does not reduce the number of steps compared to the current best solution. Besides, in the image NFT visualisation an extra step is added. However, the app design makes the process so smooth that barely no extra time is added. On the other hand, the 3D visualisation is optimised in time, while involving the same number of steps. In this case, it is also visible how the app design stands out for its visualisation-centred focus.

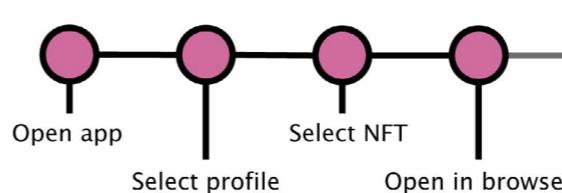
### Current Best Solution



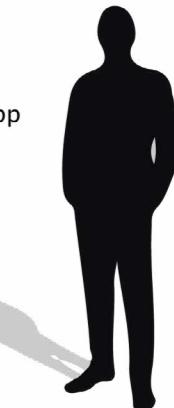
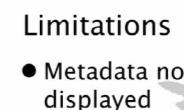
### Image NFT



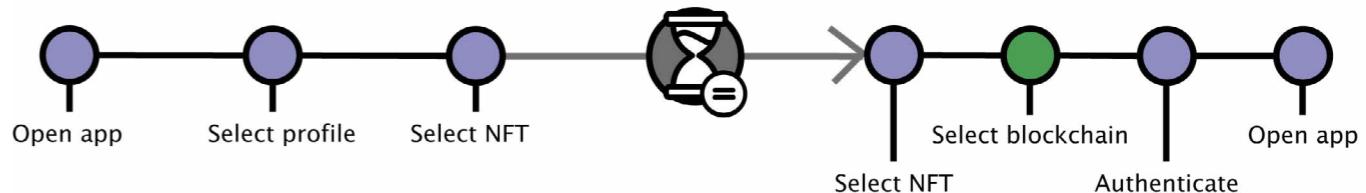
### 3D NFT



### Proposed Design



### Image NFT



### 3D NFT



 Steps to display an image NFT

 Steps to display a 3D NFT

 Different steps

**Fig. 90.** Consumer journey map. Final design VS. current solution

## 6.4 Conclusions

To sum up, the final solution has demonstrated to be as good as the best current scenario in the most optimised case and outperforming it in the rest of the cases. The experience delivered is optimal while also improving the existing visualisation methods. The centralisation combined with a powerful integration of web 3 capabilities solves the problem identified in a feasible way. Furthermore, the use of AR to blend physical and digital environments has proven to be an excellent tool for users to be **engaged and enjoy** the experience of visualisation in new ways. These features make the product meaningful for communities to express themselves and show their digital belongings.

Finally, with the solution not only user desires and technological limitations have been met and solved, but also a potential feasible and desirable solution has been reached that can help the mass adoption of NFTs become true, while also unlocking their whole potential and enabling uses that before were not possible.

The main contributions in desirability, feasibility and viability from this chapter are presented in the following **Table 04**.

Desirability	Feasibility	Viability
Usability test	Usability test	<i>Not applicable</i>
Engagement in visualisation test	Security method validation	
Consumer journey map comparison	Displaying NFTs method validation	

**Table 04.** Validation chapter. Personal contributions

# 7. Viability

In this chapter I cover at a high level the overview of the **unitary costs** of the different parts of the design solution and the benefit obtained per unit when sold. The costs are calculated using a parametric estimation, which only includes material, processes, consumption and manual labour. The costs and profit will be calculated for **2 different cases: mass and small scale production**. Mass production for consumer electronics will be considered >50,000 units sold per year, small scale production <25,000 units sold per year. I intentionally considered the difference between both production numbers big enough to observe the impact on the price.

## 7.1 Costs

In this chapter I cover the costs for each part of the design solution: **app and physical product**, for the 2 cases of production mentioned before. For the estimation of the costs I use Granta CES Edupack software, which includes an extensive database for materials, properties and manufacturing processes. External research and literature helped to obtain the remaining values.

Some general considerations for every case, that serve as input for the cost calculation are presented in **Table 05**.

Worker salary (min.) €/month	1,350
Worker salary (av.) €/month	3,380
Working days/ year	249
Working mins/day	360
Energy cost (€ per MW/h)	306.86

**Table 05.** Cost calculation. General considerations.

Sources: (Salary Explorer, 2022), (David, 2022), (Statista, 2022b)

### 7.1.1 Physical Product Costs

#### Small Scale Production Unitary Costs

The different parts of the physical product and their materials are covered in **Chapter 5.2.2** the following **Table 06** collects all the information from above and displays it in the function of a unitary product. The additional information about the production methods, consumption and others, can be seen in **Ap.Table 02**, located in **Appendix 20**.

Part	Material cost (€/u)	Production tool cost (€/u)	Post-processing tool cost (€/u)	Worker (€/u)	Machine functioning (€/u)	Total (€/u)
Body	0.01	0.25	0.00	2.15	0.09	2.51
Cover	0.01	0.15	0.00	2.15	0.06	2.37
NFC tag	-	-	-	-	-	0.38
Metal sheet	-	-	-	-	-	1.84
<b>TOTAL</b>	-	-	-	-	-	<b>7.1</b>

**Table 06.** Physical product. Small scale production costs

## Mass Production Unitary Costs

In mass production the major changes happen in the production process of the body and the cover, where 3D printing shifts to injection moulding. The following **Table 07** shows the new cost of the product when shifting to these methods and doubling the production quantities. In workers' cost, the time used includes the assembly. All the data needed to fill in the table above is derived from the general considerations and the input of **Ap.Table 03**. This table can be found in **Appendix 20**. There, also more information about the calculation and considerations can be seen.

Part	Material cost (€/u)	Production tool cost (€/u)	Workers (€/u)	Machine functioning (€/u)	Total (€/u)
Body	0.01	0.20	0.81	0.00	1.02
Cover	0.01	0.20	0.81	0.00	1.02
NFC tag	-	-	-	-	0.38
Metal sheet	-	-	-	-	1.2
TOTAL	-	-	-	-	3.62

**Table 07.** Physical product. Mass production costs

## 7.1.2 Digital Product (App) Costs

The app costs do not vary if it is for small scale or mass production. The costs associated with maintenance and production are the same. In the **Table 08** an overview of the cost per unit for large and small scale can be seen. These costs have been calculated for 1 year where 2 unity developers create and maintain and further upgrade the app, working full time. Therefore, it is expected that the unitary price changes only due to the amount of units sold. All the data needed to fill in the table is derived from the general considerations and the input of **Ap.Table 04**. This table can be found in **Appendix 21**.

Part	Play store fee (€/u)	App store fee (€/u)	Development and maintenance (€/u)	Total production (€/u)
App (small scale production)	0.00	0.00	5.60	5.60
App (mass production)	0.00	0.00	2.80	2.80

**Table 08.** App costs

## 7.1.3 Digital Product (App) Costs

Therefore, the summary of the total costs of the product combining app and physical product are shown in the following **Table 09**.

Production	Physical product cost (€)	App cost (€)	Total cost (€)
Small scale	7.1	5.60	12.7
Large scale	3.62	2.80	6.42

**Table 09.** Total costs of the design solution

## 7.2 Profit

The **goal** of this chapter is to **present a selling price** for the product to compare it with the existing solutions and position it in the competitive market. Also, the price will influence how many months the initial investment is recovered. To make an estimation of this, a **break-even point analysis** takes place.

In **Chapter 4.1.2**, the size of the target group for the US and European markets was estimated at **15 million** users. As the showcasing activities nowadays are not very common, I estimate that only **1%** of these users will be potential buyers of the product, which reduces the number of sales up to **150,000 units**.

### 7.2.1 Break Even Point

The initial numbers already indicate that the mass production is suitable for the product. Nevertheless, the break even point calculations will be made for the numbers estimated before for small scale (<25,000) and large scale (>50,000). Afterwards, an estimation of the benefits will take place taking into consideration the 1% mentioned.

In **Table 10**, the time needed for both products to meet their initial investment is presented for both of the production cases. The “extra per day” column sums up the material, energy and worker salary per day. All the data used to calculate these values can be seen in **Appendix 22**.

Production	Physical product initial investment (€)	App initial investment (€)	Total initial investment (€)	Extra per day (€)	Selling price (€)	Nº of units per day	Break even point (days)
Small scale	30,200	70,000	100,200	525	15	100	67
Large scale	100,000	70,000	170,000	684	10	201	85

**Table 10.** Break even point

The break even point is reached for the small scale production after 67 working days (less than 4 months) and in the large scale production after 85 (less than 5 months). In any case, the break even point is reached in less than half a year of production. The selling price has been chosen to obtain approximately 20% of benefit from each product sold in small scale production and more than 60% benefit in large scale production, even with a reduction in price of 30%. These even points, however, are not precise due to costs in shipping, installations, packaging, marketing and others not being taken into account. Nevertheless, it already gives an estimate on what the selling cost of the product can be and the time it will take to start obtaining benefit from the sales.

## 7.2.2 Profit per Expected Amount of Sales

Moreover, if the units are fabricated in the quantities estimated (150,000 units per year), the benefits obtained every year would be those presented in the **Table 11**. In this case, the even point is reduced to 53 days. Also, the extra per day has been adapted to meet the production volumes required in this case, an increase of 32 units per day.

Production	Physical product initial investment (€)	App initial investment (€)	Total initial investment (€)	Extra per day (€)	Selling price (€)	Nº of units per day	Break even point (days)	Yearly benefit (€)
Large scale	250,000	70,000	320,000	2,051	10	602	53	1,177,949.4

**Table 11. Benefits**

## 7.3 Conclusions

From the information gathered in the cost analysis, the design product meets the economic requirements stated in **Chapter 4.4**. The solution was expected to have a competitive price in the industry, with a price of 80% of the cheapest solution, this is, 80€. However, the price can be listed between 15% and 10% of the price of the competitors. This results in a huge market advantage that will derive in larger benefits than the ones calculated in the long term.

If the competitors do not come up with a solution that rivals the proposed design, all middle class consumers will have as most attractive option the design proposed. It is true that the missing costs could severely impact the benefits calculated, up to a half or a third. However, the increase of the price to meet these impacts still delivers a product that is at least half of the price of its competitors with more functionalities.

The results show a **benefit of almost 1,180,000€** per year. With the competitive sales price, it is expected that these numbers grow more and more each year. Therefore, the design is not only attractive to consumers but also other stakeholders that can benefit from its unique sales and revenue opportunities.

To conclude, I present now in **Table 12** my personal contributions to the project in the different fields of desirability and feasibility, and viability where applicable.

Desirability	Feasibility	Viability
<i>Not applicable</i>	<i>Not applicable</i>	Product costs (materials, fabrication processes, tools, consumption, work, and outsourcing)
		Break even point
		Benefit obtained

**Table 12. Viability chapter. Personal contributions**

# 8. Conclusions & Future Recommendations

In this chapter I present the **closure of all the work done**. In the first place I present a summary of the research questions and provide an answer to them. Secondly, a reflection on the process and main contributions of the thesis follows. In the end, future steps and improvements to the design solution, derived from the limitations of the work presented.

## 8.1 Summary & Answer to Key Research Questions

In the context of the digital world and the Metaverse the increasing use of the digital for applications in the “real” world is shaping our lives and ways of relating with others like never before. The connection between these two realities has always had constraints that limit the progress and capabilities of this relationship: digital ownership and authenticity. However, with the surge of new technologies like blockchain (and NFTs), new possibilities in this domain open. In this context, the use of NFTs have shaken the general digital ecosystem with extreme velocity. The evolution and general initial adoption have raised diverse opinions concerning the technology and its uses. Either for good or bad, NFTs have already entered many sectors and industries and are evolving towards their integration and usability in the physical world too. Consequently, this project was framed to identify and tackle issues and opportunities related to NFTs and their use. The work conducted covers an exploration of the current scenario, stakeholders, future expectations, user study and solution development. All of these stages have been guided by several research questions, which I present next.

### Answer to Research Question 1. General

*How can users undergo a self-confident and engaging experience when showcasing their owned NFTs?*

In the process of owning NFTs, showing off is a very important aspect. Nevertheless, users are sometimes incapable of completing this task due to technical constraints in visualisation. By designing a product that solves those technical constraints, users will be able to showcase their digital assets and fulfil the experience of showing off, so important for communities and individuals alike. The solution, therefore, should incorporate engaging elements in visualisation such as showcasing the NFTs in a physical context while being easy to use.

### Answer to Research Question 2. Industry Research

*How do the different industries perceive NFTs’ (and related concepts such as blockchain, digital identity and ownership, and metaverse) trends now and in the future?*

From the industry and customer points of view, NFTs are currently perceived as a hyped niche market, although they are envisioned to become mainstream and be present in almost all aspects of our lives. As the physical world becomes more linked and intertwined with the digital space, it is believed that NFTs (with their unique qualities of digital ownership and authenticity) will play a significant role in making this interaction as meaningful as possible. There is confidence that all industries will benefit in a certain way from their applications in both environments. The change will come by the hand of the entertainment industry, where it will slowly spread to the rest.

### Answer to Research Question 3. Industry Research

*How is the inclusion of NFTs in the physical environment perceived, regarding usefulness and added value, and is it a good idea to use them to bridge physical and digital realities?*

In general, NFTs are perceived to have more value in the digital domain than in the physical, but that is a consequence of the actual situation. Nevertheless, the positive opinions towards their usefulness to bridge physical and digital are numerous. Digital ownership and authenticity bring utility to the physical space in many domains. That is why, the general belief is that it is an excellent idea to use NFTs to bridge both environments. The relationship would enrich both sides with applications, new opportunities and more.

### Answer to Research Question 4. Design for Emotion

*Which shape best embodies the feeling of pride from the user’s perspective?*

The feeling of pride is expressed and understood the same way all over the globe. However, to understand exactly how this emotion is represented with shapes, users from the entertainment industry gave their opinion. The results showed that v/winged shapes are associated most with this feeling. These shapes derive directly from common figures present in the most symbolic elements of pride: trophies and medals.

### Answer to Research Question 5. Underlying Technical Problem: Usability

*Does the product showcase all types of NFTs required? (Images and 3D)*

The designed product is not only capable of showcasing 3D and images NFTs, but also all the other types like GIFs, virtual land, music and video. This is possible thanks to the development platform, Unity, which is commonly used to produce video games. The power of this tool makes it possible to incorporate any existing type, as it is adapted to deliver experiences that try to imitate the real world.

### Answer to Research Question 6. Underlying Technical Problem: Usability

*What are the main differences with the current mobile solutions?*

The main differences of the design proposed with the current mobile solutions is that it combines the best of all of them. While some mobile solutions perform well in visualisation, they lack a variety of blockchains (marketplaces). On the other side, those who are optimised for various blockchains fail in the visualisation field (wallets). The proposed solution unites all of these positive aspects into one platform, which also performs better in terms of visualisation than any other. Its unique qualities make it perform equally or better in every aspect than all of the current solutions combined.

### Answer to Research Question 7. User Experience: Engagement in Visualisation

*Does the final design deliver the emotional experience of pride in an engaging way?*

The user validation tests confirm that not only the desired experience is delivered but also the underlying technical problem is solved. Users felt in general happy with the experience and the emotions recorded were those related to pride, happiness, desire and reassurance. This verifies the solution proposed served its purpose.

## 8.2 Reflection & Main Contributions

### On the complexity of the topic covered

The initial exploration of the context and background discovered the highly intricate and vast environment that framed the thesis. Due to the impact of NFTs in the digital spectrum and possibilities to impact and be applied in the physical one, the solution had to be adapted to both environments. This resulted in a complex design that combined the power of digital and physical products which had to interact between themselves and the user to deliver a certain experience. Furthermore, all these interactions and connections had to be delivered in a product that was attractive for the users and simple to use, but meeting complex technological requirements.

Moreover, the project is framed in a very new, and fast changing environment, where the information is scarce and fast changing. This involved a high engagement with all the changes that happened during the months of work, to adapt the solution to the latest panorama.

To sum up, the complexity of the project turned out to be much higher than expected in all ambit. This is also reflected in the amount of content, methods used and contributions to the existing knowledge, explained next.

#### On the methods used

The different studies, validations and explorations conveyed during the thesis required a large amount of methods from scientific literature, iterative design processes, decision making and others. All the methods used contributed in a certain way, and helped cover the weak spots of the remaining. Although different methods could be used, these were useful to meet the requirements and demands of the project. Distinct methods could have resulted in different explorations and a different outcome. Nevertheless, all decisions made have been justified and explained, and have helped achieve a satisfying result.

#### On desirability, feasibility and viability

A number of contributions have been delivered as result of the work done shown in **Table 13**.

On the desirability aspect, in-depth knowledge about the users, their needs, problems, desires and activities have been recorded. Understanding who form the group that has adopted the new technologies also derived in exploring all areas influenced by them. In **Table 12** these are presented in a more concise manner.

On the feasibility aspect a deep understanding of the technology and how it works had to be explored beforehand. That understanding gave me the solid ground to be able to propose solutions that are innovative and exploit the different advantages of the technology. Thus, the solution delivered does not add new concepts to the knowledge but focuses in a different way of using the resources available. Therefore, my main contribution to the feasibility aspect could be

defined as an integration of different technologies and processes. Of course, the integration involves multiple particular contributions, where the design of the app occupies the main stage. **Table 12** shows all the individual contributions to this field.

Finally, the viability aspect, although it was covered, plays a secondary role in the report. Its relevance is still high, but the project's main focus was in the users rather than the industries. Therefore, I did not include an in-depth business case study, but rather a very high level overview of the costs and potential economic benefits for companies.

Desirability	Feasibility	Viability
Environments and their relations with NFTs	Requirements. Technical	Requirements. Economic
Consumer analysis	Material and fabrication process selection	Product costs (materials, fabrication processes, tools, consumption, work, and outsourcing)
Industry research	Technology selection	Break even point
Synergies between consumers and industry	App architecture (back end)	Benefit obtained
Target group sizing and identification	App visualisation (front end)	
Problem detection	Security protocol technology application	
Target group definition	Usability test	
Stakeholders analysis	Security method validation	
Desired experience definition	Displaying NFTs method validation	
Problem definition		
Requirements. User qualities		
Value Proposition Canvas		
Consumer journey map		
Design for emotion pride (exploration of look and feel)		
Product emotion test		
Envisioned user interaction		
Usability test		
Engagement in visualisation test		
Consumer journey map comparison		

**Table 13. Personal contributions**

## 8.3 Future Recommendations

This chapter provides possible future working fields to improve the solution proposed by focusing on different limitations.

### Implement all functionalities in a fully working prototype (app and physical product)

Although all the core functionalities of the product have been verified, it is important to develop a final prototype that includes all of them. Some of the tested functionalities are not integrated into a single product (retrieving NFTs, visualising NFTs) and other important ones are missing. These are the integration of all blockchains, inclusion of music and video NFTs, and the security protocols. The development and integration of all these aspects into one prototype is of major importance, as a completely functional design might have a different impact on the users than the one recorded in the validations.

### Repeat all the validation tests with a fully working prototype

The tests conveyed for the validation mostly have their limitations in functionality and amount of users. Therefore, a final verification repeating these tests with a fully-working prototype and more users will draw stronger conclusions. Users will experience the reality and full potential of the design which might result in a different appreciation.

### Offer multiple designs for the cover for higher personalization

Finally, although the physical product is mainly designed to embody the emotion pride, it is also conceived as the medium for users and communities to express themselves. For this purpose, the laser engraving on the metal sheet and a variety of colours for the body and cover are provided. Nevertheless, further improvements in this aspect can also be made by designing different covers, which will change the look of the product in more diverse and drastic ways.

## 9. Personal Reflection

When choosing this topic for my Graduation Project I had in mind it was going to be challenging for many reasons. The novelty of the topic already meant encountering difficulties when getting to know the users, their needs and designing a meaningful solution. Furthermore, the polarisation in the field, the lack of experts and previous research were also big obstacles to overcome. The more I dove into the topic, the more I discovered the magnitude and relevance of it. Clearly, this Project could have been divided into 3 different graduation projects:

1. The research itself meant the combination of different methods, with in-depth exploration in trends, consumers and industries to obtain meaningful conclusions
2. The design of the physical product meant in-depth knowledge about the users and their problems, as well as multiple iterations to refine the product into a meaningful feasible and viable outcome
3. The app development already includes multiple challenges due to dealing with Web3 integration, AR, online real-time search, user experience and interaction

Therefore, although the desired result was too ambitious for what a Graduation Project can handle, the outcomes are not less than meaningful in the personal aspect as well as for the design field.

As desired, I have gained in-depth knowledge about the NFT environment, blockchain, the metaverse and Web3 in general. This knowledge I am sure will be very valuable in the future, as I plan to keep on learning and exploring this field. The implementation of relevant technologies for the future such as AR has been of great use to develop my expertise towards this amazing field that will be present in our daily lives in the upcoming years.

Also, diving into the entertainment field and particularly gaming has helped me reassure my passion as a designer, focusing on developing products that help users imagine and create new worlds. It is very rewarding to see the outcome of the project and realise that my vision helped me reach a result I am truly proud of. Also, facing the

huge challenge I had put myself into and realising all the efforts made and the obstacles overcome, I recognize how I have learnt to deal better with struggles, failure and success, an essential skill for industrial designers.

Furthermore, getting people involved has been a must during the whole design process. From consumers, to 16 different industries, experts in cybersecurity, Web3, app development, market research and analysis, and designers, all have contributed to the result presented. It would not have been achieved without their help. Reflecting on this topic, I can see the relevant role an industrial designer plays when integrating different expertises and knowledge into a coherent whole, and the value it brings.

Finally, due to the complexity of the technology and concepts I have been dealing with, I have also learnt how to process information, synthesise it, and communicate it in a clear way. This skill is also very relevant for an industrial designer, and mostly for a person interested in this field.

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# 11. Appendices

## Appendix 01. Structure of NFTs. Smart Contracts

NFTs are based on Smart Contracts, pieces of code and data that contain all necessary information about the NFTs (Zoltu, 2022), such as the previously mentioned: characteristics, properties and ownership, among others, recorded on a blockchain. Smart Contracts are not possible to record in all blockchains (for example, bitcoin does not accept smart contracts), due to the blockchain's programmability capabilities.

Depending on the blockchain and the standard used Smart Contracts have different structures, but they essentially hold all the information necessary to define them. The most famous blockchain for NFTs is the Ethereum network, but is not the only one: Polygon, Solana, Cardano, Binance Smart Chain, Tezos and Flow are other examples of popular blockchains for NFTs. For this project, Ethereum blockchain and derivatives (Polygon) will be the main subject of study. Therefore, all the specific information presented regarding Smart Contracts (like the structure), will make reference to these blockchains.

The structure of a Smart Contract in Ethereum blockchain (Cook, 2022) would have the following elements:

- Location of the data (storage or memory). Persistent data takes the name of storage and is the one that lives in the blockchain under an address
- Environmental variables. Special global variables. Specific to gather information about the blockchain
- Functions. Pieces of code that get or set information in response to incoming transactions. There are many functions possible in a contract (view, constructor, writing, built-in...), but in this chapter only the most important and relevant to the project will be explained:

- `uri()`. Returns the URI, also known as Universal Resource Identifier (Zhao, 2022). It is a link to the metadata (explained later, in section Interaction with Smart Contracts).
- `balanceOf(account, id)`. Shows the amount of tokens with a certain id within an account
- `ownerOf(contract address, id)`. Identifies the owner of a certain NFT within a specific contract
- `tokenID(contract address)`. Identifies an NFT within a specific contract
- Events and logs. They let you communicate with the smart contract

Smart Contracts can be seen as normal contracts or collections, where one can define multiple elements. The same way that in a contract you have multiple sections referring to different aspects or even different assets, a smart contract can define different assets, each one unique and different from the rest.

As well as the accounts, each Smart Contract has an identification number or address, to which one can refer to and interact with. Users cannot control a smart contract once it is deployed, not further than the controllable options coded in it. This way, the integrity of an NFT will be very difficult to alter. For example, you can change an owner if a transaction takes place but you cannot change the attributes if there is not a function coded inside the smart contract that does.

Smart Contracts are coded in specific languages, the most common being Solidity and Vyper. However, for them to function in the blockchain they need to be transformed into bytecode

(K.K, 2022). In other words, a smart contract like the one shown in *Ap. Fig. 01* will have to look like the one shown in *Ap. Fig. 02*.

```
1 pragma solidity 0.4.24;
2
3 contract Greeter {
4
5     function greet() public constant returns (string) {
6         return "Hello";
7     }
8 }
```

### **Ap.Fig. 01. Smart Contract. Solidity**

### **Ap. Fig. 02. Smart Contract. Bytecode**

## Appendix 02. S.W.O.T Analysis

## Weaknesses

High Prices and Volatility. In the year 2021 NFTs suffered an unprecedented boom in sales and engagement. The market cap of NFT art in Opensea (one of the main Ethereum-based marketplaces) surged from \$XXXbn to \$XXXbn (XXX check Opensea evolution). This resulted in what many denominated as a market bubble, with historical sales like CryptoPunk #7523 for \$11,754,000 in 2021 and the all-time record \$69,346,250 Beeple's "Everydays: The First 5000 Days" (*Thomas, 2022*).

However, volatility is quite predominant in these markets. From January 2022 to March of the same year, the average price of the NFTs went from over \$6,800 to less than \$2000, according to market tracker NonFungible (*Ap. Fig 03*).

Regulatory and tax ambiguity. In terms of legislation and control, there is a big challenge fitting this new novel asset into the current regulatory landscape. For now, NFTs fall in a grey-zone and regulators must move at a fast pace to catch up with the exponential market surge, NFT adoption and evolution.

High cost per transaction on some blockchain, both environmental and monetary. This issue is one of the biggest (if not the major) drawbacks surrounding the NFT space. As of 2021 the major blockchain used for NFTs has been Ethereum. A single transaction in Ethereum blockchain consumes as much as much power as an average

U.S household during almost 9 days, by the time this information was gathered (5th of April 2022) (*de Vries, 2020*), (*Digiconomist, 2022*).

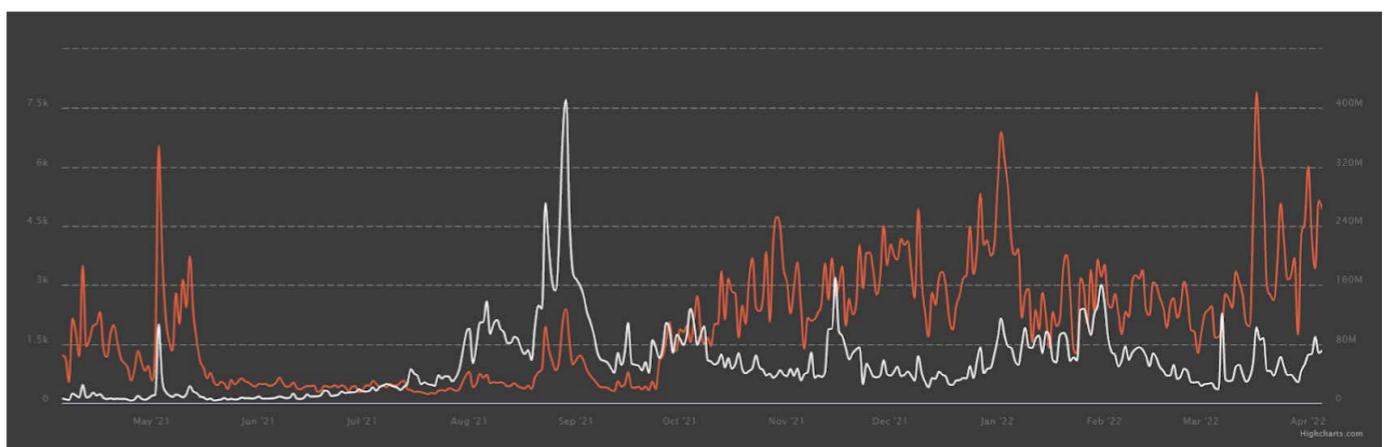
## Sustainability in NFTs

## How block mining works

Within the cryptocurrency environment, there are several existing methods that create or generate cryptocurrencies as a reward for being part of the network and providing certain services, for example verifying transactions. The most famous cryptocurrencies Bitcoin and Ethereum are based on a principle called proof-of-work (POW). The basics of this principle relies on computational power. To obtain the Bitcoin reward for verifying a transaction, computers from all around the world compete to be the 1st ones to solve a complicated mathematical problem, which generates a 64 number digit called “hash”.

The calculation process is extremely energy-intensive and relies on electricity. As most of the energy supply nowadays relies on fossil fuels, the mining activity is directly involved in severe environmental impact. Furthermore, with some cryptocurrencies like Bitcoin the problem becomes worse as mining increases the complexity of the mathematical problem, increasing also the computing power needed and decreasing the reward.

In the case of Bitcoin the supply is limited: twenty one million Bitcoins out of which already nineteen million are in circulation. But the last two million coins will take the most time because of the reduction feature stated above. Experts are



Ap. Fig. 03. Average NFT USD price (red) VS. NFT sales (white). Source (NonFungible, 2022.)

predicting that the remaining bitcoins will be mined by 2140.

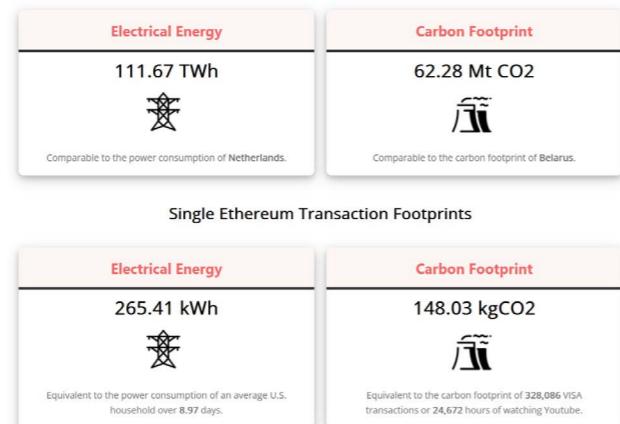
### Mining and global warming

In the case of Ethereum, the energy consumption of the whole network is around 110TWh/year (*Ap.Fig. 04*).

By the time this information is gathered (5th April 2022), the energy consumption of the whole Ethereum network (*Ap.Fig. 05*) is comparable to the power consumption of The Netherlands (111.67TWh), and with a carbon footprint comparable to the one from Belarus (62.28 Mt CO<sub>2</sub>). If we speak about single transactions, the average in energy consumption is estimated to be equal to the average power consumption of a U.S household over almost 9 days (265.41 kWh), and a carbon footprint similar to 24672 hours watching Youtube (148.03 kg CO<sub>2</sub>).



*Ap.Fig. 04.* Ethereum energy consumption.  
Source (Digiconomist, 2022)



*Ap.Fig. 05.* Annualized total Ethereum footprints.  
Source (Digiconomist, 2022)

### Threats

**Hacking.** The underlying technology (blockchain) is very complicated to hack, as hackers would need to dominate more than 50% of the network, for example. However, this is of a very high complexity in big blockchains such as Ethereum or Bitcoin. Nevertheless, these attacks have happened in the past, like the 51% attacks on Ethereum Classic (*Shen, 2021*), (*Voell, 2020*). These kinds of attacks, though rare, take place in small blockchains with little validators, where it is easier to overcome the whole network.

Therefore, hackers usually target weaker intermediaries such as digital services, platforms and networks that asset owners use to purchase, trade or store those crypto assets. The most common types of attack are the scam and phishing through fake links, same practices as with fiat. Hence, it is necessary for users to learn what are the best practices to minimize those risks while platforms work on their security. A record of some of the biggest hacks using these techniques have been \$532m - Coincheck, January 2018, \$540m - Ronin Bridge, March 2022 and \$611m - Poly Network, August 2021 (*Tidy, 2022*).

**Technology complexity.** Due to the technical nature of this technology there are many users that do not know and/or understand how NFTs

work. The ignorance of the underlying technology makes the NFT concept less attractive and exposes them to all sorts of attacks.

**Market Crash/speculation.** Cryptocurrencies are not stable coins as the Dollar or the Euro might be. They are still young in time and consequently their real value has not been reached yet. Although some cryptocurrencies are called "stable" there is still a lot of speculation around these digital forms of currency. A very important example that illustrates this is the case of Terra (LUNA), an algorithmic stablecoin (Terra USD) that relied on a speculative asset (LUNA) to keep its parity with the USD. Once a massive selling isolated LUNA, the whole system crashed, with losses of 99% of the value in just 1 day (*Powell et al., 2022*).

NFTs, as previously mentioned, are assets built around different blockchains, and therefore, the ways of interacting with them are unavoidably linked to cryptocurrencies. With the tremendous

growth of the NFT market in a very short time period, undeniably comes high uncertainty and speculation. This is a big threat for investors, as there is no "safe bet" in such a fast-changing environment.

Regardless, companies are making important moves, such as the partnership between Ledger (one of the largest crypto wallets) and The Sandbox (one of the most important metaverses), where they plan to educate users about crypto (*Ap.Fig. 06*) (*Partz, 2022*).

### Strengths

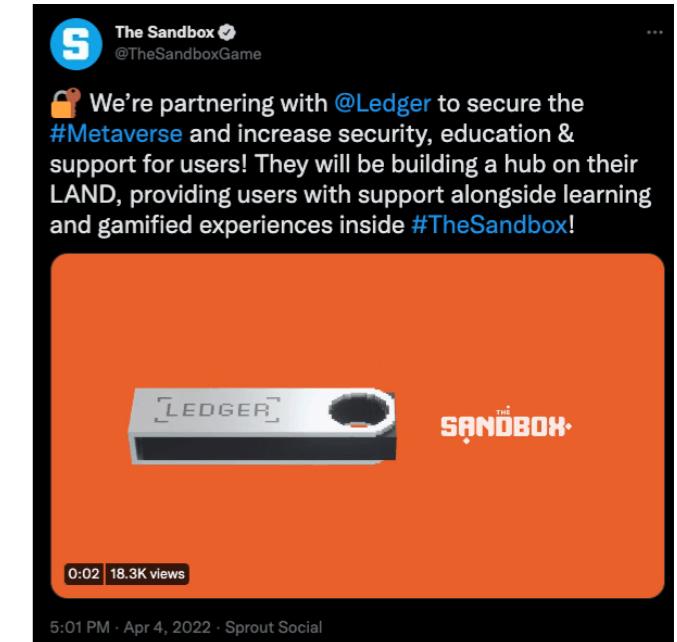
**Digital authenticity and ownership.** These are probably the most important attributes of NFTs. By providing digital assets with a certificate that proves their uniqueness and links them to specific owners, their value increases thanks to scarcity.

**Source Tracking.** The nature of the assets, embracing blockchain technology and embedded in one of the multiple web3.0 ledgers, makes them traceable to the source, with all transactions being recorded and visible for everyone to see. This is very important because it creates an environment where trust, transparency and visibility can be easily achieved and adopted.

**Decentralized economy.** Digital assets that can be held and interchanged between creator and consumer without intermediation. In Web3.0 users will not need to rely on middlemen for many services, as opposed to web 2.0, defined by social interaction.

### Opportunities

**Create new business models** (both physical and digital). From Gaming Guilds to special events, to multi experience consumer journey, NFTs can revolutionize the way business is conceived. They have the potential to enhance experiences for users, which is closely related to blending digital and physical worlds, bringing benefit to both environments.



*Ap.Fig. 06.* Ledger-Sandbox partnership. Source (Partz, 2022)

**Blend digital and physical offering.** The opportunities to blend physical and digital become greater thanks to digital ownership and authenticity. Now, digital assets are easily identifiable and traceable, making them prone to interactions with the physical environment. Interactions can vary from redeemability to digital twins, contracts and much more. NFTs can be used as a bridge between physical and digital worlds.

**Appeal the new generations of consumers.** New generations born in the internet era engage more with online content. In this context NFTs have a higher potential to be adopted by under 18 users as they are more affine to these types of content.

# Appendix 03. Consumer Research. Question Selection

## Section 1: Demographic profiles (user demographics)

S1. What is your gender?

1. Male
2. Female
3. Other/Non-binary

S2. How old are you?

1. [...]
2. Prefer not to say

## Section 3: Key concepts. Awareness, knowledge and intentions

B1. The next part of the survey is about some new technologies that you may have heard of.

Please think carefully about each one and indicate the answer that best describes your level of knowledge. If you have never heard of the technology before today, that is fine: in this case select "Never heard of this".

[Rows]

1. Non-Fungible tokens (NFTs)

2. The Metaverse

3. Cryptocurrency (Crypto)

[Columns]

1. Advanced knowledge

2. Good knowledge

3. Basic knowledge

4. Very basic knowledge

5. Only heard the name

6. Never heard of this

B2. Which of the following statements best describes your current relationship with each of these technologies?

[Rows]

1. Non-Fungible tokens (NFTs)
2. The Metaverse
3. Cryptocurrency (Crypto)
4. Blockchain gaming/Play to earn

[Columns]

1. Currently using this
2. Expect to start using it in the next two years
3. Expect to start using this in the than two years or so
4. Do not expect to use this at all

## Section 5: Focus: Ownership

D1. Based on the description on the previous page, have you already been involved in any kind of NFT trading in the past, that involve you buying or selling assets on a blockchain?

1. Yes, been doing this a lot
2. Yes, been doing this a bit
3. Yes, but hardly at all
4. No
5. I don't know

D2a. Please look at the list below and say how strongly you agree or disagree with each statement about Non-Fungible Tokens (NFTs):

[Rows]

1. There is a lot of hype around NFTs, which I expect to come to very little
2. The potential impact of NFTs in trading them is huge, and yet to be exploited

3. NFTs are restricted in their scope to digital assets only

4. NFTs will empower people to become creators and traders in the future

5. In five years' time NFTs will be the established way of certifying digital ownership

6. In ten years' time NFTs will be the established way of certifying ownership in general

7. Proof of ownership of in-game items is not a problem that needs to be solved (with NFTs or otherwise)

8. NFTs are the best way to ensure safe and certified trading of in-game items

[Columns]

1. Completely disagree
2. Strongly disagree
3. Disagree
4. Neither agree nor disagree
5. Agree
6. Strongly agree
7. Completely agree
8. I don't know

D3. Based what you know about Non-Fungible Tokens (NFTs), which of the following best describes your level of interest in creating, or trading them in the future?

[Rows]

1. Creating
2. Trading

[Columns]

1. Very interested
2. Interested
3. Not interested
4. Not at all interested
5. I don't know

D4. Finally which three (if any) of the following areas, do you expect benefit most immediately from increased use of Non-Fungible Tokens (NFTs)?

1. Esports
2. Sports (excluding esports)
3. Fashion and apparel
4. Art and design
5. Music
6. Collectibles and memorabilia
7. Video gaming (blockchain and traditional)
8. Digital identification (ID Cards/ passports, etc.)
9. I cannot say

## Section 6: Classification

D1 Based on the description on the previous page, have you already been involved in any kind of NFT trading in the past, that involve you buying or selling assets on a blockchain?

E1. In which of the following bands would you place your household's current combined yearly income (before tax and other deductions)? All the answers are treated with the strictest confidence

1. Less than \$20,000
2. \$20,000 - \$29,999
3. \$30,000 - \$39,999
4. \$40,000 - \$49,999
5. \$50,000 - \$59,999
6. \$60,000 - \$74,999
7. \$75,000 - \$99,999
8. \$100,000 - \$149,999
9. \$150,000 or more

E2. What is your current situation?

1. I live alone
2. I live with my parents/legal guardians

3. I live with a partner and no kids at home
4. I live with a partner and kids at home
5. I live with housemates
6. Other

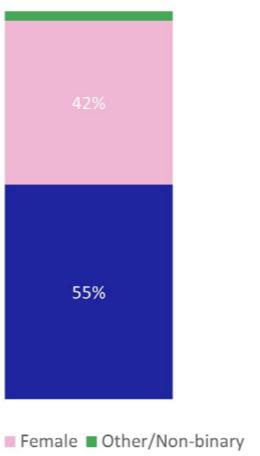
E3. What is your current work situation?

1. Full-time employee
2. Part-time employee
3. Self-employed or independent
4. Full-time homemaker
5. Student
6. Unemployed
7. Retired
8. Extended leave of absence/  
Currently furloughed

## Appendix 04. Consumer Research Results

### Section 1: Demographic profiles (user demographics)

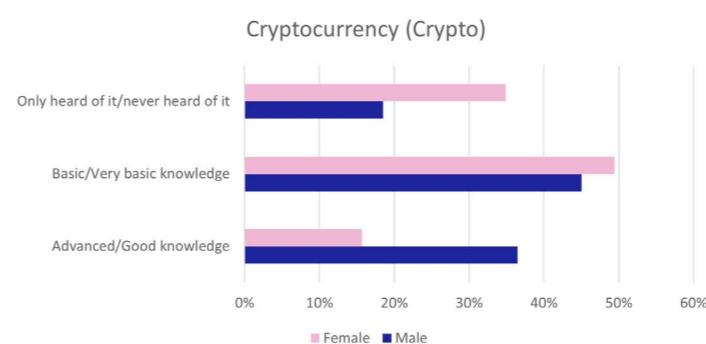
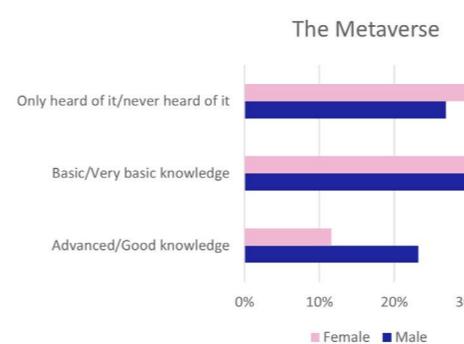
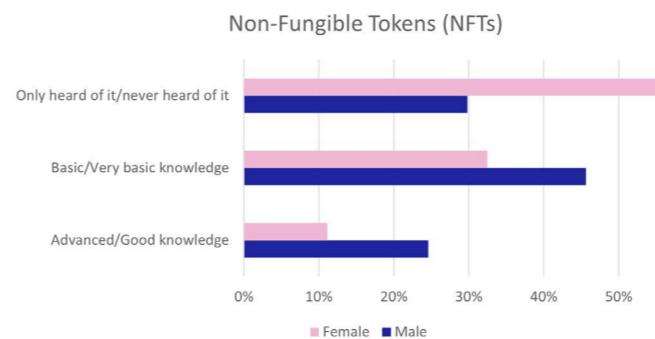
S1. What is your gender?



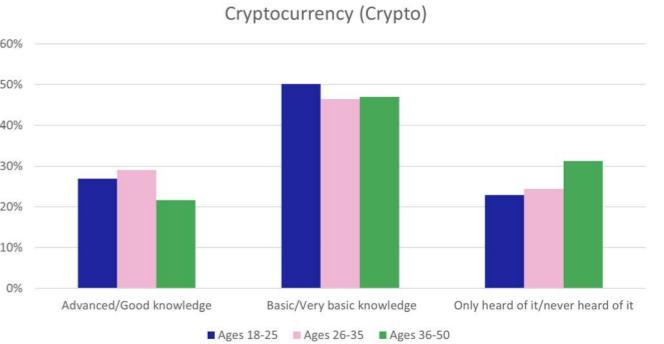
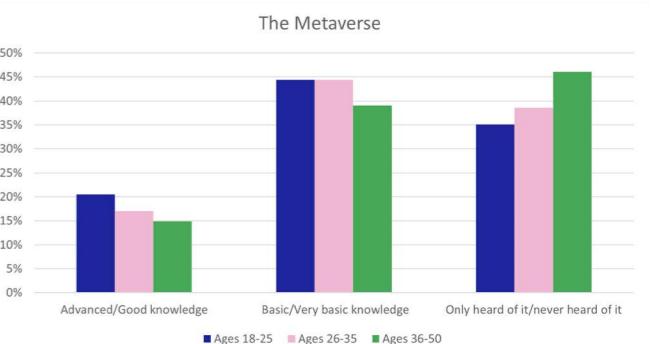
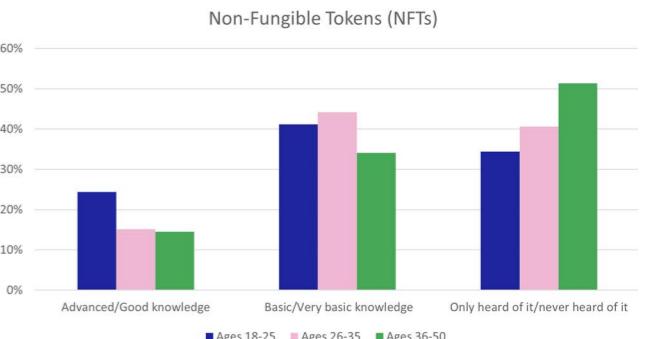
Ap.Fig. 07. Gender representation

### Section 3: Key concepts. Awareness, knowledge and intentions

B1. Please think carefully about each one and indicate the answer that best describes your level of knowledge. If you have never heard of the technology before today, that is fine: in this case select “Never heard of this”.

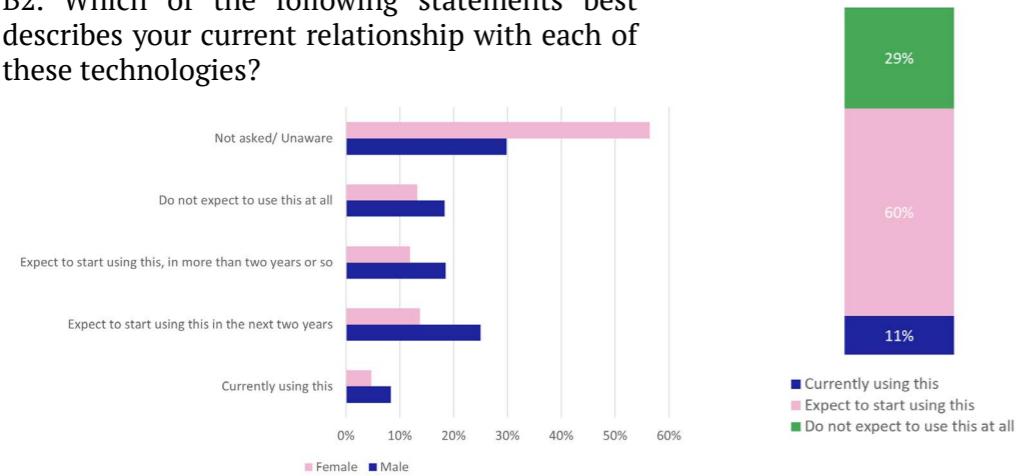


Ap.Fig. 08. Key concepts. Genre representation

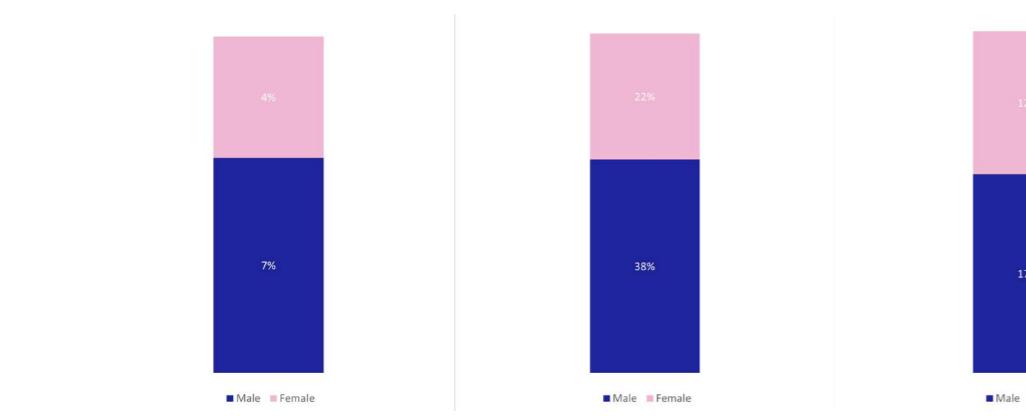


Ap.Fig. 09. Key concepts. Age representation

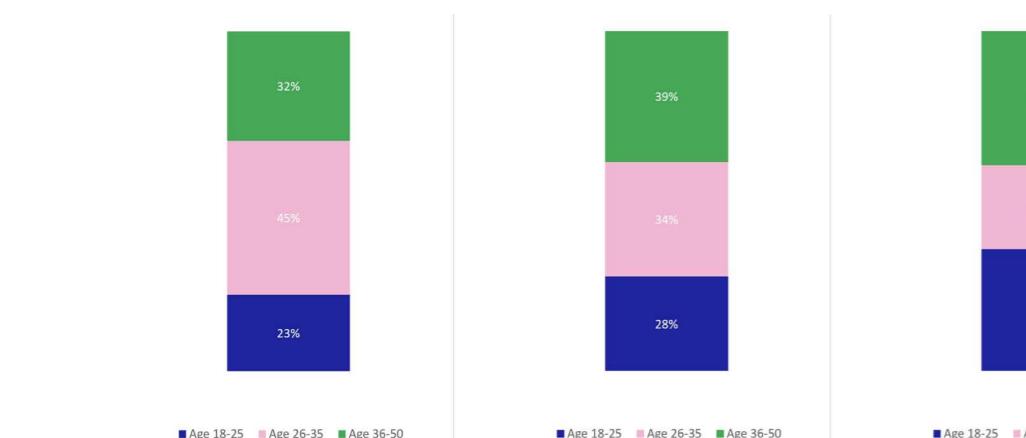
B2. Which of the following statements best describes your current relationship with each of these technologies?



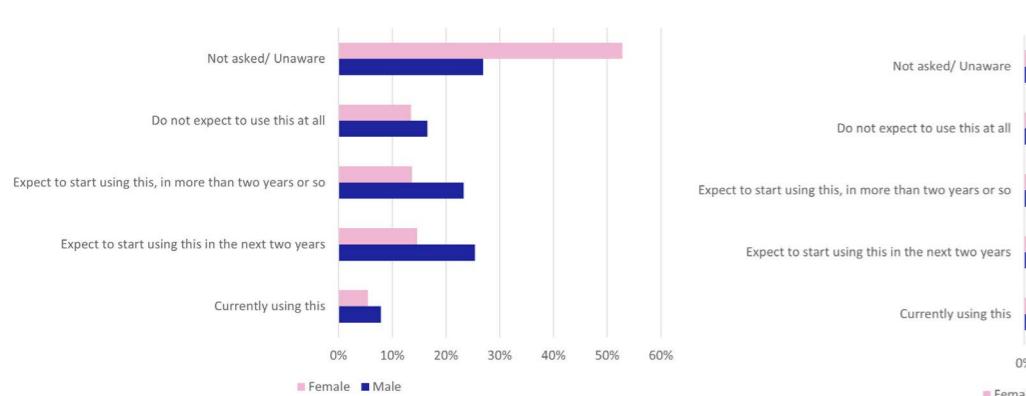
#### **Ap. Fig. 10. Relationships with NFTs. Genre**



### *Ap. Fig. 13. NFTs. Currently using. Genre*



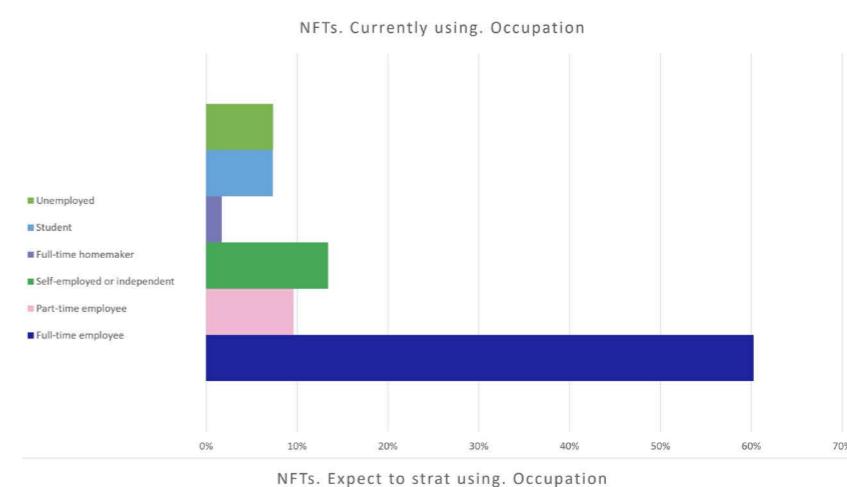
**Ap. Fig. 16.** NFTs.  
Currently using Age



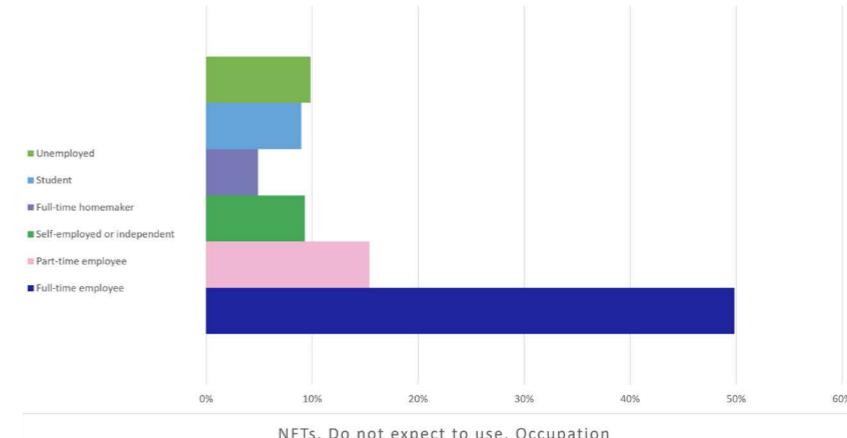
**Ap.Fig. 19. Relationships with Metaverse. Genre**

**Ap. Fig. 20. Relationships with Criptocurrency. Genre**

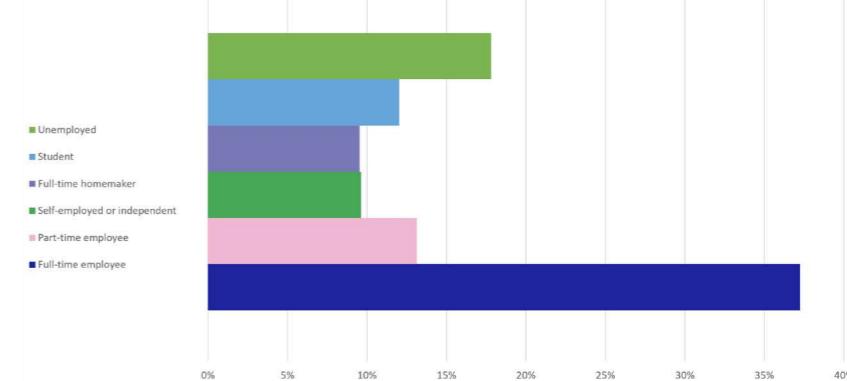
108



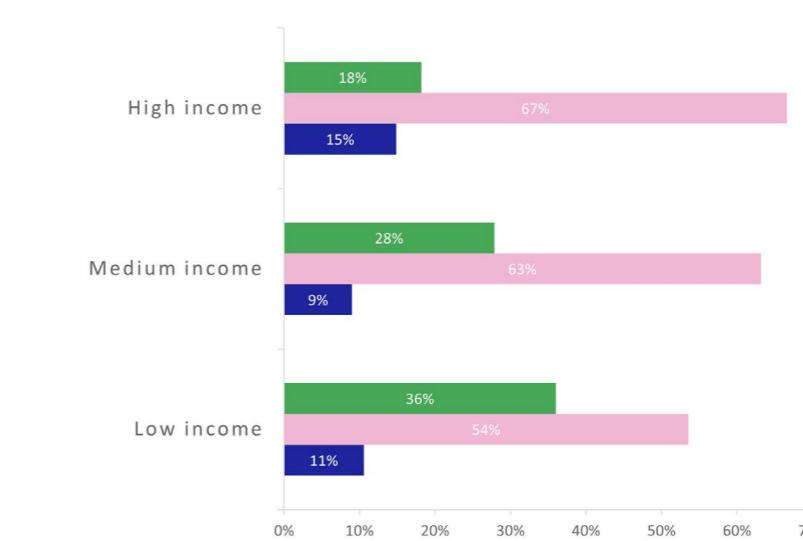
**Ap. Fig. 12. NFTs.**  
*General population*



...to be next exposed to local occupation.



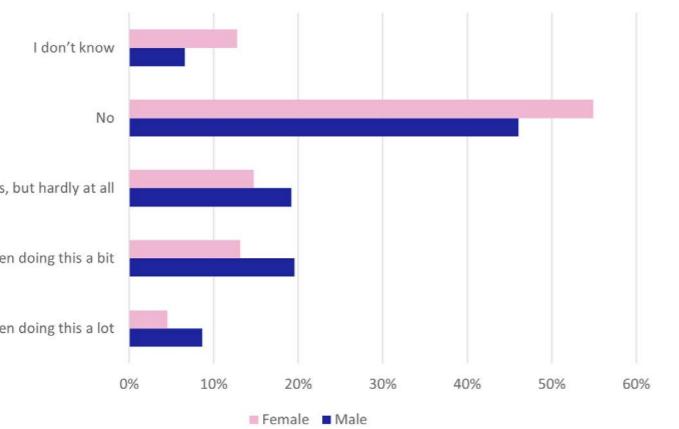
**Ap. Fig. 21. Relationships with NFTs. Occupation profiles**



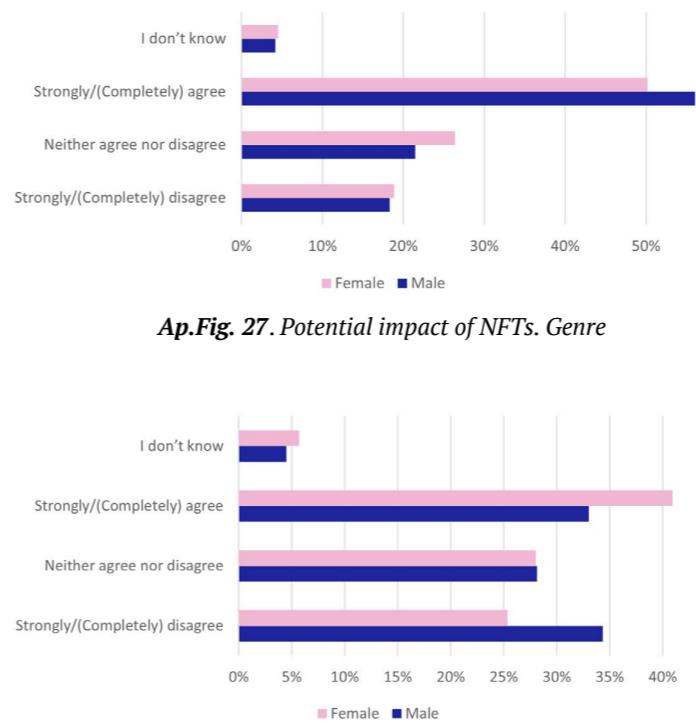
**Ap. Fig. 22.** Relationship with NFTs, Income profiles

## Section 5: Focus: Ownership

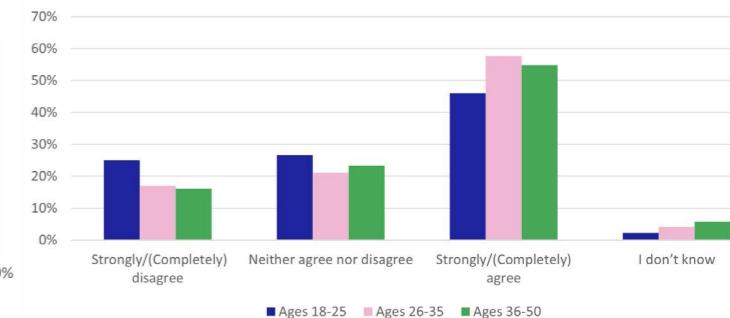
D1. Based on the description on the previous page, have you already been involved in any kind of NFT trading in the past, that involve you buying or selling assets on a blockchain?



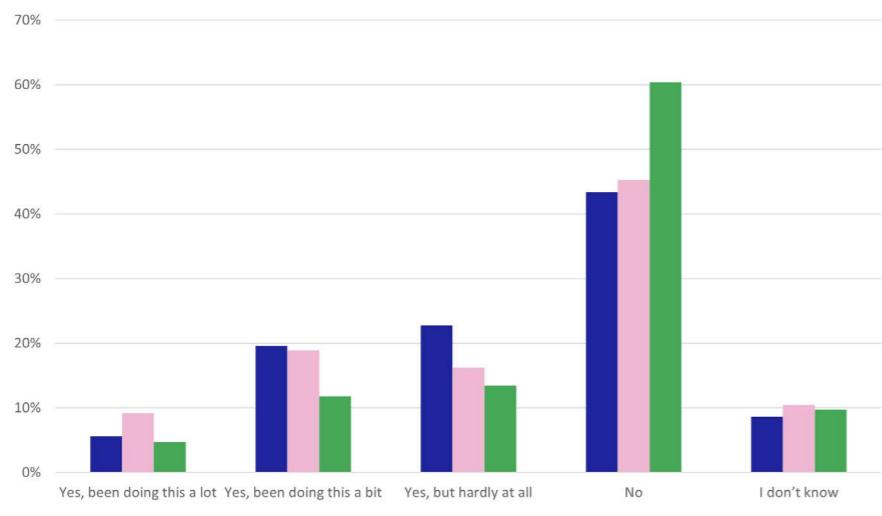
Ap.Fig. 23. Already trading NFTs. Genre



Ap.Fig. 27. Potential impact of NFTs. Genre

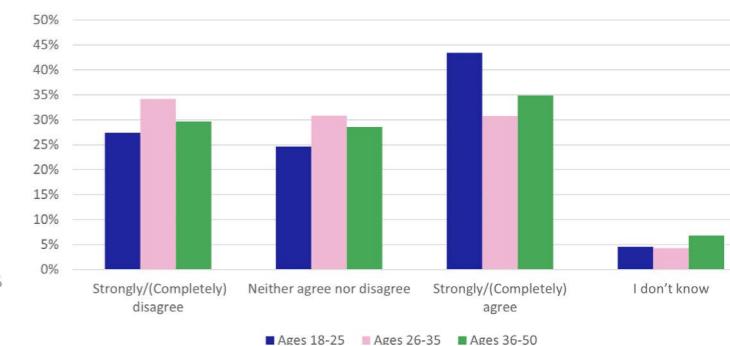


Ap.Fig. 28. Potential impact of NFTs. Age



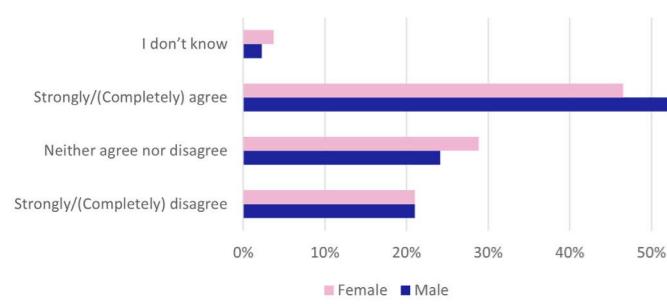
Ap.Fig. 24. Already trading NFTs. Age

Ap.Fig. 29. NFTs only in digital space. Genre

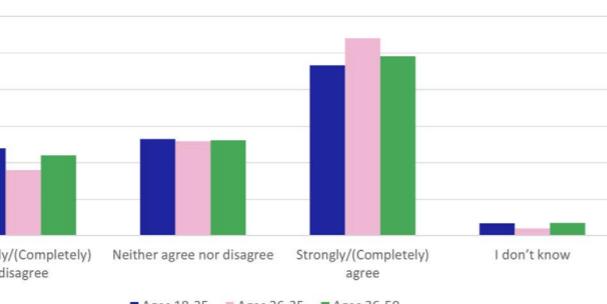


Ap.Fig. 30. NFTs only in digital space. Age

D2a. Please look at the list below and say how strongly you agree or disagree with each statement about Non-Fungible Tokens (NFTs):



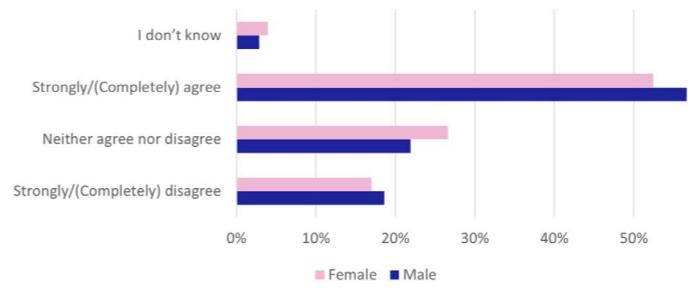
Ap.Fig. 25. Hype around NFTs. Age



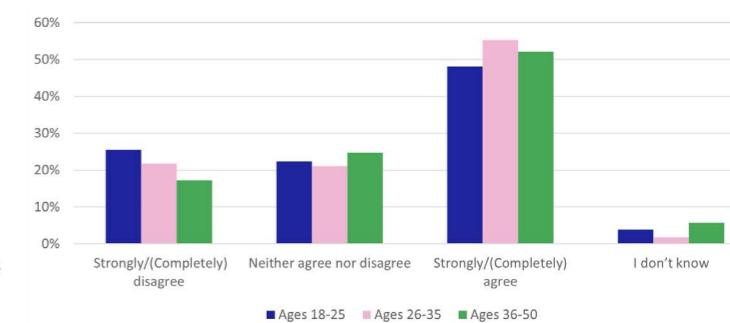
Ap.Fig. 26. Hype around NFTs. Genre

Ap.Fig. 31. NFT empowerment. Genre

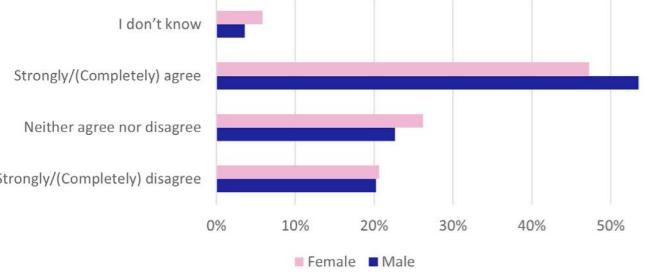
Ap.Fig. 32. NFT empowerment. Age



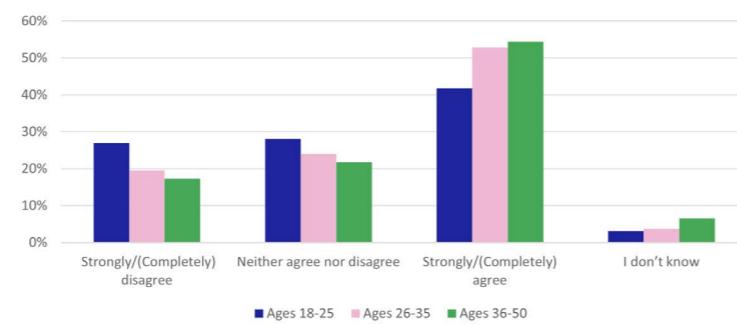
Ap.Fig. 31. NFT empowerment. Genre



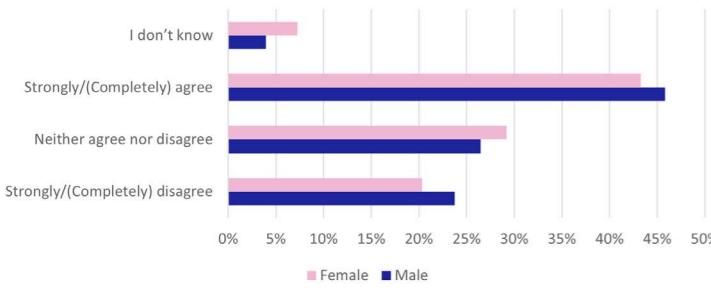
Ap.Fig. 32. NFT empowerment. Age



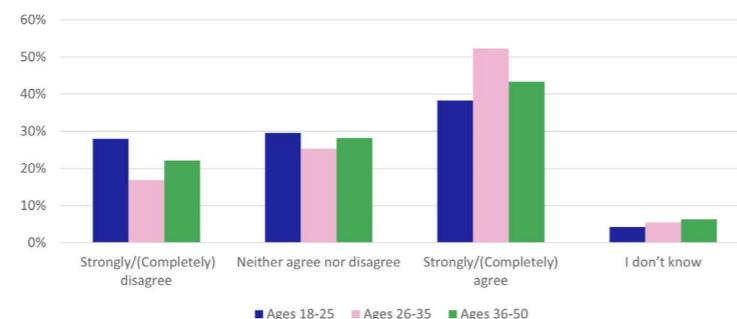
Ap.Fig. 35. NFTs in 10 years as digital ownership tool. Genre



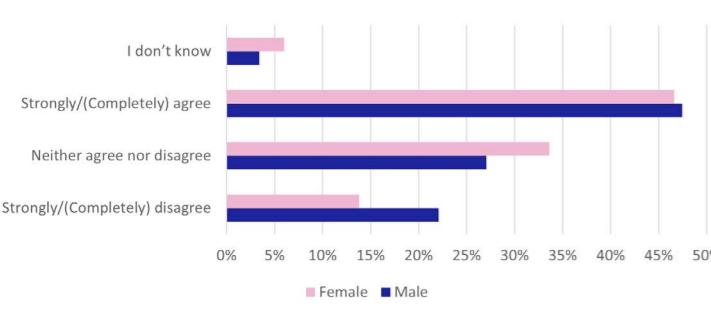
Ap.Fig. 36. NFTs in 10 years as digital ownership tool. Age



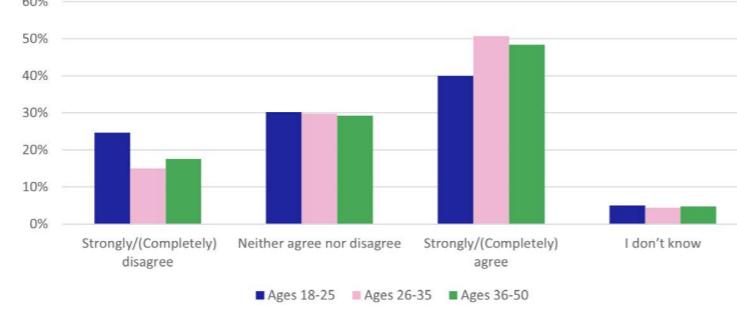
Ap.Fig. 37. Proof of ownership doesn't need solving. Genre



Ap.Fig. 38. Proof of ownership doesn't need solving. Age



Ap.Fig. 39. NFTs for trading in-game items. Genre

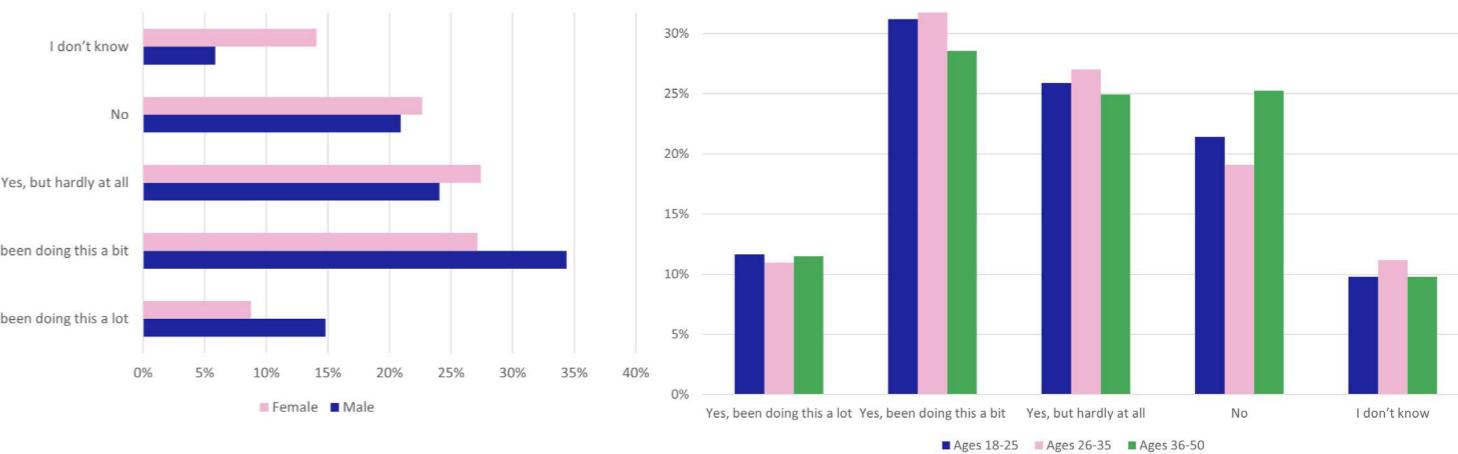


Ap.Fig. 40. NFTs for trading in-game items. Age

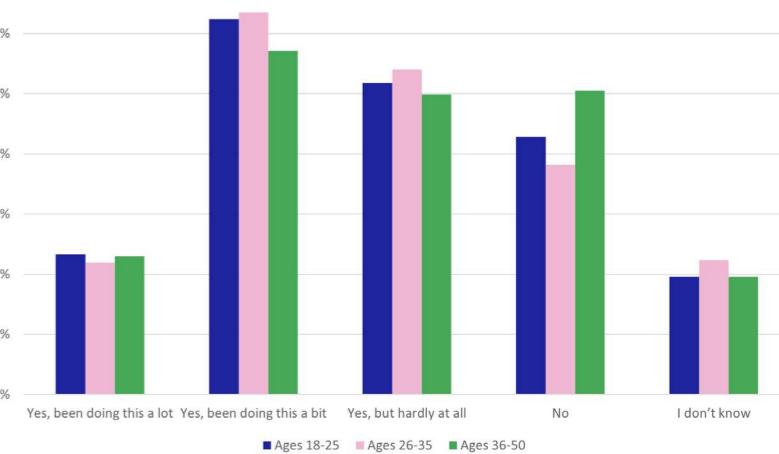


Ap.Fig. 41. Interest in NFTs. General

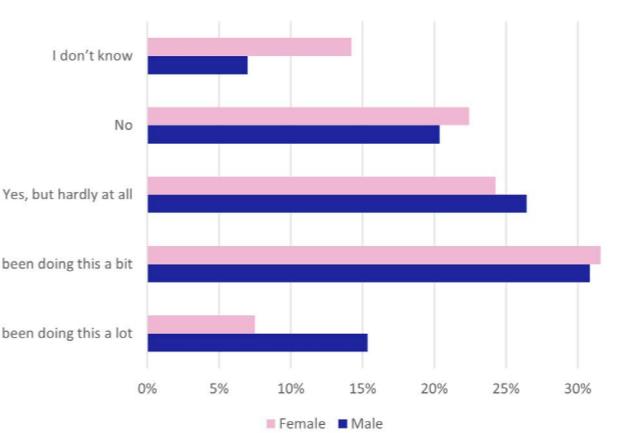
D3. Based what you know about Non-Fungible Tokens (NFTs), which of the following best describes your level of interest in creating, or trading them in the future?



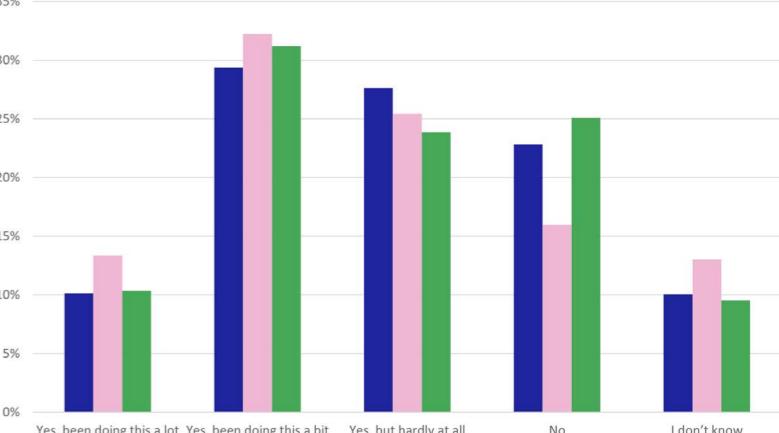
Ap.Fig. 42. Interest in NFTs. Trading. Genre



Ap.Fig. 43. Interest in NFTs. Trading. Age

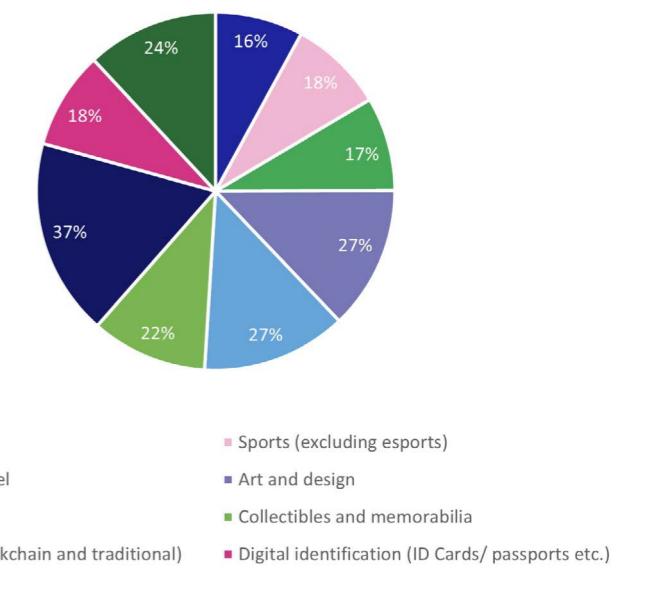


Ap.Fig. 44. Interest in NFTs. Creating. Genre



Ap.Fig. 45. Interest in NFTs. Creating. Age

D4. Finally which three (if any) of the following areas, do you expect benefit most immediately from increased use of Non-Fungible Tokens (NFTs)?



Ap.Fig. 46. NFT opportunity areas

# Appendix 05. Industry Research. Question Overview

## Q1 Static

Thank you for participating! The survey should take you between 10 and 15 minutes to fill in.

The questionnaire is part of a TU Delft Master Graduation Project focused on the design of a product that helps to bridge the gap between the virtual and physical world by use of NFTs. For the research phase of my project, I am at Newzoo under the mentorship of Peter Warman (co-founder and chairman). No prior knowledge about NFTs and related terms is expected. A brief outline of terms is integrated into the survey.

The main focus of the questionnaire is related to the core challenge of my Graduation Project: the potential overlap of the virtual and physical world and the role NFTs could play.

The questionnaire will be distributed to 20 to 40 people of different industries and roles, where NFTs could play a role in the short- or long-term. When multiple answers are possible in a question, it will be indicated.

The results will remain anonymous and aggregated on an industry and/or company role. At the end of the survey, you will be asked if you want to receive high-level results, and your availability for future engagement including the product development phase.

Thank you for your time!

## S1 Radio

What industry do you work in?

- 1 Consumer Electronics
- 2 Hardware & Components
- 3 Game Tech & Services
- 4 Game Development
- 5 Tech Giant
- 6 Finance & Consulting
- 7 Media & Agencies
- 8 Sports
- 9 Telecom & Mobile Services
- 10 Arts & Culture
- 11 Transport, Travel & Tourism
- 12 Government & NGO's
- 13 Fashion & Beauty
- 14 Fast-Moving Consumer Goods
- 15 Automotive
- 16 Entertainment & Collectibles
- 17 Music
- 18 Other

## S2 Text

### Response Defaults

Min length

0

Max length

2000

In which country is your workplace located? If you don't have a physical workplace/work from home please indicate the country your company office/branch is located.

## S2\_1

## S3 Radio

What is your role in the company?

- 1 CEO/Founder
- 2 VP/Director
- 3 Marketing
- 4 Product Development
- 5 Business Development
- 6 Analyst/Research
- 7 Consultant
- 8 Student
- 9 Intern
- 10 Press/Media
- 11 Other

## Q2 Static

Thank you for your responses so far. We will now ask you about your level of understanding of NFTs and related topics, as well as the impact that they could have on your company and its business.

## A1 Radio

Do you understand the concept of "blockchain"?

### Shared Response List

- 1 No, not really
- 2 I have heard of it
- 3 I understand the basic concept
- 4 I have an advanced understanding of the concept
- 5 I consider myself an expert

## A2 Radio

Are you familiar with what the "metaverse" is?

### Shared Response List

- 1 No, not really
- 2 I have heard of it
- 3 I understand the basic concept
- 4 I have an advanced understanding of the concept
- 5 I consider myself an expert

**A3 Radio**

Do you understand what an "NFT" is?

**Shared Response List**

- 1 No, not really
- 2 I have heard of it
- 3 I understand the basic concept
- 4 I have an advanced understanding of the concept
- 5 I consider myself an expert

**A4 Radio**

Are you familiar with "VR/AR" technologies?

**Shared Response List**

- 1 No, not really
- 2 I have heard of it
- 3 I understand the basic concept
- 4 I have an advanced understanding of the concept
- 5 I consider myself an expert

**A5 Grid**

How important are NFTs (and related topics such as metaverse, blockchain) for your **company** in the following time stamps? Rate using a scale of 1 to 7, with 1 being "Not at all important" and 7 "Extremely important".

	H	1
1	Now	<div style="border: 1px solid #ccc; padding: 2px; display: inline-block;"> <span style="border: 1px solid #ccc; padding: 2px 5px; border-radius: 5px; display: inline-block;">A5_1</span> <span>-- Select --</span> </div> <div style="margin-top: 10px;"> <b>Shared Response List</b> <ul style="list-style-type: none"> <li><input type="radio"/> 1 - Not at all important</li> <li><input type="radio"/> 2 - Barely important</li> <li><input type="radio"/> 3 - Slightly important</li> <li><input type="radio"/> 4 - Neutral</li> <li><input type="radio"/> 5 - Moderately important</li> <li><input type="radio"/> 6 - Important</li> <li><input type="radio"/> 7 - Extremely important</li> <li><input type="radio"/> 8 - I don't know</li> </ul> </div>
2	In 1 year	<div style="border: 1px solid #ccc; padding: 2px; display: inline-block;"> <span style="border: 1px solid #ccc; padding: 2px 5px; border-radius: 5px; display: inline-block;">A5_2</span> <span>-- Select --</span> </div> <div style="margin-top: 10px;"> <b>Shared Response List</b> <ul style="list-style-type: none"> <li><input type="radio"/> 1 - Not at all important</li> <li><input type="radio"/> 2 - Barely important</li> <li><input type="radio"/> 3 - Slightly important</li> <li><input type="radio"/> 4 - Neutral</li> <li><input type="radio"/> 5 - Moderately important</li> <li><input type="radio"/> 6 - Important</li> <li><input type="radio"/> 7 - Extremely important</li> <li><input type="radio"/> 8 - I don't know</li> </ul> </div>
3	In 5 years	<div style="border: 1px solid #ccc; padding: 2px; display: inline-block;"> <span style="border: 1px solid #ccc; padding: 2px 5px; border-radius: 5px; display: inline-block;">A5_3</span> <span>-- Select --</span> </div> <div style="margin-top: 10px;"> <b>Shared Response List</b> <ul style="list-style-type: none"> <li><input type="radio"/> 1 - Not at all important</li> <li><input type="radio"/> 2 - Barely important</li> <li><input type="radio"/> 3 - Slightly important</li> <li><input type="radio"/> 4 - Neutral</li> <li><input type="radio"/> 5 - Moderately important</li> <li><input type="radio"/> 6 - Important</li> <li><input type="radio"/> 7 - Extremely important</li> <li><input type="radio"/> 8 - I don't know</li> </ul> </div>
4	In 10 years	<div style="border: 1px solid #ccc; padding: 2px; display: inline-block;"> <span style="border: 1px solid #ccc; padding: 2px 5px; border-radius: 5px; display: inline-block;">A5_4</span> <span>-- Select --</span> </div> <div style="margin-top: 10px;"> <b>Shared Response List</b> <ul style="list-style-type: none"> <li><input type="radio"/> 1 - Not at all important</li> <li><input type="radio"/> 2 - Barely important</li> <li><input type="radio"/> 3 - Slightly important</li> <li><input type="radio"/> 4 - Neutral</li> <li><input type="radio"/> 5 - Moderately important</li> <li><input type="radio"/> 6 - Important</li> <li><input type="radio"/> 7 - Extremely important</li> <li><input type="radio"/> 8 - I don't know</li> </ul> </div>

**Q3 Static**

Thank you for your answers so far. We will now ask you about digital ownership and authenticity. In case you are not familiar with these terms we provide a small explanation:

**Digital ownership:** meaning that you can be the TRUE owner of a digital asset (image, video, 3D model, music...). Therefore, assets can be associated to a certain person.

**Digital authenticity:** meaning that one asset can have its own "identity signature" or "identification code", the digital equivalent of a signature of authenticity. This means that even though you can have infinite exact copies of an image (for example), you can always identify which was the original image.

You will be asked about these concepts, (presented underlined) in relation to a certain **context or aspect** (presented in bold). Please, pay attention to these elements for a better understanding of the question.

The order followed will be:

- 1 - Questions about digital ownership
- 2 - Questions about digital authenticity

**Q4 Static**

The following questions are related to digital ownership

**B1 Dropdown**

How useful do you think it is to introduce true ownership of items in the **digital world**? Rate on a scale of 1 to 7, with 1 being "Not at all useful" and 7 being "Extremely useful".

-- Select --

- 1 - Not at all useful
- 2 - Barely useful
- 3 - Slightly useful
- 4 - Neutral
- 5 - Moderately useful
- 6 - Useful
- 7 - Extremely useful
- 8 - I don't know

**B2 Dropdown**

Do you think that digital ownership can help in bringing the **physical and digital** worlds together? Rate on a scale of 1 to 7, with 1 being "Not at all" and 7 being "For sure".

-- Select --

**Shared Response List**

- 1 - Not at all
- 2 - Small chance
- 3 - Slightly
- 4 - Neutral
- 5 - Moderately
- 6 - Big chance
- 7 - For sure
- 8 - I don't know

**B3 Checkbox**

Min Count

1

How do you think that digital ownership can help in bringing the **physical and digital** worlds together?

*Please select all that apply.*

B3\_1 Establishing a link between physical and digital assets

B3\_2 Higher traceability and inclusion from digital to physical environment

B3\_3 Replacement of physical assets with digital ones, maintaining same value

B3\_5 Elimination of costs (material post-processing, manufacturing, transport, storage...)

B3\_4 Other

B3\_4\_SP

**Q5 Static**

The following questions are related to digital authenticity.

**B4 Dropdown**

How useful do you think it is to introduce true authenticity of items in the **digital world**? Rate on a scale of 1 to 7, with 1 being "Not at all useful" and 7 being "Extremely useful".

-- Select --

- 1 - Not at all useful
- 2 - Barely useful
- 3 - Slightly useful
- 4 - Neutral
- 5 - Moderately useful
- 6 - Useful
- 7 - Extremely useful
- 8 - I don't know

**B5 Dropdown**

Do you think that digital authenticity can help in bringing the **physical and digital** worlds together? Rate on a scale of 1 to 7, with 1 being "Not at all" and 7 being "For sure".

-- Select --

**Shared Response List**

- 1 - Not at all
- 2 - Small chance
- 3 - Slightly
- 4 - Neutral
- 5 - Moderately
- 6 - Big chance
- 7 - For sure
- 8 - I don't know

**B6 Checkbox**  
Min Count 1

How do you think that digital authenticity can help in bringing the **physical and digital** worlds together?

Please select all that apply.

**B6\_1** Faster verification of personal data, useful for both environments

**B6\_2** Establishing a link between physical and digital assets

**B6\_3** Higher traceability and inclusion from physical to digital environment

**B6\_5** Increased security for both environments

**B6\_4** Other

**B7 Grid**

Digital ownership and authenticity will make you the true owner of a unique digital asset. Which **industries** do you think would receive **most benefit** from this concept in the span of 1,5 and 10 years?

Please select a maximum of 5 that apply for each time period.

	H	1	2	3
H		1 year	5 years	10 years
1	Consumer Electronics	<input type="checkbox"/> B7_1 B7_1_1	<input type="checkbox"/> B7_2 B7_2_1	<input type="checkbox"/> B7_3 B7_3_1
2	Fashion & Beauty	<input type="checkbox"/> B7_1_2	<input type="checkbox"/> B7_2_2	<input type="checkbox"/> B7_3_2
3	Entertainment & Collectibles	<input type="checkbox"/> B7_1_3	<input type="checkbox"/> B7_2_3	<input type="checkbox"/> B7_3_3
4	Game Tech/ Services/ Development	<input type="checkbox"/> B7_1_4	<input type="checkbox"/> B7_2_4	<input type="checkbox"/> B7_3_4
5	Hardware & Components	<input type="checkbox"/> B7_1_5	<input type="checkbox"/> B7_2_5	<input type="checkbox"/> B7_3_5
6	Media & Agencies	<input type="checkbox"/> B7_1_6	<input type="checkbox"/> B7_2_6	<input type="checkbox"/> B7_3_6
7	Tech Giants	<input type="checkbox"/> B7_1_7	<input type="checkbox"/> B7_2_7	<input type="checkbox"/> B7_3_7
8	Music	<input type="checkbox"/> B7_1_8	<input type="checkbox"/> B7_2_8	<input type="checkbox"/> B7_3_8
9	Transport, Travel & Tourism	<input type="checkbox"/> B7_1_9	<input type="checkbox"/> B7_2_9	<input type="checkbox"/> B7_3_9
10	Finance & Consulting	<input type="checkbox"/> B7_1_10	<input type="checkbox"/> B7_2_10	<input type="checkbox"/> B7_3_10
11	Sports	<input type="checkbox"/> B7_1_11	<input type="checkbox"/> B7_2_11	<input type="checkbox"/> B7_3_11
12	Telecom & Mobile Services	<input type="checkbox"/> B7_1_12	<input type="checkbox"/> B7_2_12	<input type="checkbox"/> B7_3_12
13	Arts & Culture	<input type="checkbox"/> B7_1_13	<input type="checkbox"/> B7_2_13	<input type="checkbox"/> B7_3_13
14	Governments & NGO's	<input type="checkbox"/> B7_1_14	<input type="checkbox"/> B7_2_14	<input type="checkbox"/> B7_3_14
15	Fast-Moving Consumer Goods	<input type="checkbox"/> B7_1_15	<input type="checkbox"/> B7_2_15	<input type="checkbox"/> B7_3_15
16	Automotive	<input type="checkbox"/> B7_1_16	<input type="checkbox"/> B7_2_16	<input type="checkbox"/> B7_3_16
17	Other	<input type="checkbox"/> B7_1_17	<input type="checkbox"/> B7_2_17	<input type="checkbox"/> B7_3_17
18	None of the above	<input type="checkbox"/> B7_1_18	<input type="checkbox"/> B7_2_18	<input type="checkbox"/> B7_3_18

**Q6 Static**

Thank you for your answers so far. In this section you will be asked about NFTs and will be subdivided in 3 chapters:

- 1 - Questions related to **NFTs in general**
- 2 - Questions related to **NFTs and community building**
- 3 - Question related to the combination of **physical and digital environments**

In case you are not familiar with what an NFT is we provide a brief explanation:

**NFTs:** acronym for Non-Fungible-Tokens. Fungibility means that an asset's individual units are interchangeable and essentially indistinguishable from each other. For example, fiat currencies. This means that a non-fungible token is unique. Therefore, Non-Fungible-Token is a type of cryptographic token on a blockchain that represents a unique asset.

**Blockchain:** A blockchain is a special type of database that has certain unique properties. There are rules about how data can be added, and once the data has been stored, it's virtually impossible to modify or delete it. Data is added over time in structures called blocks. Each block is built on top of the last and includes a piece of information that links back to the previous one.

**Q7 Static**

The following questions related to NFTs in general

**C1 Checkbox**  
Min Count 1

Select the following that apply to you:

**C1\_1** I own digital currency (cryptocurrency)

**C1\_2** I am an NFT creator

**C1\_3** I am an NFT collector

**C1\_4** I am actively involved in the NFT community

**C1\_5** None of the above

**C2 Grid**

How widely do you believe NFTs will spread in 1, 5 and 10 years from now on a scale of 1 to 7, with 1 being "Will remain niche" and 7 being "Will become mainstream"?

	H	1
1	1 year	<b>C2_1</b> <input type="button" value="-- Select --"/> <b>Shared Response List</b> <ul style="list-style-type: none"> <li><input type="radio"/> 1 – Will remain niche</li> <li><input type="radio"/> 2 – Will barely spread</li> <li><input type="radio"/> 3 – Will slightly spread</li> <li><input type="radio"/> 4 – Will spread</li> <li><input type="radio"/> 5 – Will moderately spread</li> <li><input type="radio"/> 6 – Will largely spread</li> <li><input type="radio"/> 7 – Will become mainstream</li> <li><input type="radio"/> 8 – I don't know</li> </ul>
2	5 years	<b>C2_2</b> <input type="button" value="-- Select --"/> <b>Shared Response List</b> <ul style="list-style-type: none"> <li><input type="radio"/> 1 – Will remain niche</li> <li><input type="radio"/> 2 – Will barely spread</li> <li><input type="radio"/> 3 – Will slightly spread</li> <li><input type="radio"/> 4 – Will spread</li> <li><input type="radio"/> 5 – Will moderately spread</li> <li><input type="radio"/> 6 – Will largely spread</li> <li><input type="radio"/> 7 – Will become mainstream</li> <li><input type="radio"/> 8 – I don't know</li> </ul>
3	10 years	<b>C2_3</b> <input type="button" value="-- Select --"/> <b>Shared Response List</b> <ul style="list-style-type: none"> <li><input type="radio"/> 1 – Will remain niche</li> <li><input type="radio"/> 2 – Will barely spread</li> <li><input type="radio"/> 3 – Will slightly spread</li> <li><input type="radio"/> 4 – Will spread</li> <li><input type="radio"/> 5 – Will moderately spread</li> <li><input type="radio"/> 6 – Will largely spread</li> <li><input type="radio"/> 7 – Will become mainstream</li> <li><input type="radio"/> 8 – I don't know</li> </ul>

**C2\_Extra Text**

Require a response	No
<b>Response Defaults</b>	
Min length	0
Max length	2000

Please tell us why you picked these options.

*It is not mandatory to answer this question.*

**C2\_Extra\_1**

**C3 Radio**

Choose the option that you believe is most realistic in the near- to mid-future.

- 1 NFTs have no valuable applications at all.
- 2 NFTs only belong to the digital world and cannot have valuable applications in the physical world.
- 3 NFTs can have very limited valuable applications in the physical world.
- 4 NFTs can have a wide range of valuable applications in the physical world.

**C3\_Extra Text**

Require a response	No
<b>Response Defaults</b>	
Min length	0
Max length	2000

Please tell us why you picked this option.

*It is not mandatory to answer this question.*

**C3\_Extra\_1**

**Q8 Static**

Thank you for your answers so far. In this section you will be asked about NFTs and *community building*. The questions will ask about a quality of the NFTs (presented underlined), in a certain **context** (presented in bold), and always referring to *community building* (presented in italic). Please pay attention to these elements for a better understanding of the question.

**C4 Grid**

What do you think is the relevance of NFTs for *community building* in the **digital world** in the following time stamps? Rate on a scale of 1 to 7, with 1 being "Not at all relevant" and 7 being "Extremely relevant".

	H	1
1	Now	<div style="border: 1px solid #ccc; padding: 5px; margin-bottom: 10px;"> <span>C4_1</span> <span>-- Select --</span> <span>▼</span> </div> <div style="border: 1px solid #ccc; padding: 5px; margin-bottom: 10px;"> <b>Shared Response List</b> <ul style="list-style-type: none"> <li><input type="radio"/> 1 - Not at all relevant</li> <li><input type="radio"/> 2 - Barely relevant</li> <li><input type="radio"/> 3 - Slightly relevant</li> <li><input type="radio"/> 4 - Neutral</li> <li><input type="radio"/> 5 - Moderately relevant</li> <li><input type="radio"/> 6 - Relevant</li> <li><input type="radio"/> 7 - Extremely relevant</li> <li><input type="radio"/> 8 - I don't know</li> </ul> </div> <div style="border: 1px solid #ccc; padding: 5px; margin-bottom: 10px;"> <span>C4_2</span> <span>-- Select --</span> <span>▼</span> </div> <div style="border: 1px solid #ccc; padding: 5px; margin-bottom: 10px;"> <b>Shared Response List</b> <ul style="list-style-type: none"> <li><input type="radio"/> 1 - Not at all relevant</li> <li><input type="radio"/> 2 - Barely relevant</li> <li><input type="radio"/> 3 - Slightly relevant</li> <li><input type="radio"/> 4 - Neutral</li> <li><input type="radio"/> 5 - Moderately relevant</li> <li><input type="radio"/> 6 - Relevant</li> <li><input type="radio"/> 7 - Extremely relevant</li> <li><input type="radio"/> 8 - I don't know</li> </ul> </div> <div style="border: 1px solid #ccc; padding: 5px; margin-bottom: 10px;"> <span>C4_3</span> <span>-- Select --</span> <span>▼</span> </div> <div style="border: 1px solid #ccc; padding: 5px; margin-bottom: 10px;"> <b>Shared Response List</b> <ul style="list-style-type: none"> <li><input type="radio"/> 1 - Not at all relevant</li> <li><input type="radio"/> 2 - Barely relevant</li> <li><input type="radio"/> 3 - Slightly relevant</li> <li><input type="radio"/> 4 - Neutral</li> <li><input type="radio"/> 5 - Moderately relevant</li> <li><input type="radio"/> 6 - Relevant</li> <li><input type="radio"/> 7 - Extremely relevant</li> <li><input type="radio"/> 8 - I don't know</li> </ul> </div> <div style="border: 1px solid #ccc; padding: 5px; margin-bottom: 10px;"> <span>C4_4</span> <span>-- Select --</span> <span>▼</span> </div> <div style="border: 1px solid #ccc; padding: 5px; margin-bottom: 10px;"> <b>Shared Response List</b> <ul style="list-style-type: none"> <li><input type="radio"/> 1 - Not at all relevant</li> <li><input type="radio"/> 2 - Barely relevant</li> <li><input type="radio"/> 3 - Slightly relevant</li> <li><input type="radio"/> 4 - Neutral</li> <li><input type="radio"/> 5 - Moderately relevant</li> <li><input type="radio"/> 6 - Relevant</li> <li><input type="radio"/> 7 - Extremely relevant</li> <li><input type="radio"/> 8 - I don't know</li> </ul> </div>
2	In 1 year	
3	In 5 years	
4	In 10 years	

**C5 Text****Response Defaults**

Min length  
Max length

0  
2000

What do you believe is the main reason?

*This question is mandatory.*

**C5\_1****C6 Checkbox**

Min Count

1

How can NFTs be relevant for *community building* in the **digital world**?

*Please select all that apply.*

**C6\_1** They enable new ways of trading

**C6\_2** They become important for building communities due to ownership of similar assets

**C6\_3** They enable creativity and engagement (content creator communities)

**C6\_4** Other **C6\_4\_SP**

**C7 Grid**

What do you think is the relevance of NFTs for *community building* in the **physical world** in the following time stamps? Rate on a scale of 1 to 7, with 1 being "Not at all relevant" and 7 being "Extremely relevant".

	H	1
1	Now	<div style="border: 1px solid #ccc; padding: 5px; margin-bottom: 10px;"> <span style="border: 1px solid #ccc; padding: 2px 10px; display: inline-block;">C7_1</span> <span style="border: 1px solid #ccc; padding: 2px 10px; display: inline-block;">-- Select --</span> </div> <p><b>Shared Response List</b></p> <ul style="list-style-type: none"> <li><input type="radio"/> 1 - Not at all relevant</li> <li><input type="radio"/> 2 - Barely relevant</li> <li><input type="radio"/> 3 - Slightly relevant</li> <li><input type="radio"/> 4 - Neutral</li> <li><input type="radio"/> 5 - Moderately relevant</li> <li><input type="radio"/> 6 - Relevant</li> <li><input type="radio"/> 7 - Extremely relevant</li> <li><input type="radio"/> I don't know</li> </ul>
2	In 1 year	<div style="border: 1px solid #ccc; padding: 5px; margin-bottom: 10px;"> <span style="border: 1px solid #ccc; padding: 2px 10px; display: inline-block;">C7_2</span> <span style="border: 1px solid #ccc; padding: 2px 10px; display: inline-block;">-- Select --</span> </div> <p><b>Shared Response List</b></p> <ul style="list-style-type: none"> <li><input type="radio"/> 1 - Not at all relevant</li> <li><input type="radio"/> 2 - Barely relevant</li> <li><input type="radio"/> 3 - Slightly relevant</li> <li><input type="radio"/> 4 - Neutral</li> <li><input type="radio"/> 5 - Moderately relevant</li> <li><input type="radio"/> 6 - Relevant</li> <li><input type="radio"/> 7 - Extremely relevant</li> <li><input type="radio"/> I don't know</li> </ul>
3	In 5 years	<div style="border: 1px solid #ccc; padding: 5px; margin-bottom: 10px;"> <span style="border: 1px solid #ccc; padding: 2px 10px; display: inline-block;">C7_3</span> <span style="border: 1px solid #ccc; padding: 2px 10px; display: inline-block;">-- Select --</span> </div> <p><b>Shared Response List</b></p> <ul style="list-style-type: none"> <li><input type="radio"/> 1 - Not at all relevant</li> <li><input type="radio"/> 2 - Barely relevant</li> <li><input type="radio"/> 3 - Slightly relevant</li> <li><input type="radio"/> 4 - Neutral</li> <li><input type="radio"/> 5 - Moderately relevant</li> <li><input type="radio"/> 6 - Relevant</li> <li><input type="radio"/> 7 - Extremely relevant</li> <li><input type="radio"/> I don't know</li> </ul>
4	In 10 years	<div style="border: 1px solid #ccc; padding: 5px; margin-bottom: 10px;"> <span style="border: 1px solid #ccc; padding: 2px 10px; display: inline-block;">C7_4</span> <span style="border: 1px solid #ccc; padding: 2px 10px; display: inline-block;">-- Select --</span> </div> <p><b>Shared Response List</b></p> <ul style="list-style-type: none"> <li><input type="radio"/> 1 - Not at all relevant</li> <li><input type="radio"/> 2 - Barely relevant</li> <li><input type="radio"/> 3 - Slightly relevant</li> <li><input type="radio"/> 4 - Neutral</li> <li><input type="radio"/> 5 - Moderately relevant</li> <li><input type="radio"/> 6 - Relevant</li> <li><input type="radio"/> 7 - Extremely relevant</li> <li><input type="radio"/> I don't know</li> </ul>

**C8 Text****Response Defaults**

Min length	0
Max length	2000

What do you believe is the main reason?

*This question is mandatory.*

**C8\_1****C9 Checkbox**

Min Count	1
-----------	---

How can NFTs be relevant for *community building* in the **physical world**?

*Please select all that apply.*

- C9\_1 They enable new ways of trading
- C9\_2 They become important for building communities due to ownership of similar assets
- C9\_3 They enable exchanging and/or interacting with physical goods
- C9\_5 They enable enhancing digital assets by including them in a physical environment (industry communities)

Other

C9\_4
C9\_4\_SP

**C10 Checkbox**

Min Count	1
Max Count	3
Randomize responses	START to END, Not randomized 1 to 10, Randomized 9, anchored 10, anchored

What type of NFT do you believe will be most relevant for *community building* in the **future**?

*Please select a maximum of 3 that apply.*

- C10\_1 Collectibles and Profile Pictures
- C10\_2 Art (as unique single pieces, different from collectibles)
- C10\_3 Sports and Fan Tokens
- C10\_4 Metaverse Digital Land
- C10\_5 Metaverse Digital Clothing
- C10\_6 Utility NFTs (linked to redeemability, both digital and physical)
- C10\_7 Credentials and Identity Portability (digital identification)
- C10\_8 Gaming (assets)
- C10\_9 Other C10\_9\_SP
- C10\_10 None of the above

**Q9 Static**

Thank you for your answers so far. In this section you will be asked questions related to the combination of physical and digital environments. When referring to the *environments* it will always appear in italic, and the main topic of the question underlined. Please pay attention to these elements for a better understanding of the question.

**C11 Checkbox**

Min Count 1  
Max Count 3

What technology do you believe is most suitable for bringing *physical and digital* worlds together?

Please select a maximum of 3 that apply.

**C11\_1** Blockchain (*digital ownership and authenticity, NFTs, smart contracts...*)

**C11\_2** Virtual Reality (VR)

**C11\_3** Augmented Reality (AR)

**C11\_4** Self Sovereign Identity (*decentralized digital identity*)

**C11\_5** Other **C11\_5\_SP**

**C11\_6** None of the above

**C11\_6**

Mutually exclusive Yes

**C11\_Extra Text**

Require a response No

**Response Defaults**

Min length 0

Max length 2000

Please tell us why you picked these options.

*It is not mandatory to answer this question.*

**C11\_Extra\_1**

**C12 Radio**

Please tell which of the statements best describes in your opinion the added value of *bridging physical and digital* worlds:

**1** Value is only added to the digital environment

**2** Value is only added to the physical environment

**3** Value is added to both environments

**4** Value isn't added to either of the environments

**C13 Radio**

Do you think more applications of NFTs in the *physical world* can add extra value and at the same time enrich the experience in the *digital space*?

*If yes, answer why*

**1** No

**2** I don't know

**3** Yes, because **C13\_3\_SP**

**C14 Radio**

Would a physical product that enables physical interaction with NFTs (e.g., showcasing your NFTs in a real environment with the use of Augmented Reality or exchanging them for physical goods) be interesting in your own opinion?

*Select one of the following and specify why.*

**1** Yes, because **C14\_1\_SP**

**2** No, because **C14\_2\_SP**

**3** I don't know

**Q10 Static**

Thank you for your responses so far. To conclude we will now ask about future engagement with the project.

**D1 Radio**

Are you interested in receiving high-level aggregated results of this survey?

**1** Yes

**2** No

**D2 Radio**

Are you available for a 20-minute follow-up interview in the coming three weeks?

**1** Yes

**2** No

## Appendix 06. Industry Research Results

### D3 Radio

Are you interested to keep up to date on the process of the project and give feedback on the intermediate results and product concepts?

1 Yes

2 No

### D4 Text

#### Response Defaults

Min length

0

Max length

2000

This section is shown because you have selected "Yes" in one of the last 3 questions. Please provide your name and e-mail so that we can contact you in relation to your answer.

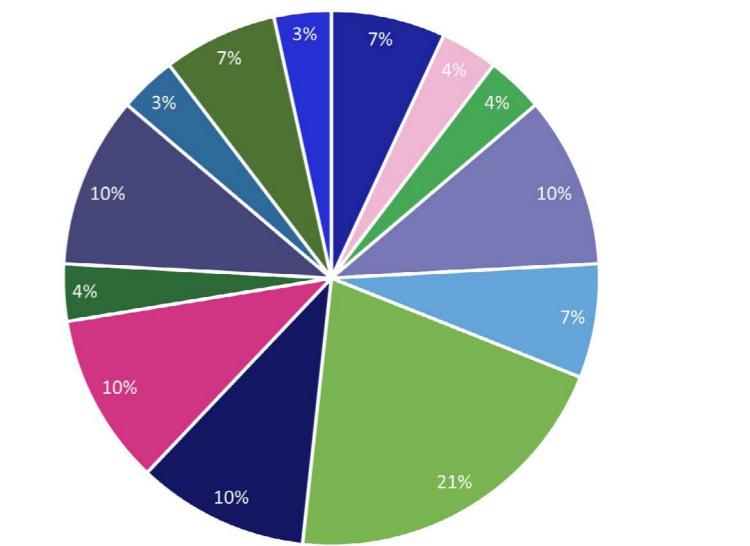
Please type your contact details below:

D4\_1 Name:

D4\_2 E-mail:

### S1 Radio

What industry do you work in?



Ap.Fig. 47. Industries that have participated in the industry research

### S2 Text

#### Response Defaults

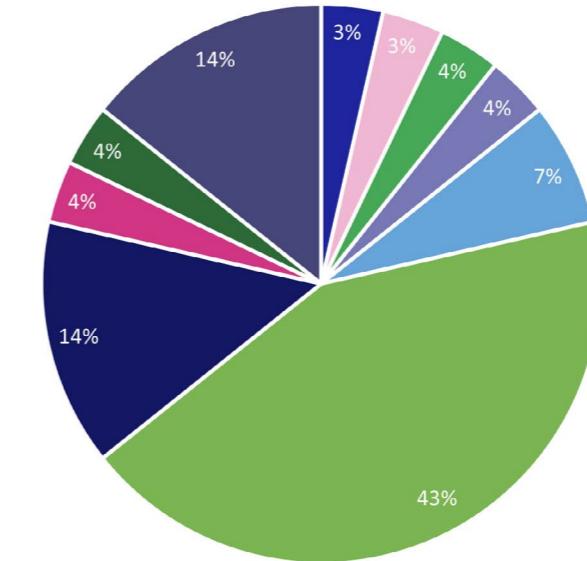
Min length

0

Max length

2000

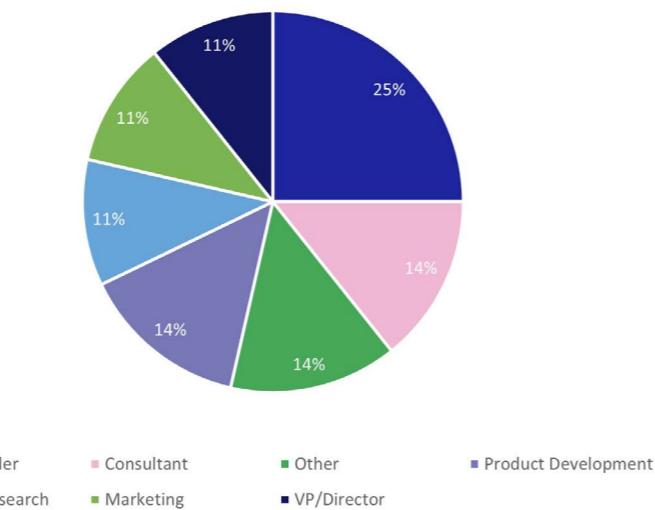
In which country is your workplace located? If you don't have a physical workplace/work from home please indicate the country your company office/branch is located.



Ap.Fig. 48. Markets that have participated in the industry research

**S3 Radio**

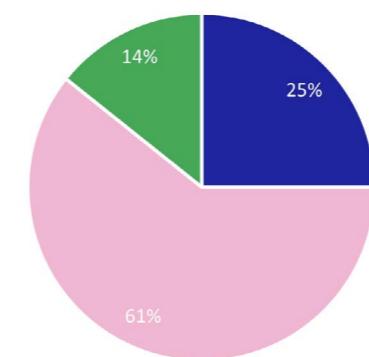
What is your role in the company?



**Ap.Fig. 49. Company roles in the industry research**

**A4 Radio**

Are you familiar with "VR/AR" technologies?

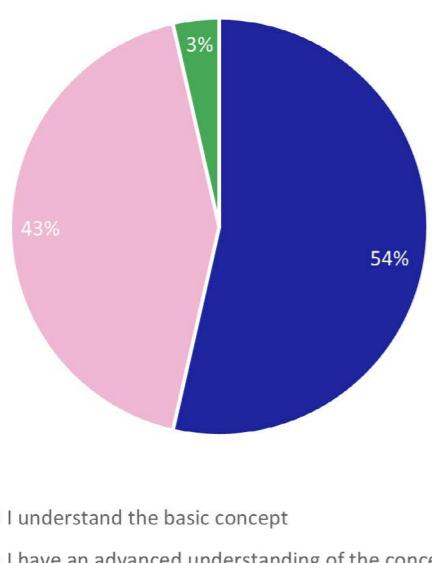


- I understand the basic concept
- I have an advanced understanding of the concept
- I consider myself an expert

**Ap.Fig. 53. AR/VR familiarity**

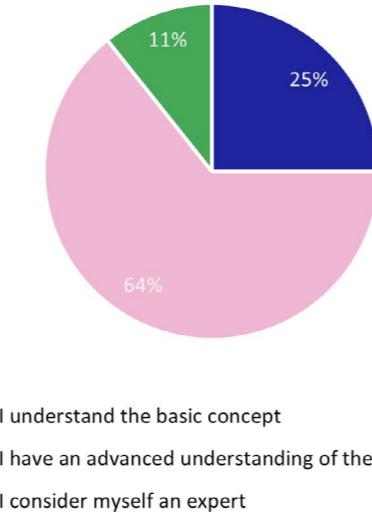
**A1 Radio**

Do you understand the concept of "blockchain"?



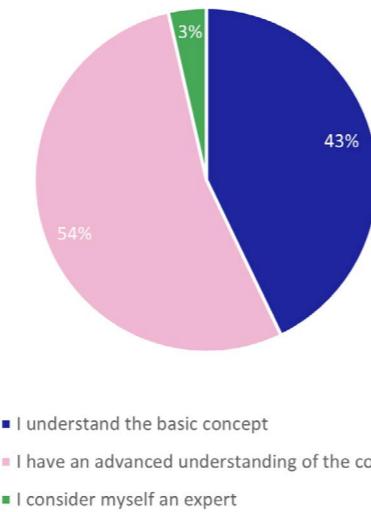
**A2 Radio**

Are you familiar with what the "metaverse" is?



**Ap.Fig. 51. Understanding of the concept "metaverse"**

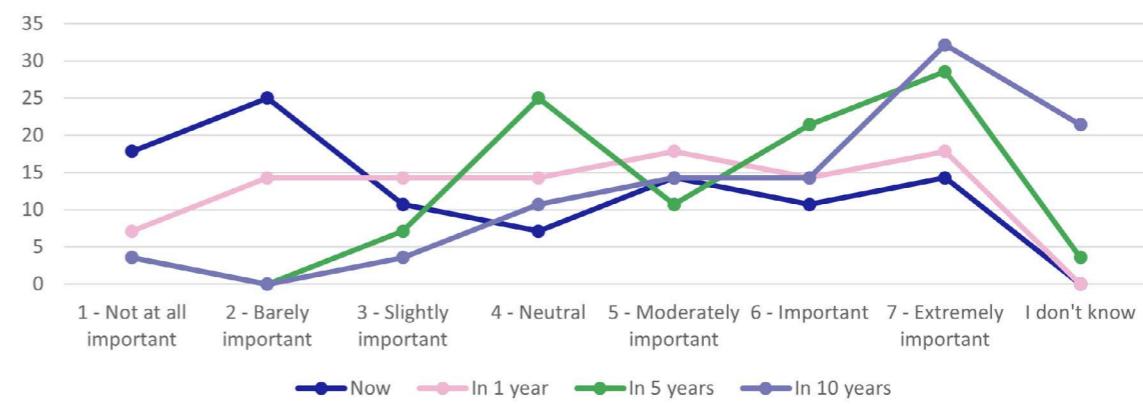
**Ap.Fig. 50. Understanding of the concept "blockchain"**



**Ap.Fig. 52. Understanding of the concept "NFT"**

**A5 Grid**

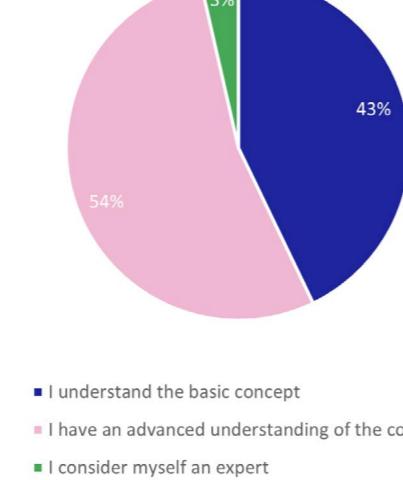
How important are NFTs (and related topics such as metaverse, blockchain) for your **company** in the following time stamps? Rate using a scale of 1 to 7, with 1 being "Not at all important" and 7 "Extremely important".



**Ap.Fig. 54. Importance of NFTs for companies in different time stamps. Detail**

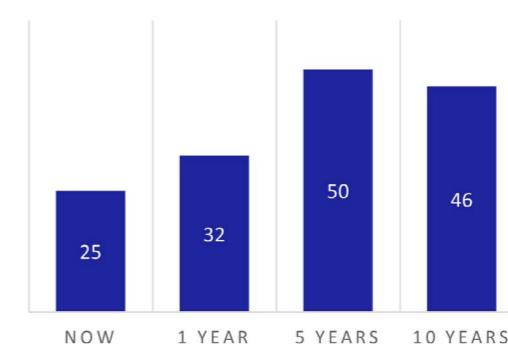
**A3 Radio**

Do you understand what an "NFT" is?



**Ap.Fig. 52. Understanding of the concept "NFT"**

■ (Extremely) important



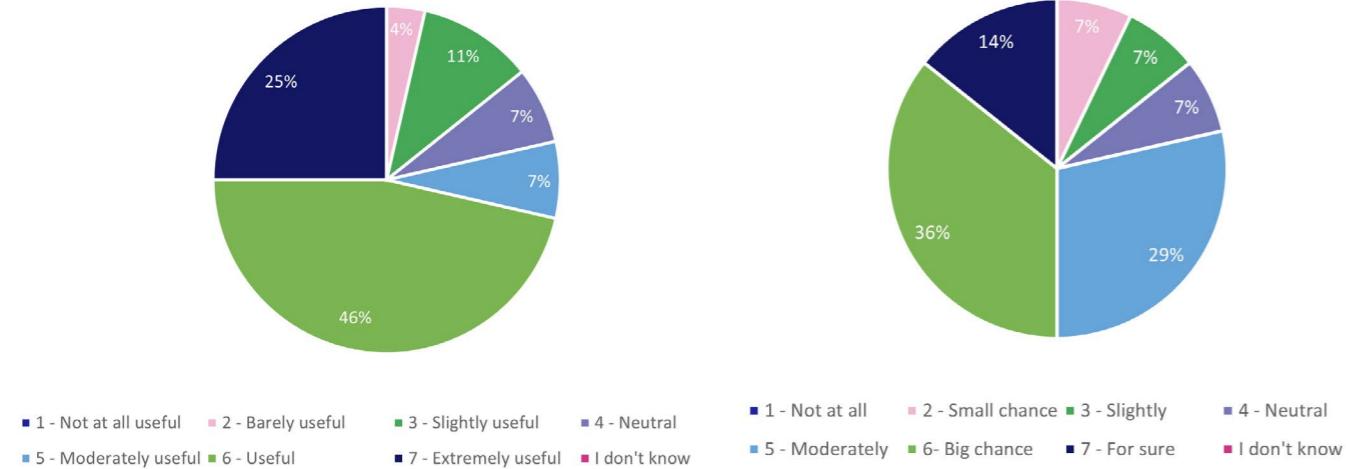
**Ap.Fig. 55. Importance of NFTs for companies in different time stamps. Overview**

**B1 Dropdown**

How useful do you think it is to introduce true ownership of items in the **digital world**? Rate on a scale of 1 to 7, with 1 being "Not at all useful" and 7 being "Extremely useful".

**B2 Dropdown**

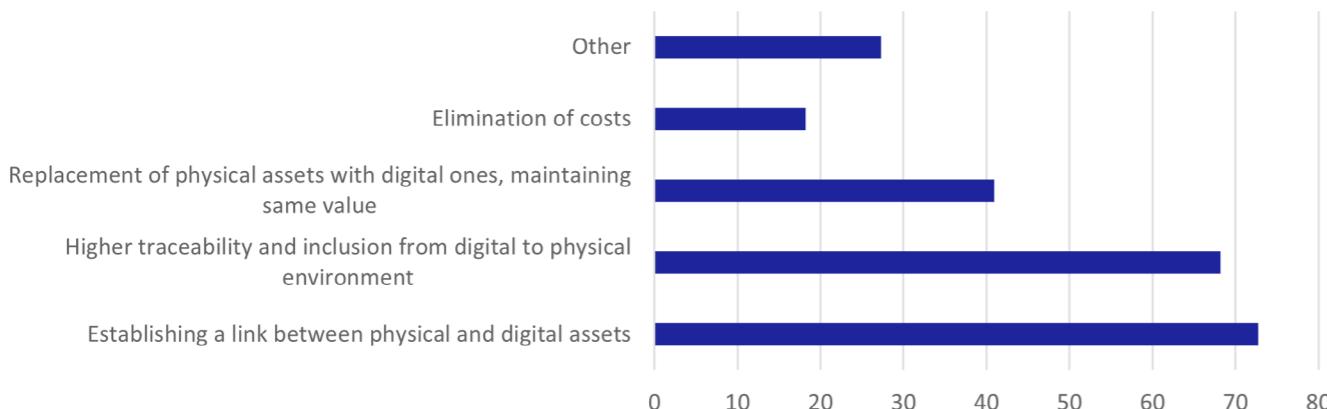
Do you think that digital ownership can help in bringing the **physical and digital** worlds together? Rate on a scale of 1 to 7, with 1 being "Not at all" and 7 being "For sure".

**Ap.Fig. 56. Usefulness of ownership in digital world****Ap.Fig. 57. Digital ownership as tool to bridge physical and digital environments****B3 Checkbox**

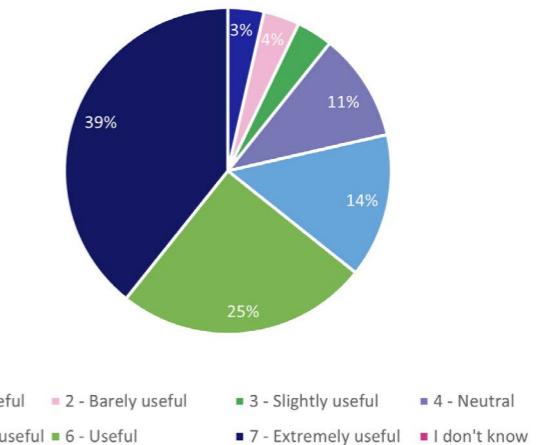
Min Count

1

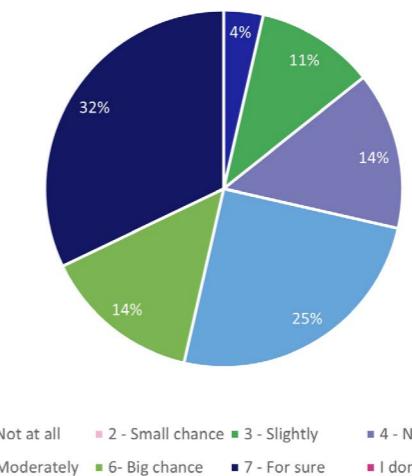
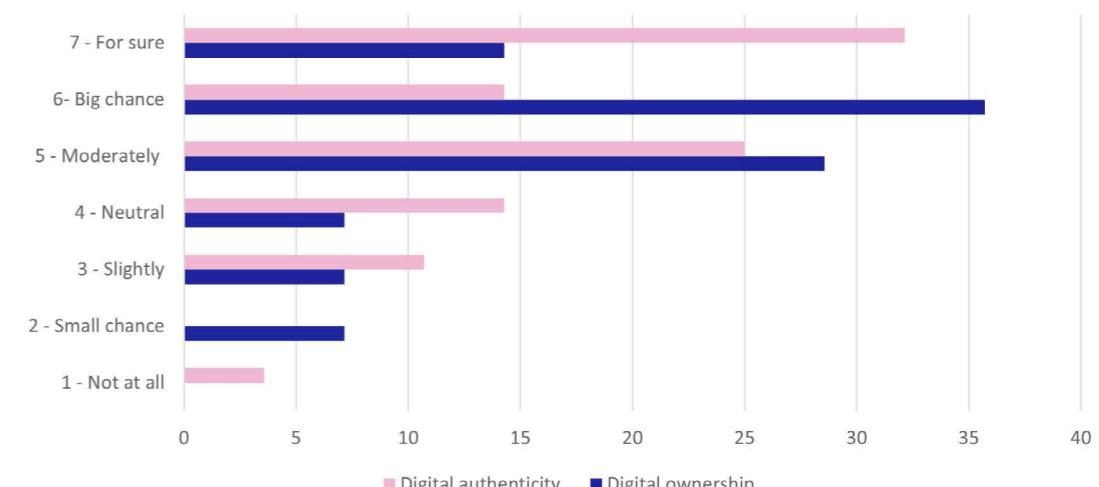
How do you think that digital ownership can help in bringing the **physical and digital** worlds together?

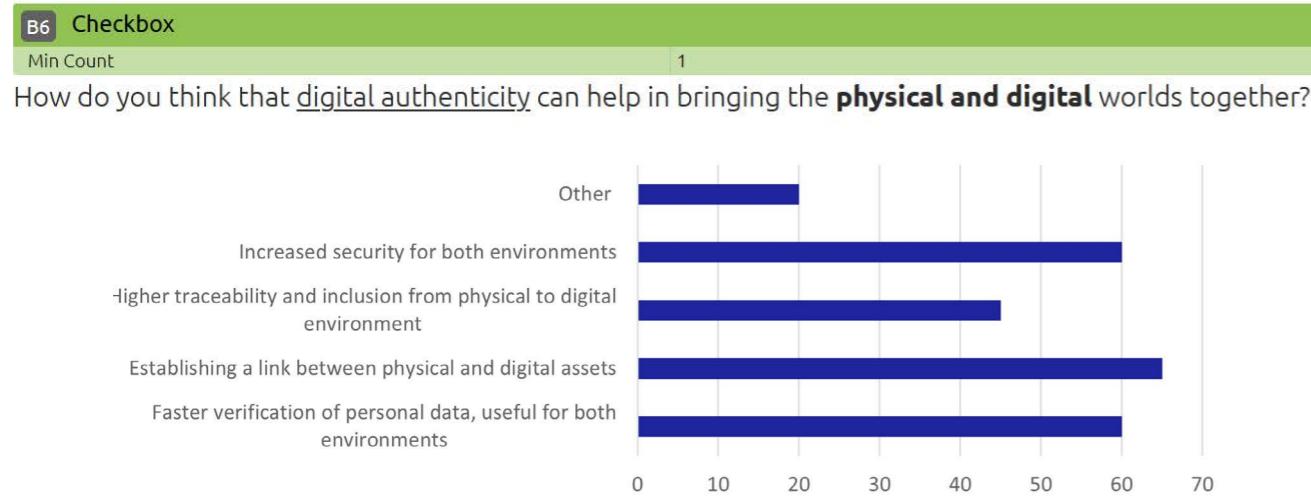
**Ap.Fig. 58. Usefulness of digital ownership to bridge physical and digital worlds****B4 Dropdown**

How useful do you think it is to introduce true authenticity of items in the **digital world**? Rate on a scale of 1 to 7, with 1 being "Not at all useful" and 7 being "Extremely useful".

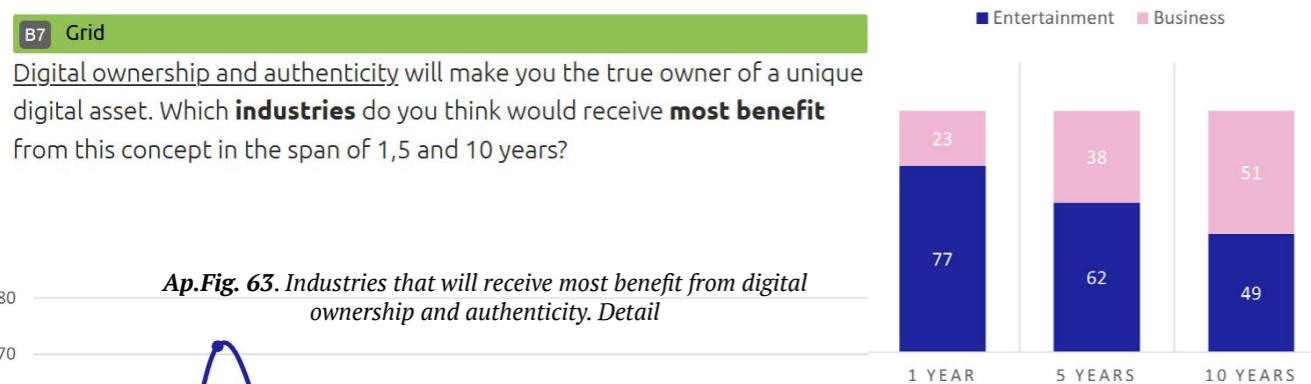
**Ap.Fig. 59. Usefulness of authenticity in the digital world****B5 Dropdown**

Do you think that digital authenticity can help in bringing the **physical and digital** worlds together? Rate on a scale of 1 to 7, with 1 being "Not at all" and 7 being "For sure".

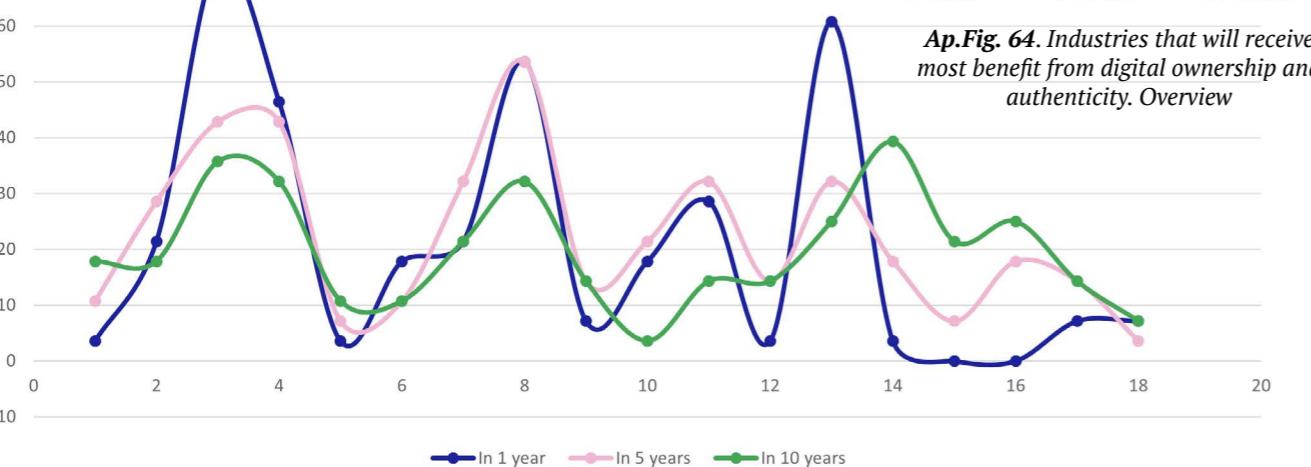
**Ap.Fig. 60. Usefulness of digital authenticity to bridge physical and digital worlds****Ap.Fig. 61. Usefulness of digital authenticity VS. ownership to bridge physical and digital worlds**



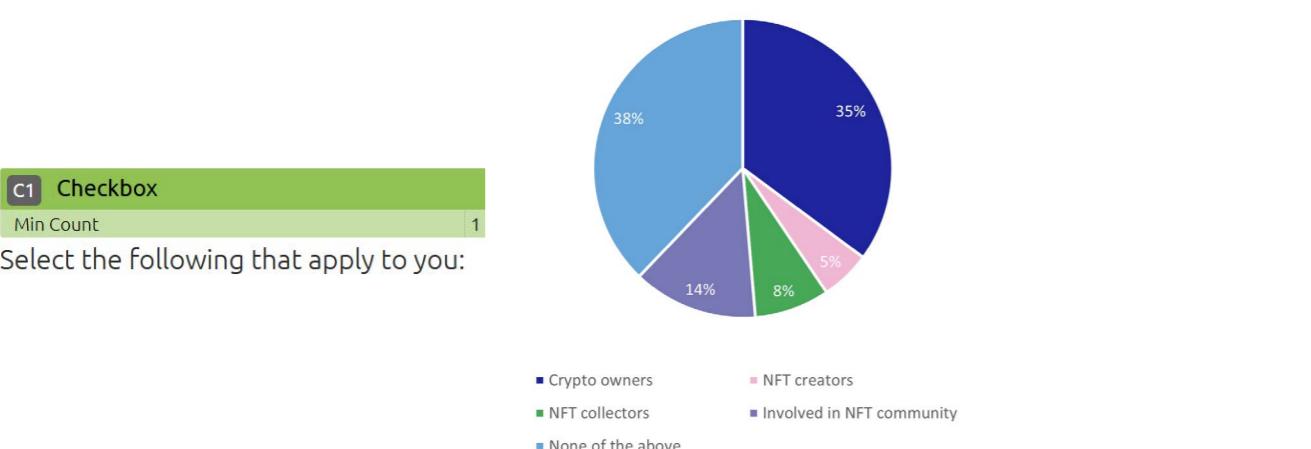
Ap.Fig. 62. How can digital authenticity bridge physical and digital worlds



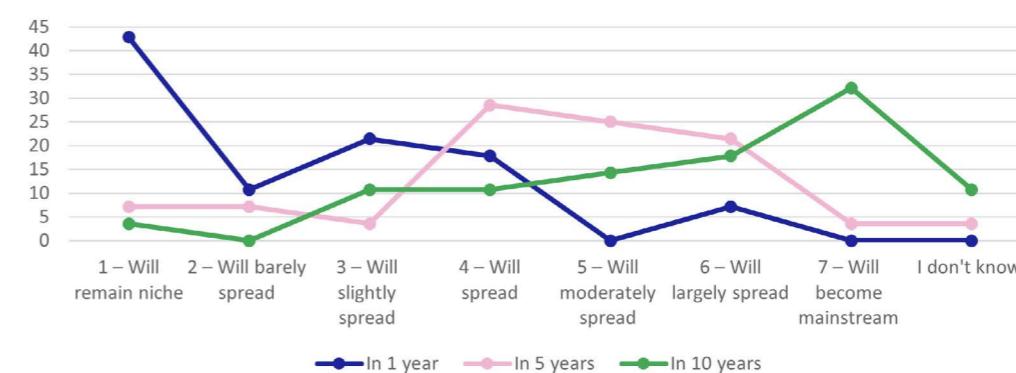
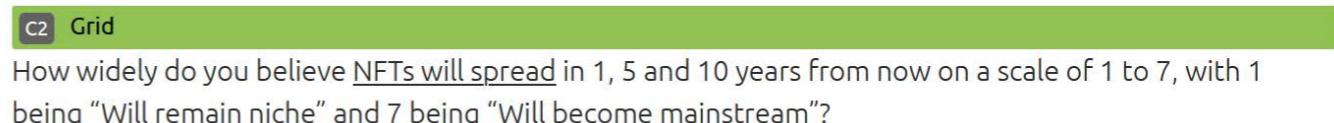
Ap.Fig. 63. Industries that will receive most benefit from digital ownership and authenticity. Detail



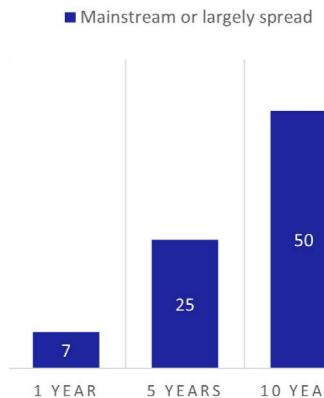
Ap.Fig. 64. Industries that will receive most benefit from digital ownership and authenticity. Overview



Ap.Fig. 65. Users and their engagement with NFTs and crypto



Ap.Fig. 66. How widely NFTs will spread in different time spans. Detail



Ap.Fig. 67. How widely NFTs will spread in different time spans. Overview

**C2\_Extra** Text

Require a response	No
Response Defaults	
Min length	0
Max length	2000

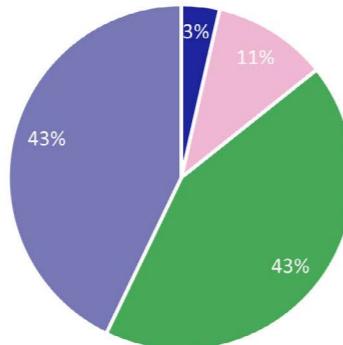
Please tell us why you picked these options.

- "It took 5 years for Cryptocurrency to become "mainstream". I don't see the same happening to NFTs"**
- "The appeal of NFT's is undeniable and we are only scratching the surface of what they will enable. However, 2021 saw a boom in speculative activity around NFT's (not so different from ICO's). I am expecting a negative reaction and some disillusionment in the market (similar to the Internet "bubble bursting" in 2001 before the industry retools and things truly take off.)"**
- "NFTs will hype but not sure if they will grow in trades or as a tool"**
- "As generations age up it will become more mainstream"**
- "Right now NFTs are mostly seen as investments and they have little to no underlying utility. However, in the long term I can see several industries leveraging NFTs as a way to authenticate ownership in a safer, hack-proof way"**
- "NFTs will penetrate most industries in the next 3-5 years"**
- "NFTs and the whole web3 concept will need to be completely in the background to become mainstream, such that consumers don't even really know its there"**
- "Find it though to see all the applications of NFT. Easier for Blockchain or crypto's. But I believe I underestimate the NFT's."**
- "I think there will be a craze for the next 3-5 years, then a better technology will supplant NFTs by 10 yrs from now."**

10. "I think that the ownership of digital assets spread constantly for the importance of community and decentralization of ownership"
11. "New use cases will appear and people will learn more about the tech, making it more meaningful in people's lives. Current issues will be resolved and the ecosystem as a whole will mature, making people more comfortable to own and use NFTs. This being said, I'm not sure 10 years will be enough for NFTs to become mainstream."
12. "NFT will be a basic technology in games, virtual worlds and for digital assets and become "normal"

**C3 Radio**

Choose the option that you believe is most realistic in the near- to mid-future.



- NFTs have no valuable applications at all (%)
- NFTs only belong to the digital world and cannot have valuable applications in the physical world (%)
- NFTs can have very limited valuable applications in the physical world (%)
- NFTs can have a wide range of valuable applications in the physical world (%)

Ap.Fig. 68. Applications of NFTs

**C3\_Extra Text**

Require a response	No
Response Defaults	
Min length	0

Max length 2000

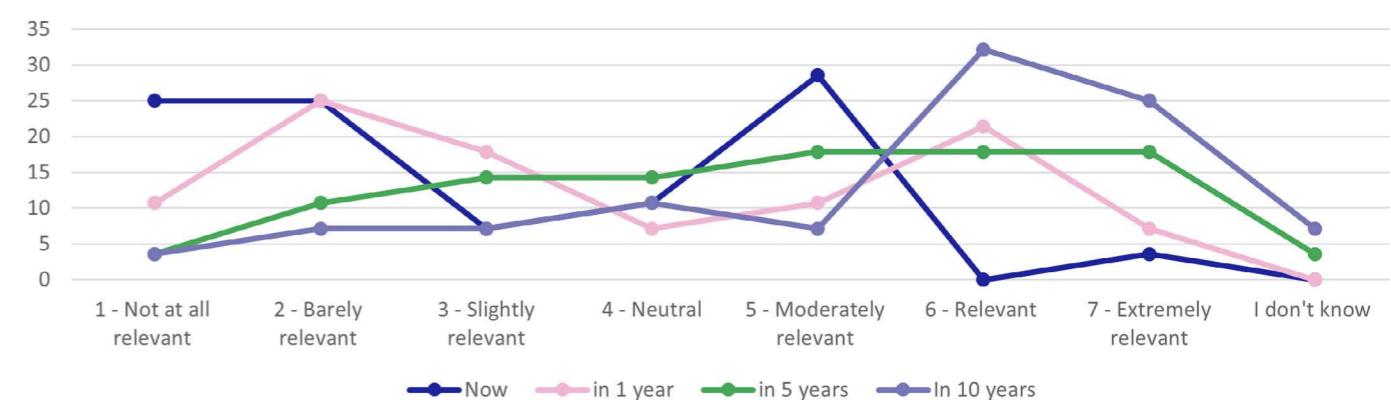
Please tell us why you picked this option.

1. "Already many processes in the physical world are supported by digital systems and applications. NFTs could take this to the next level and remain valuable in the digital world as well"
2. "It will take years for them to become Mainstream , but that will happen because real cases won't take time to grow. Projects run through NFTs with real utility already exist and time will only bring more to the table."
3. "Unless you have a physical product with some sort of link to the digital word -either through the device itself or a code you can ready with your phone- it has no link with the digital world."

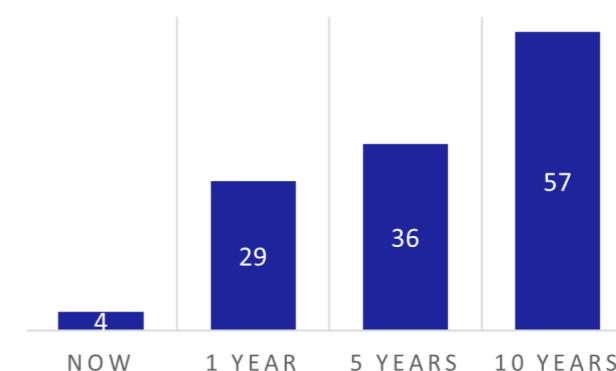
4. "The concept of digital to physical is all around us already (such as Warby Parker) and a generation growing up with smart phones understands that intuitively."
5. "People will try to make money trading NFTs... that's a problem I think"
6. "Physical assets are made more valuable by authentication"
7. "Concept of membership type cards for real life benefits are clear, but not huge value and already sort of exist - would just intertwine digital activity to it. Otherwise hard to think of obvious physical applications that are huge value at this point."
8. "See previous answer, hard to see other applications than collecting artist images or collectable pictures of historical events etc."
9. "Because there are a lot of market where could be used: like ticketing, certifications, rights ownership, brand whitelists..."
10. **Can't think of any application for NFTs in the physical world in the mentioned timeframe.**
11. "Depending on brands, products and purposes NFTs can give access to virtual or real life events and experiences"

**C4 Grid**

What do you think is the relevance of NFTs for *community building* in the **digital world** in the following time stamps? Rate on a scale of 1 to 7, with 1 being "Not at all relevant" and 7 being "Extremely relevant".



Ap.Fig. 68. Relevance of NFTs for community building in the digital world over different time spans. Detail



Ap.Fig. 69. Relevance of NFTs for community building in the digital world over different time spans. Overview

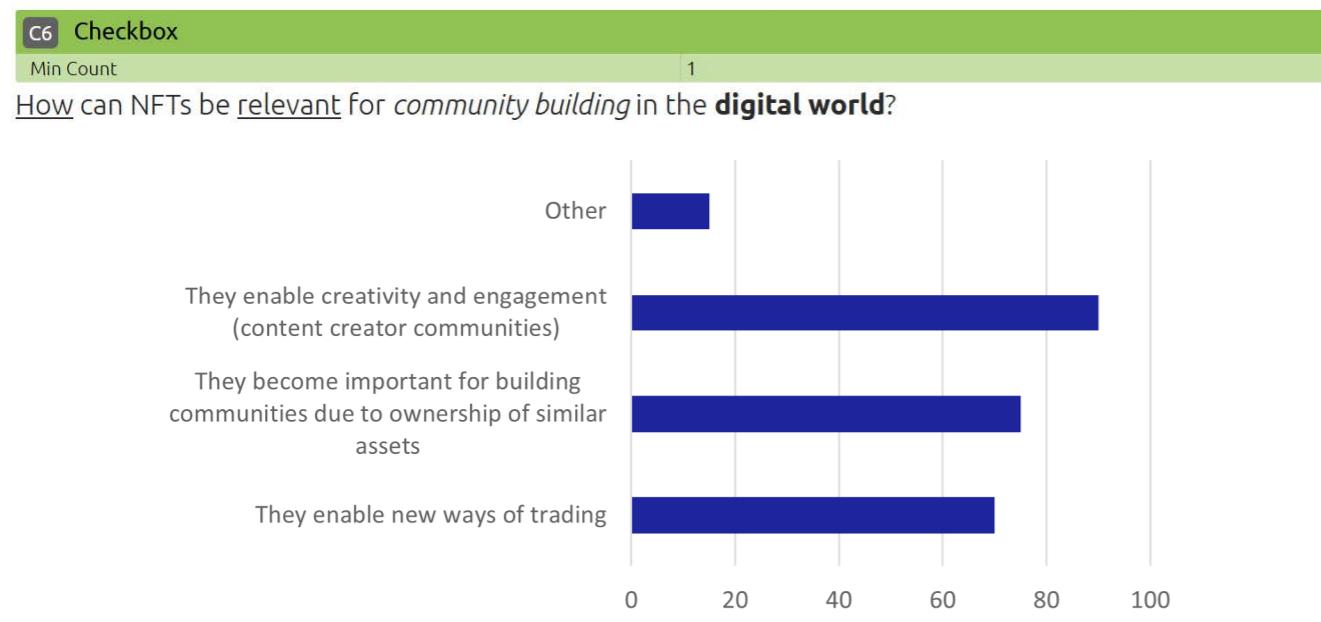
C5	Text
Response Defaults	
Min length	0
Max length	2000

What do you believe is the main reason?

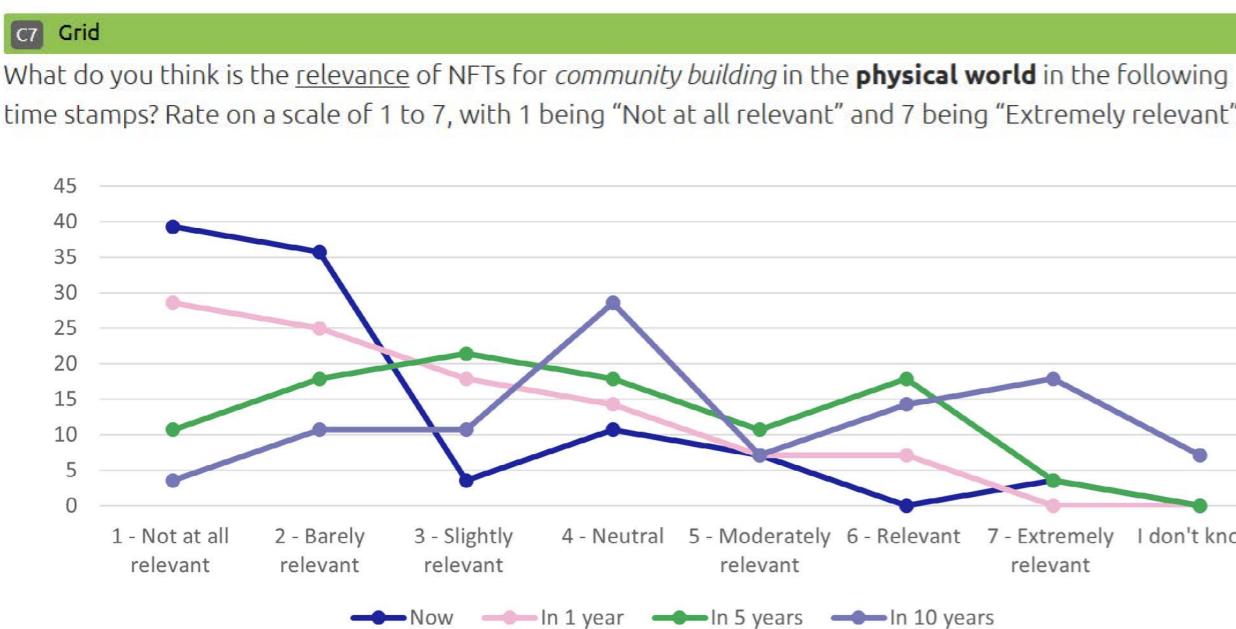
1. **“Communities form around common interests. NFTs can be related to these interest and help bond and grow the community. At the same time not every member of a community might find ownership and authenticity equally important.”**
2. **“Depending on the company’s business model & approach towards each audience it will make sense to be an innovator bringing the space to the customers, rather than the customers asking for that space within their consumer journeys in those brands.”**
3. **“As we move to a more digital world, and with the development of parallel digital “universes” the option of having something only yours its more attractive”**
4. **“Communities are like brand evangelists, without this a brand would not take part of the modern world”**
5. **“There’s a lot of information to be explained about something that is going to become important in our lives, so people are gonna want to now about, to be a part of it”**
6. **“Understanding and knowledge of the new related concepts need time to spread”**
7. **“Able to purchase or swap assets”**
8. **“Communities are built around a particular interest. Some more niche ones on what people own (shoes, cars). NFTs could be relevant for “proving” you’re part of the latter community, but it can also be used to “Gatekeep”.”**
9. **“The value of NFT’s and what they can is going to expand; it will bring people together around common interests and purposes -- many potentially through DAO’s.”**
10. **“We first need a usable Metaverse or similar to connect to...unless you also take social media into the equation”**
11. **“Its mainly going to be used for scams”**
12. **“Everyone wants access and to belong to something”**
13. **“Ownership of certain assets has always had societal implications. As the concept of shared virtual communities becomes more relevant, owning NFTs will gradually become more relevant”**
14. **“The NFT market places are creating a big community of people that want to exchange their NFT”**
15. **“NFTs is about community, sharing and enjoying life and collectibles from a holistic approach (digital and physical worlds)”**

16. **“NFTs are all about communities. Companies must integrate NFTs into their CRM strategies within the next 12-18 months.”**

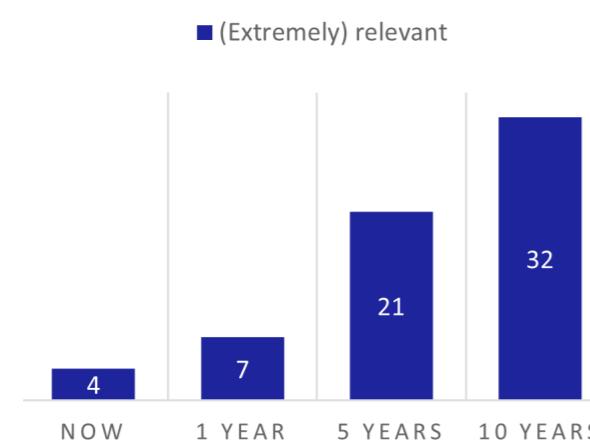
17. **“Because people want to use another tech than accounts/database.”**
18. **“NFTs are the instrument to redistribute value creation in the digital world, which will be a huge incentive for community building”**
19. **“I see communities but I find it hard to understand why people have them. Feels like a frenzy?”**
20. **“It’s a hype bubble where people will be disappointed in their returns”**
21. **“Sense of ownership, provable belonging to community, opportunity to identify members and reward them etc.”**
22. **“Communities built around NFTs don’t make sense, as substitute techs function just the same (or are better) than NFTs.”**
23. **“Because the decentralization bases its power on the community. In the recently years the evolution from social to community is spreading a lot”**
24. **“I think it’s a hype bubble with little use cases right now. These use cases will likely materialize in the coming decade”**
25. **“Right now, NFTs in the context of community building have very limited applications. Some people can use them to differentiate their Twitter profile photos shape and I assume other social platforms might do the same, but other than that there are no other meaningful applications. Assuming NFTs will continue to expand, I assume new use cases will be created as time passes which will make them more meaningful in establishing a sense of community with unique actors.”**
26. **“Community of tech enthusiasts focussed on NFT”**
27. **“Can provide a community”**
28. **“Collectors love to show off their assets and identify with items to discuss with same minded people.”**



Ap.Fig. 70. Relevance of NFTs for community building in the digital world



Ap.Fig. 71. Relevance of NFTs for community building in the physical world over different time spans. Detail



Ap.Fig. 72. Relevance of NFTs for community building in the physical world over different time spans. Overview

**C8 Text**  
Response Defaults  
Min length 0  
Max length 2000

What do you believe is the main reason?

1. *"Part of the fun of ownership is showing other people or sharing it with other people. Showing and sharing in the digital world only is suboptimal in that sense. Preferably it would add value to a physical community experience or growth."*
2. *"Repeated question/answer"*
3. *"The interplay between the physical and the digital world is still reduced. However, the development of 3D printing could prove useful for the "translation" of certain things into the physical world"*
4. *"A community building is the only way a brand survives in an ever more digital world. If not, other brands will dethrone with their network effects"*
5. *"It is going to become such an important part of our society, just like paintings or real estate"*
6. *"Physical world mapping to NFTs is not a real need, and difficult to build trust"*
7. *"Hard to translate NFT to the physical world"*
8. *"Same answer to the previous question - only relevant for validating authenticity of items that are sought after in a community."*
9. *"As mentioned earlier, digital to physical is self-evident for the generation that grew up with the iPhone."*
10. *"Money seems to be the main reason now... and there is no clear indicator for value that creates unpredictable behaviour just like cryptos"*
11. *"See previous"*
12. *"Fractional ownership of assets will become more mainstream and easily traceable. Owning an NFT gives you access to special clubs, experiences and real estate."*
13. *"While I see how NFTs could have utility in the physical world, I don't think they will be relevant for building relations/communities in it."*
14. *"The link between the digital and physical is still not very much developed"*
15. *"Community building is always relevant!"*
16. *"Same as in the digital world. Physical and digital will converge."*
17. *"Like for memberships proofs"*
18. *"Sorry - main reason for what?"*

19. "Like previous answer: it is happening and I don't really get it."

20. "I don't believe NFTS have a role in community building outside of maybe gaming"

21. "Linking ownership to real life events and products."

22. "I see no mechanism by which physical in-person communities can form around NFTs spread across the world digitally"

23. "Because the possibility matched with NFTs are enormous: with ticketing, benefits related to events or entertainment, feedbacks or exclusive merch, exclusive pass for events or manifestations,...,"

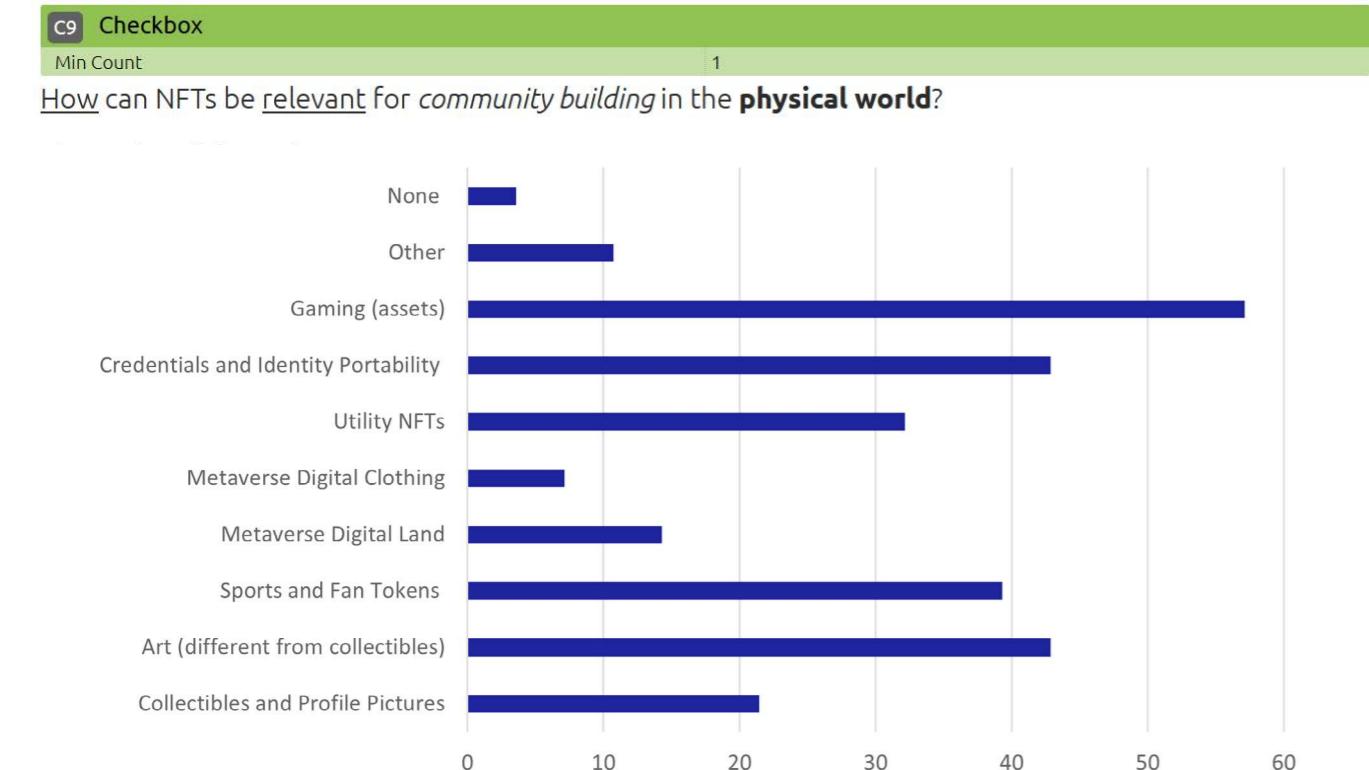
24. "Technology hasn't proven itself yet, but might"

25. "It's harder for me to see meaningful ways of community building in the physical world for NFTs other than groups of people with similar assets/interests getting together in dedicated events. As NFTs spread, the audience interested in them will likely grow making such events more relevant."

26. "Increasing use of NFT applications"

27. "Not sure"

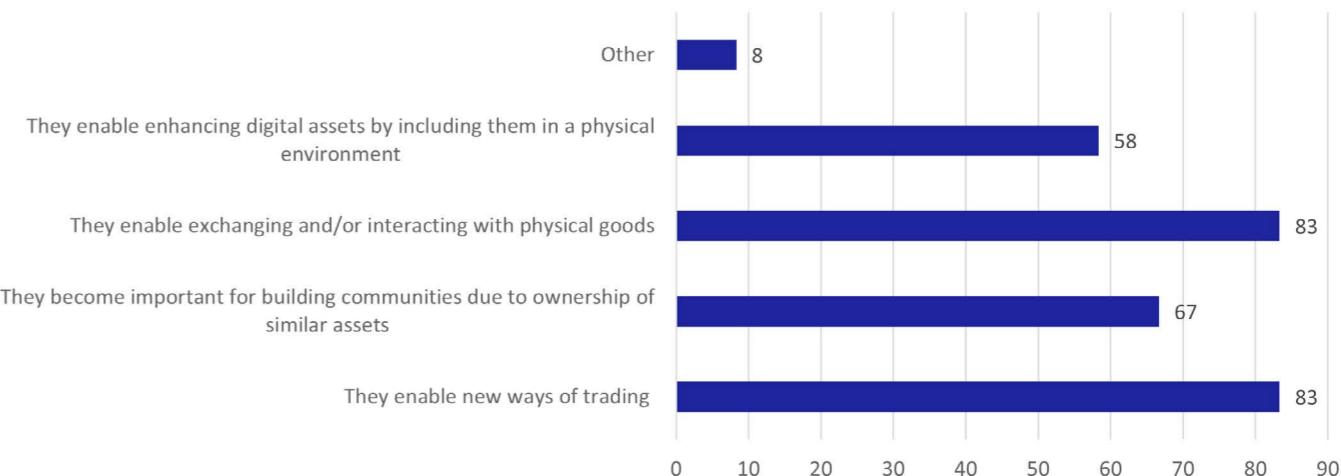
28. "The physical world still needs to be experienced without being forced to use NFTs"



Ap.Fig. 73. Relevance of NFTs for community building in the physical world

C10 Checkbox	
Min Count	1
Max Count	3
Randomize responses	START to END, Not randomized 1 to 10, Randomized 9, anchored 10, anchored

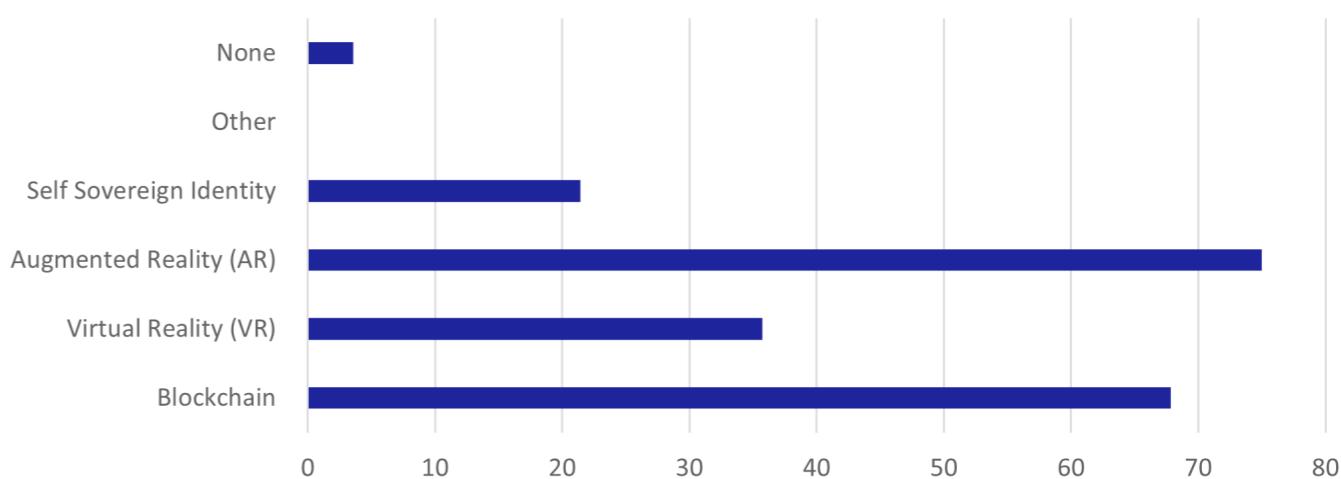
What type of NFT do you believe will be most relevant for community building in the **future**?



Ap.Fig. 74. Type of NFT most relevant for community building in the future

C11 Checkbox	
Min Count	1
Max Count	3

What technology do you believe is most suitable for bringing **physical and digital worlds** together?



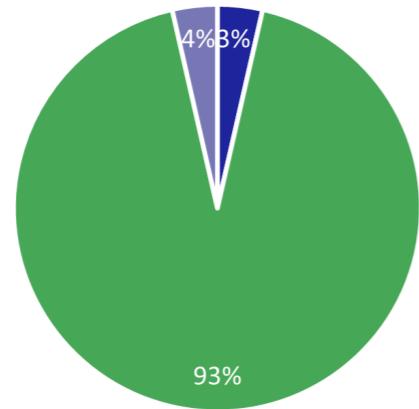
Ap.Fig. 75. Most suitable technology to bridge physical and digital worlds

C11_Extra Text	
Require a response	No
Response Defaults	
Min length	0
Max length	2000

Please tell us why you picked these options.

1. **“VR closes you off from the physical world, AR mixes both. Blockchain has the potential to solve several physical world limitations and problems.”**
2. **“I think is a good way to mix them without the need of living it”**
3. **“Interaction with the digital world has become more physical over the last few years as consumer-level VR devices, such as the Quest 2, become available. We’ve seen games like Rec-Room, Beat Saber and VRChat, where new communities have emerged. Augmented reality will bring that back to the real world. The blockchain is mostly useful for decentralized authentication of payments and ownership of real world goods - and is far less tangible than the other two.”**
4. **“NFTs are built on the blockchain; AR reaches everyone with a smartphone (so everyone); governments will gain great value by helping to digitize identity”**
5. **“Those technologies are improving and can bring solutions to other industries”**
6. **“Because blockchain is the really powerful technology of the crypto world”**

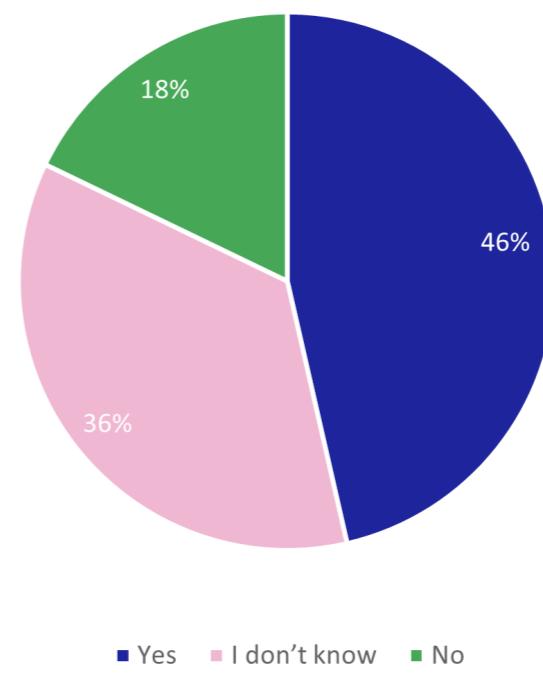
C12 Radio	
Please tell which of the statements best describes in your opinion the <u>added value</u> of <u>bridging physical and digital worlds</u> :	



- Value is only added to the digital environment
- Value is only added to the physical environment
- Value is added to both environments
- Value isn't added to either of the environments

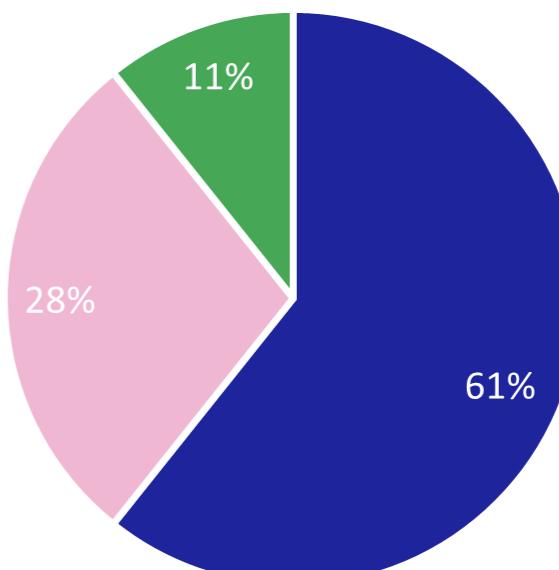
Ap.Fig. 76. Value added when bridging physical and digital worlds

C13 Radio	
Do you think more <u>applications</u> of NFTs in the <i>physical world</i> can add extra <u>value</u> and at the same time enrich the experience in the <i>digital space</i> ?	



Ap.Fig. 77. Value added when applying NFTs in physical space

C14 Radio	
Would a <u>physical product</u> that enables <u>physical interaction with NFTs</u> (e.g., showcasing your NFTs in a real environment with the use of Augmented Reality or exchanging them for physical goods) be <u>interesting</u> in your own opinion?	



Ap.Fig. 78. Interest in a physical product that enables physical interaction with NFTs

## Appendix 07. Questions Interviews to Users

- Q1- Do you own a NFT?
- Q2- Why did you decide to buy/create one?
- Q3- Which types of NFTs do you have?
- Q4- What is the process of getting them?
- Q5- Do you find any struggles in the process or any step you would like to improve?
- Q6- What do you do with the NFTs once you own them?
- Q7- What is the best and worst part of having a NFT?
- Q8- Can you show me your NFT? First with a computer laptop, second with your phone
- Q9- Do you feel there is any difference between showing them online or with the phone?
- Q10- Are you often asked to show your NFTs? Why?
- Q11- How would you describe the process of showing your NFTs, in terms of speed, comfort, safety and visualisation?
- Q12- Would a product that helped you showing your NFTs with the use of only one app, faster than the current method, safer and optimised for visualisation be interesting for you?

## Appendix 08. Interviews. Profile Insights

### Participants. Profit Seeker

- Visualization is a very important aspect
- Community is very relevant in NFT space
- Security concerns when visualizing
- Only share with other users

### Insights

- Showing your NFTs is a big part of owning them
- Concerns with security (not even wanting to have the wallet app installed)
- Showcasing mostly happens when owning a famous collection and between users who have NFTs.
- People don't generally ask you to show your NFTs, but it will be relevant in the future

A product that makes the process of showcasing easier and increases security is VERY attractive.

### Participants. Learner and Curious

- Visualization in social media is a must
- Visualization in a real environment is attractive
- Community is very relevant in NFT space
- Security concerns in general
- Barely share

### Participants. Art Collector

- Visualization is most relevant, but already easy (wallet)
- Centralized environment to show NFTs is very attractive
- Easy to visualize
- Security concerns expected due to novelty. Not too worried
- Never asked to share

### Participants. Game Developer

- Visualization is critical for mainstream adoption
- Centralized environment to show NFTs is very attractive and needed
- Wallets are not adapted to visualization. In general too many issues even in platforms
- Security concerns. Expected improvement
- Never asked to share, but sees it key for the future (utility NFTs)

## Appendix 09. NFT Standards

As mentioned beforehand, another crucial element for the structure of a Smart Contract, apart from the blockchain, is the standard used. The types of standards are the following:

ERC 20. This standard is not an NFT standard but a fungible token standard (used for cryptocurrency for example). It defines a token equal to its equivalents (*Pilehchiha, 2022*)

ERC 721. This is a standard for NFTs that implements an API function meaning that it is easy to communicate and interact with the smart contract thanks to the use of functions (*Tarcan, 2022*).

ERC1155. It is a multi token standard. It can do what the previous 2 can integrated in one. Its benefits come by the hand of batch transactions of NFTs mixed with currencies (*Douglas, 2022*). This standard is extremely useful in the gaming industry where money and object trading are very common. The main difference with the ERC 721 standard is that it allows for batch transfer, while the ERC 721 only allows the transfer of one NFT at a time. This saves a lot of power and avoids fees.

The standard for the Smart Contracts presented will be ERC 1155 as it is the most flexible standard and the one necessary for the gaming industry.

To sum up, a NFT defined by an ERC 1155 Smart Contract in the Ethereum network would be identified by an address and will contain certain functions and events. The ABI (*Appendix 12*) will let us interact with the functions and the metadata (*Appendix 12*) will show the properties and attributes of the smart contract, including the links to where the actual asset is located.

Finally, as referred previously, NFTs are almost impossible to hack if the Smart Contract lives in the blockchain, which highly grants ownership

(at least out of legal regulations, which are non-existent in this environment). However, due to the fact that NFTs are essentially code, they can get corrupted and be useless. This could happen due to bad coding or files being deleted from their storage. As mentioned, the files do not live in the blockchain but in servers, which could be compromised or centralised, meaning that the content is controlled by a person or entity.

However, if the file is stored in a decentralised database it is extremely complicated that they get compromised, as they are redundant and the whole network would have to fail at the same time. Therefore, NFTs are not immortal or 100% secure, but they do a great job at providing digital ownership and authenticity for digital assets, as well as enhancing the trading capabilities online.

## Appendix 10. Visualisation Methods

### In native platforms (in-game)

- Only able to visualize the NFTs belonging to that platform.
- Interoperability is not a reality
- Need to login in the platform
- Dependent on the platform
- Security issues when connecting wallet

### Through a marketplace

- Highest variety of types of NFTs
- Multiple protocols
- Only able to visualize the NFTs belonging to that platform.
- Limited blockchains
- Too many different marketplaces
- When used in phone 1 app needed per marketplace
- Security concerns when connecting the wallet (api)

### Inside wallets

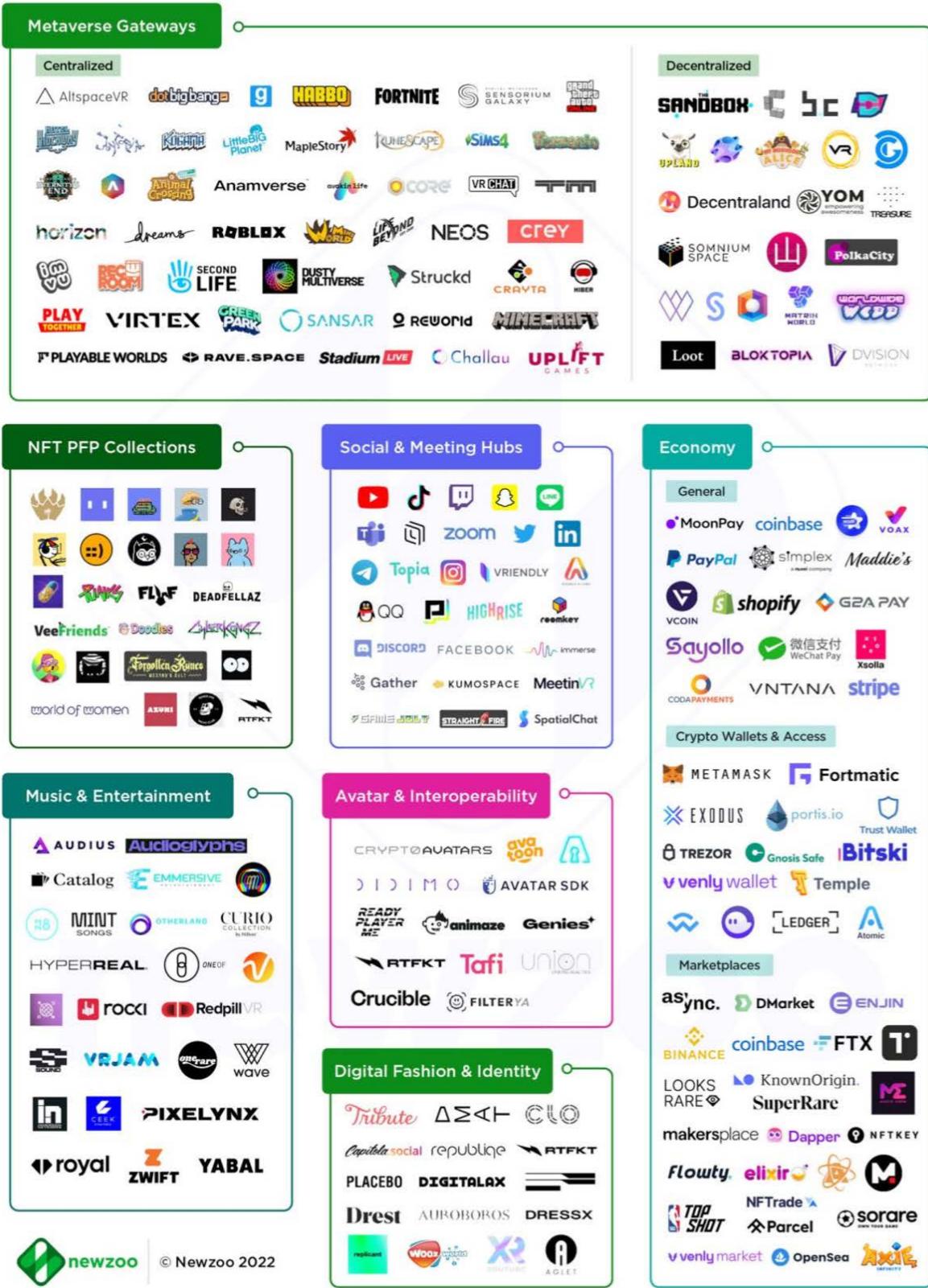
- Highest security of all (when standalone)
- Security issues when connecting to other services
- All NFT formats available
- Can connect multiple blockchains
- Not optimized for visualization (most limited of all options)

### Online social media sites

- Optimized for visualization
- VERY unreliable
- Security concerns when connecting the wallet
- All NFT formats available
- Limited blockchains

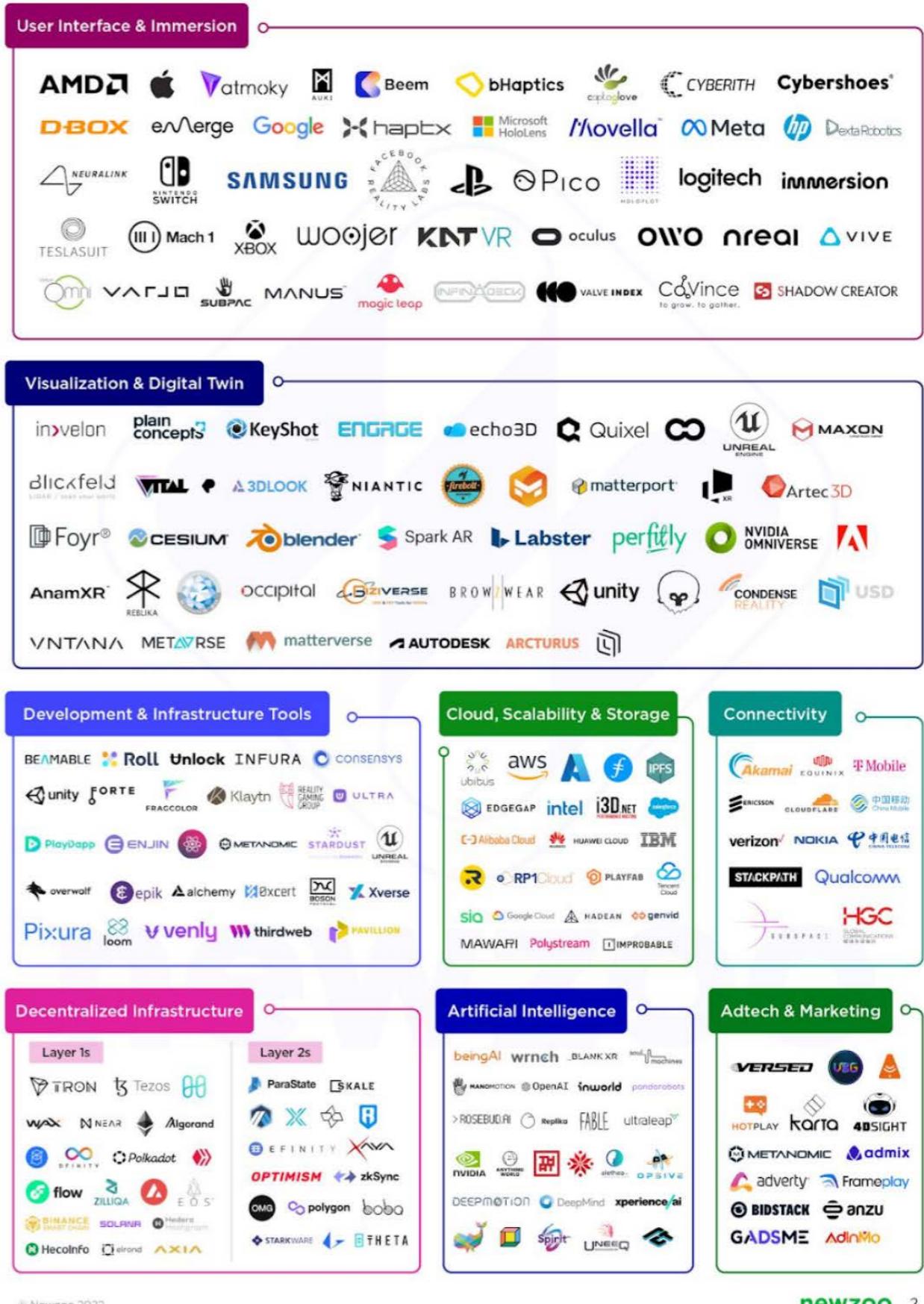
# Appendix 11. Metaverse Stakeholders Overview

## Metaverse Ecosystem Diagram (1/2)



Ap.Fig. 79. Metaverse ecosystem diagram (1/2). Source (Newzoo, 2022)

## Metaverse Ecosystem Diagram (2/2)



Ap.Fig. 80. Metaverse ecosystem diagram (2/2). Source (Newzoo, 2022)

## Appendix 12. Interaction with Smart Contracts

As previously mentioned, users can interact with smart contracts. To do this, 2 crucial elements must be known: the metadata and the ABI.

The metadata in general terms is data that provides information about other data. In NFTs, it is a piece of information that describes the NFT's essential properties (NFT School, 2022), (Pastel, 2021). An example of NFT metadata can be seen in *Ap.Fig 81*. NFTs can be any type of digital asset (pictures, music), but cannot be stored directly in the blockchain due to the big amount of space they require, which is translated into computing power and eventually money. To have an idea of how expensive this is, to store 1 gigabyte of data in the Ethereum blockchain the cost would be equivalent to 35 million USD, as of June 2021 (Gemini, 2022). Therefore, what is stored in the blockchain is the Smart Contract, containing the metadata link (URI). The metadata is a JSON file and contains the links where the assets are stored. JSON stands for JavaScript Object Notation, and is a lightweight format used to store and transport data (W3Schools, n.d.). Its advantages are that it is easy to understand and takes very little memory.

An example of a place where NFT assets are stored is the Interplanetary File System (IPFS) (Athanere

```
{
  "description": "Friendly OpenSea Creature that enjoys long swims in the ocean.",
  "external_url": "https://openseaCreatures.io/3",
  "image": "https://storage.googleapis.com/opensea-prod.appspot.com/puffs/3.png",
  "name": "Dave Starbelly",
  "attributes": [ ... ],
}
```

*Ap.Fig. 81. Metadata. Source (Opensea Developers, 2022)*

& Thakur, 2022), (Benet, 2014). IPFS is a peer-to-peer distributed file storage system based on hyperlinks to identify the data (IPFS, 2022).

The Application Binary Interface (ABI) is created by the compiler of the smart contract (K.K, 2022), (Smith, 2022). The ABI is also a JSON file, but describes the deployed contract and its smart contract functions. This helps bridge the gap between web2 and web3. JSON format is used for the ABI because it is needed to understand and call the contract's functions. An example of an ABI contract can be seen in *Ap.Fig. 82*.

```

1  [
2    {
3      "constant": true,
4      "inputs": [],
5      "name": "name",
6      "outputs": [
7        {
8          "name": "",
9          "type": "string"
10        }
11      ],
12      "payable": false,
13      "stateMutability": "view",
14      "type": "function"
15    },
16    {
17      "constant": false,
18      "inputs": [
19        {
20          "name": "_spender",
21          "type": "address"
22        },
23        {
24          "name": "_value",
25          "type": "uint256"
26        }
27      ],
28      "name": "approve",
29      "outputs": [
30        {
31          "name": "",
32          "type": "bool"
33        }
34      ],
35      "payable": false,
36      "stateMutability": "nonpayable",
37      "type": "function"
38    },

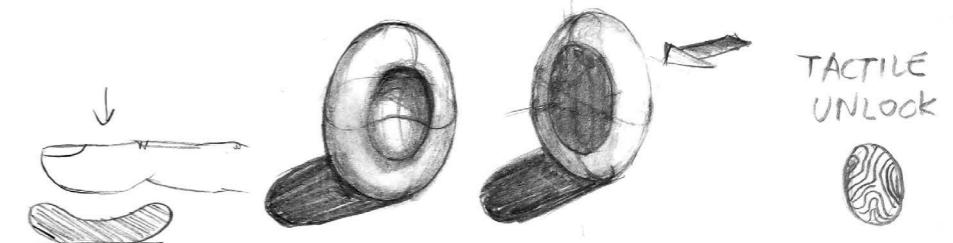
```

*Ap.Fig. 82. ABI contract. Source (Smith, 2022)*

## Appendix 13. Harris Profile Results

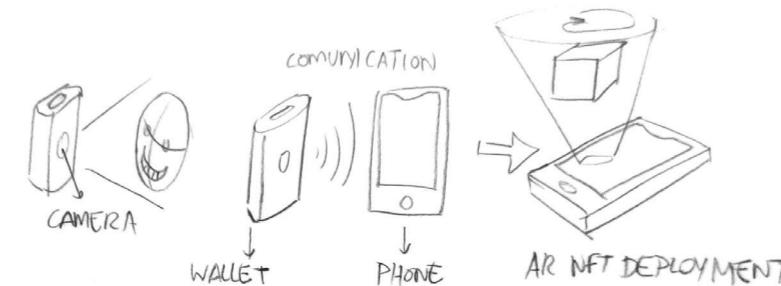
IDENTITY OF A PERSON:

- NAME
- COUNTRY
- BIRTH DATE
- SIGNATURE
- FINGERPRINT 



	--	-	+	++
Connectivity with phone				
Object should advocate NFT properties (authenticity & ownership )				
Adaptability to any type of user (uniqueness). Flexible design				
Usability. Simple to interact with				
Technology simplicity				
Desirability. How attractive could it be for early adopters				
Mass production possible				
Cheap				
Durability				
Portability				
Environmentally friendly (avoid e-waste)				
Safety				
Resistance to different environments				

*Ap.Fig. 83. Harris profile. Tactile direction*



	--	-	+	++
Connectivity with phone				
Object should advocate NFT properties (authenticity & ownership )				
Adaptability to any type of user (uniqueness). Flexible design				
Usability. Simple to interact with				
Technology simplicity				
Desirability. How attractive could it be for early adopters				
Mass production possible				
Cheap				
Durability				
Portability				
Environmentally friendly (avoid e-waste)				
Safety				
Resistance to different environments				

*Ap.Fig. 84. Harris profile. Facial recognition direction*

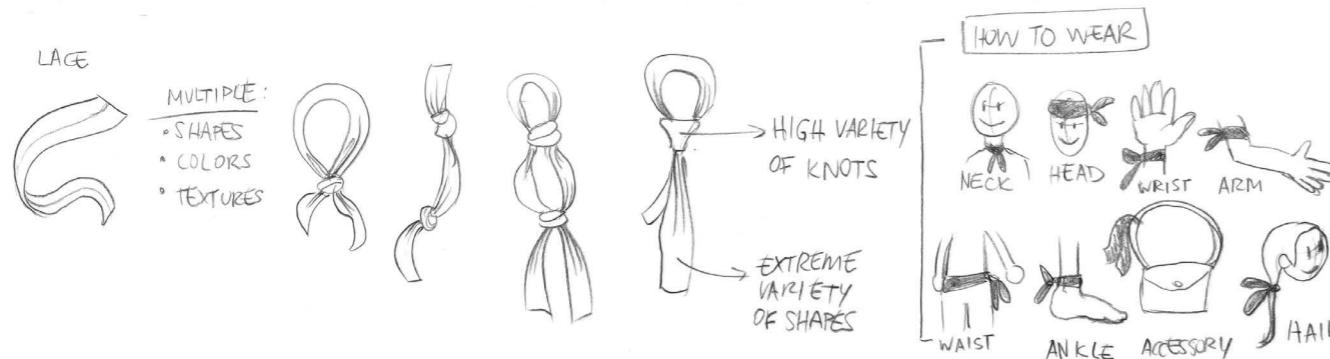


PERSONAL  
INTIMATE

ENABLED BY  
TOUCH  
(WARMTH)

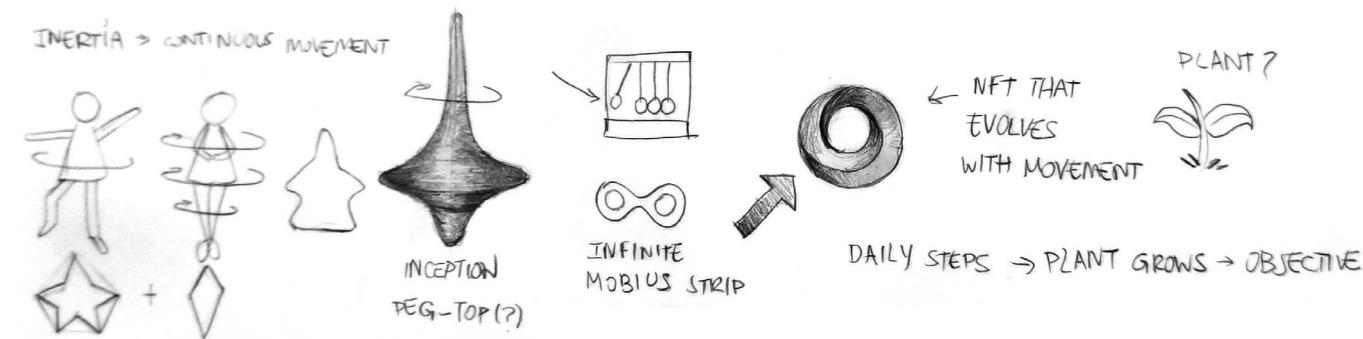
	--	-	+	++
Connectivity with phone				
Object should advocate NFT properties (authenticity & ownership )				
Adaptability to any type of user (uniqueness). Flexible design				
Usability. Simple to interact with				
Technology simplicity				
Desirability. How attractive could it be for early adopters				
Mass production possible				
Cheap				
Durability				
Portability				
Environmentally friendly (avoid e-waste)				
Safety				
Resistance to different environments				

Ap.Fig. 85. Harris profile. Heat recognition direction



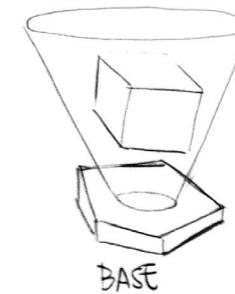
	--	-	+	++
Connectivity with phone				
Object should advocate NFT properties (authenticity & ownership )				
Adaptability to any type of user (uniqueness). Flexible design				
Usability. Simple to interact with				
Technology simplicity				
Desirability. How attractive could it be for early adopters				
Mass production possible				
Cheap				
Durability				
Portability				
Environmentally friendly (avoid e-waste)				
Safety				
Resistance to different environments				

Ap.Fig. 86. Harris profile. Laces direction



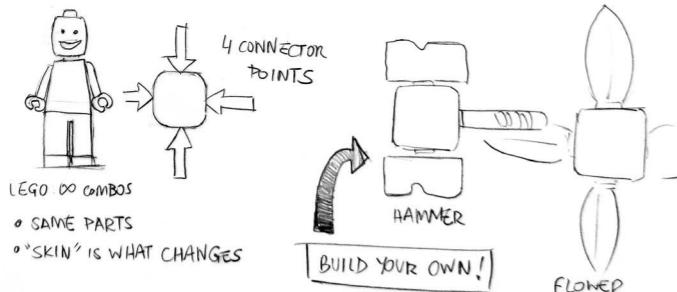
	--	-	+	++
Connectivity with phone				
Object should advocate NFT properties (authenticity & ownership )				
Adaptability to any type of user (uniqueness). Flexible design				
Usability. Simple to interact with				
Technology simplicity				
Desirability. How attractive could it be for early adopters				
Mass production possible				
Cheap				
Durability				
Portability				
Environmentally friendly (avoid e-waste)				
Safety				
Resistance to different environments				

Ap.Fig. 87. Harris profile. Spin and Mobius directions



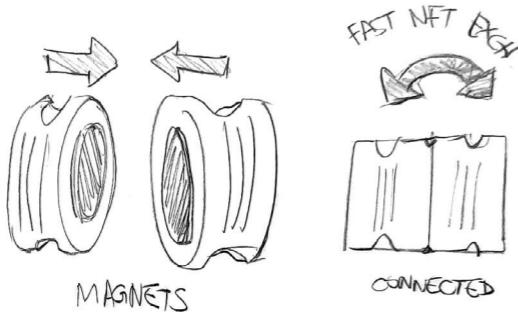
	--	-	+	++
Connectivity with phone				
Object should advocate NFT properties (authenticity & ownership )				
Adaptability to any type of user (uniqueness). Flexible design				
Usability. Simple to interact with				
Technology simplicity				
Desirability. How attractive could it be for early adopters				
Mass production possible				
Cheap				
Durability				
Portability				
Environmentally friendly (avoid e-waste)				
Safety				
Resistance to different environments				

Ap.Fig. 89. Harris profile. Hologram direction



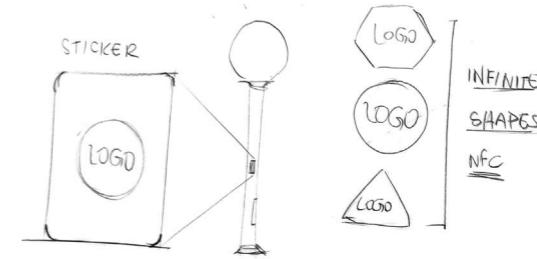
	--	-	+	++
Connectivity with phone				
Object should advocate NFT properties (authenticity & ownership )				
Adaptability to any type of user (uniqueness). Flexible design				
Usability. Simple to interact with				
Technology simplicity				
Desirability. How attractive could it be for early adopters				
Mass production possible				
Cheap				
Durability				
Portability				
Environmentally friendly (avoid e-waste)				
Safety				
Resistance to different environments				

Ap.Fig. 89. Harris profile. Lego direction



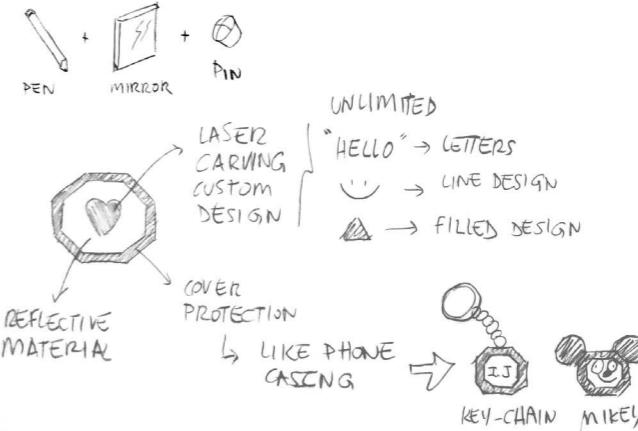
	--	-	+	++
Connectivity with phone				
Object should advocate NFT properties (authenticity & ownership )				
Adaptability to any type of user (uniqueness). Flexible design				
Usability. Simple to interact with				
Technology simplicity				
Desirability. How attractive could it be for early adopters				
Mass production possible				
Cheap				
Durability				
Portability				
Environmentally friendly (avoid e-waste)				
Safety				
Resistance to different environments				

Ap.Fig. 90. Harris profile. Magnet direction



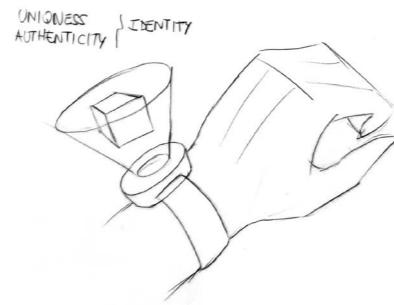
	--	-	+	++
Connectivity with phone				
Object should advocate NFT properties (authenticity & ownership )				
Adaptability to any type of user (uniqueness). Flexible design				
Usability. Simple to interact with				
Technology simplicity				
Desirability. How attractive could it be for early adopters				
Mass production possible				
Cheap				
Durability				
Portability				
Environmentally friendly (avoid e-waste)				
Safety				
Resistance to different environments				

Ap.Fig. 91. Harris profile. Sticker direction



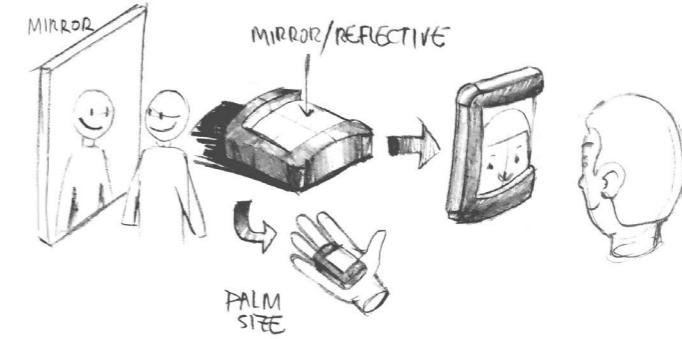
	--	-	+	++
Connectivity with phone				
Object should advocate NFT properties (authenticity & ownership )				
Adaptability to any type of user (uniqueness). Flexible design				
Usability. Simple to interact with				
Technology simplicity				
Desirability. How attractive could it be for early adopters				
Mass production possible				
Cheap				
Durability				
Portability				
Environmentally friendly (avoid e-waste)				
Safety				
Resistance to different environments				

Ap.Fig. 92. Harris profile. Mirror + pen + pin direction



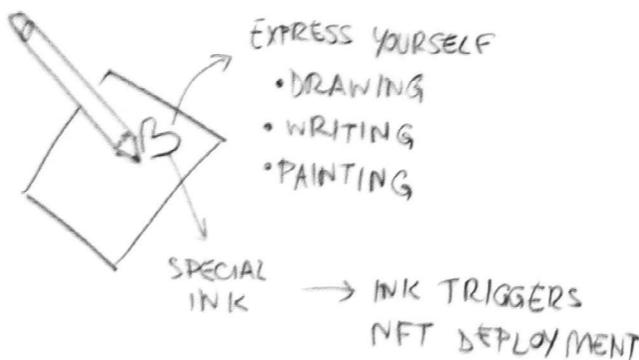
	--	-	+	++
Connectivity with phone				
Object should advocate NFT properties (authenticity & ownership )				
Adaptability to any type of user (uniqueness). Flexible design				
Usability. Simple to interact with				
Technology simplicity				
Desirability. How attractive could it be for early adopters				
Mass production possible				
Cheap				
Durability				
Portability				
Environmentally friendly (avoid e-waste)				
Safety				
Resistance to different environments				

Ap.Fig. 93. Harris profile. Wearable direction



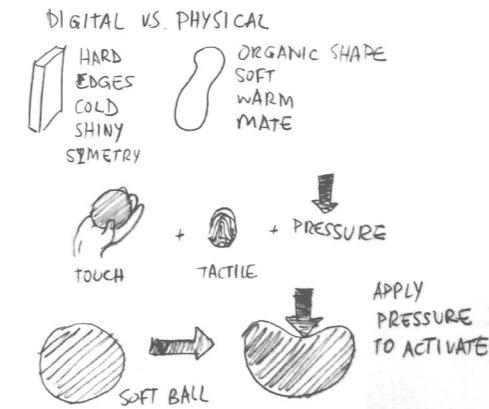
	--	-	+	++
Connectivity with phone				
Object should advocate NFT properties (authenticity & ownership )				
Adaptability to any type of user (uniqueness). Flexible design				
Usability. Simple to interact with				
Technology simplicity				
Desirability. How attractive could it be for early adopters				
Mass production possible				
Cheap				
Durability				
Portability				
Environmentally friendly (avoid e-waste)				
Safety				
Resistance to different environments				

Ap.Fig. 95. Harris profile. Mirror direction



	--	-	+	++
Connectivity with phone				
Object should advocate NFT properties (authenticity & ownership )				
Adaptability to any type of user (uniqueness). Flexible design				
Usability. Simple to interact with				
Technology simplicity				
Desirability. How attractive could it be for early adopters				
Mass production possible				
Cheap				
Durability				
Portability				
Environmentally friendly (avoid e-waste)				
Safety				

Ap.Fig. 94. Harris profile. Drawing direction



	--	-	+	++
Connectivity with phone				
Object should advocate NFT properties (authenticity & ownership )				
Adaptability to any type of user (uniqueness). Flexible design				
Usability. Simple to interact with				
Technology simplicity				
Desirability. How attractive could it be for early adopters				
Mass production possible				
Cheap				
Durability				
Portability				
Environmentally friendly (avoid e-waste)				
Safety				
Resistance to different environments				

Ap.Fig. 96. Harris profile. Warmth + tactile + pressure direction

# Appendix 14. Pride. Feel Exploration in the Entertainment Industries

First, the definition of pride is presented, which derives into an association to different concepts extracted from that definition and my personal knowledge of the entertainment industry. After the concepts were created I conducted online observations to identify the common concept of pride for the gaming, art and music industry. The result was then compared to the NFT industry. The relevance of this comparison lies in identifying if the pride feeling has the same associations in the entertainment industry as well as the entertainment.

Pride is a feeling of satisfaction linked to self-esteem or possession of something others admire (*Oxford Learner's Dictionaries*, n.d.). Furthermore, a universal way of expressing pride for humans consists of an upward-tilted face position with an expanded pose. This is even found in blind people (Durkee *et al.*, 2019). Therefore, when users express their intentions of showing-off their assets, that feeling is unequivocally linked to pride.

To have a better grasp of this emotion, I created a collage (Ap.Fig. 97) where pride is illustrated in the form of actions, situations and objects.



Ap.Fig. 97. Collage. Pride feeling

Pride in the entertainment environment can be associated with different concepts depending on the industry. From the definition presented previously and personal knowledge of the sector, I derived that the emotion is associated to:

- Belonging to a group
- Success/ achievement/ progress
- Possession
- Technique/ beauty
- Size

After the identification of these associations of pride in the entertainment sector I deepened the exploration making distinctions between the three major industries of the space (games, art, music). The goal was to identify which of these associations of pride was the predominant in the 3 industries, to further compare it with the associations it has in the NFT industry. The information collected is the outcome of observations. I conducted those observations online, mostly on social media, where people express more freely their emotions and thoughts.

How pride is manifested in games (Ap.Fig. 98).

- Belonging: clans, groups, teams
- Success, achievement, progress. In many cases this is represented with medals, cups, stars and gems/ precious materials. As in real life, trophies, diplomas or flags are the most common elements that symbolise this feeling
- Possession: Related to items of the game or progress. The more rare the more you want to show/play with them



Ap.Fig. 98. Collage. Pride feeling in games

How pride is manifested in art (Ap.Fig. 99)

- Size
- Possession
- Technique/ beauty



Ap.Fig. 99. Collage. Pride feeling in art

How pride is manifested in music (Ap.Fig. 100)

- Gems or precious materials. Depending on the culture within the music industry it has more or less relevance
- Money. Same as the gems and precious materials.
- Trophies. Trophies in a competitive environment are always a way of differentiation and creating status. Therefore, they become part of the reasons why artists can experience pride
- Fashion/ self expression. As previously mentioned, the music industry involves different cultures. Belonging to one of these communities and being able to express yourself within them is also linked to pride, as a medium for expressing self-esteem.



Ap.Fig. 100. Collage. Pride feeling in music

The results obtained show synergies between the 3 industries. The belonging to a group (self expression), progression/success, and possession are present in all of them. When compared to the NFT industry the overlap is total. As obtained from the previous Chapter 3. Discover and Chapter 4. Define the importance of communities (belonging to a group), and the importance of owning an NFT (possession) overlap with the findings of the observations.

Therefore, it is possible to confirm that the NFT industry associates the feeling of pride to the same concepts as the entertainment industry. The finding proves that the relevance of a product that evokes price will have a major impact also outside the target group.

## Appendix 15. Product Emotion User Test. Questionnaire

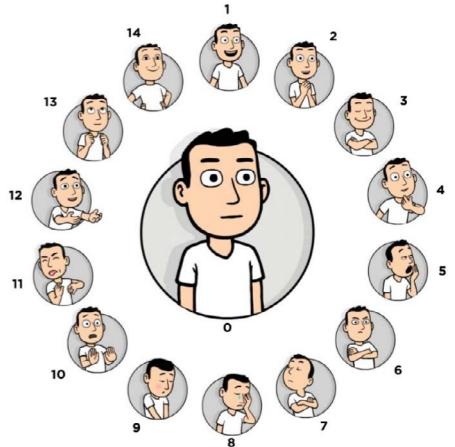
### Product Emotion

This questionnaire is part of my graduation project, focused on solving problems of NFTs. The survey focuses on gathering the emotions certain sketches/products awaken on consumers, based on shape and form.

You will be presented with 14 shapes, and you will have to choose which emotion that shape could express. You can repeat your answers as much as you want. There are no wrong or correct answers, the test is completely subjective!

No personal information will be collected. It shouldn't take you more than 5 minutes to complete.

The emotions you will be choosing from are the following:

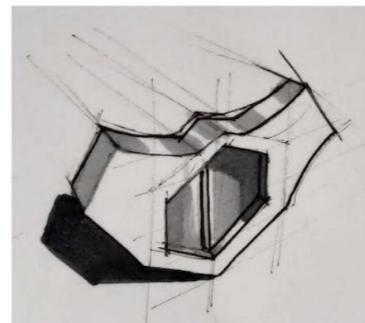


Choose the emotion the following design expresses in your opinion: \*



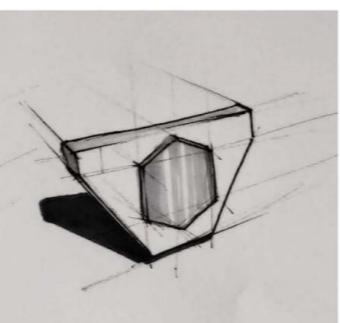
Choose

Choose the emotion the following design expresses in your opinion: \*



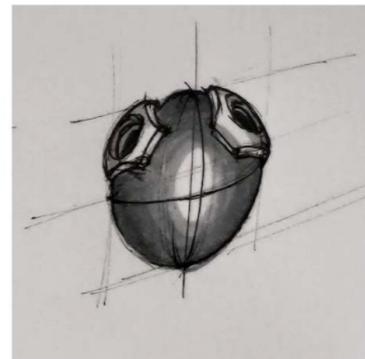
Choose

Choose the emotion the following design expresses in your opinion: \*



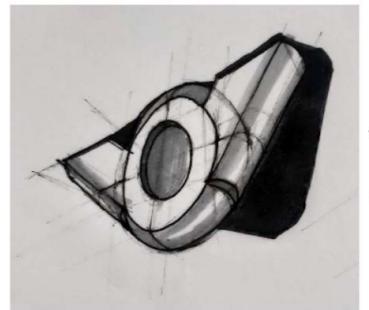
Choose

Choose the emotion the following design expresses in your opinion: \*



Choose

Choose the emotion the following design expresses in your opinion: \*



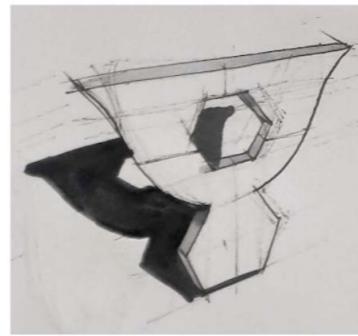
Choose

Choose the emotion the following design expresses in your opinion: \*



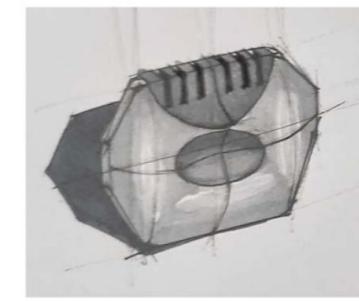
Choose

Choose the emotion the following design expresses in your opinion: \*



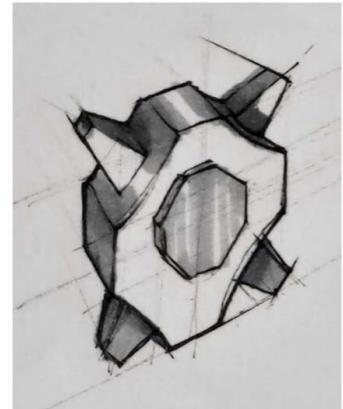
Choose

Choose the emotion the following design expresses in your opinion: \*



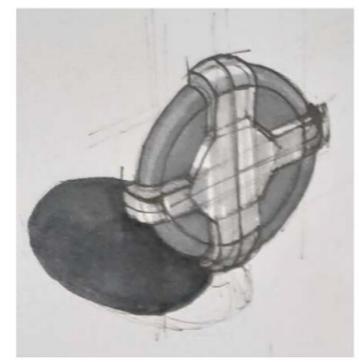
Choose

Choose the emotion the following design expresses in your opinion: \*



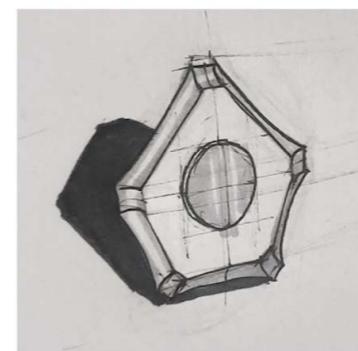
Choose

Choose the emotion the following design expresses in your opinion: \*



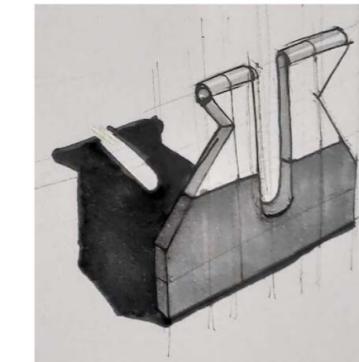
Choose

Choose the emotion the following design expresses in your opinion: \*



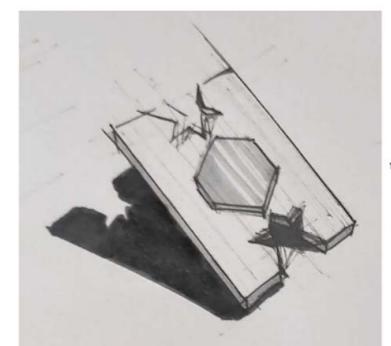
Choose

Choose the emotion the following design expresses in your opinion: \*



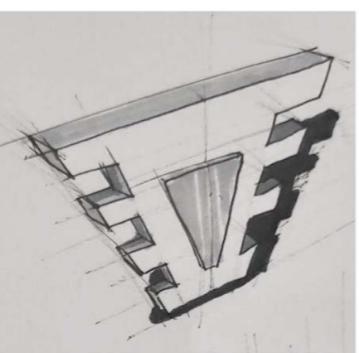
Choose

Choose the emotion the following design expresses in your opinion: \*



Choose

Choose the emotion the following design expresses in your opinion: \*

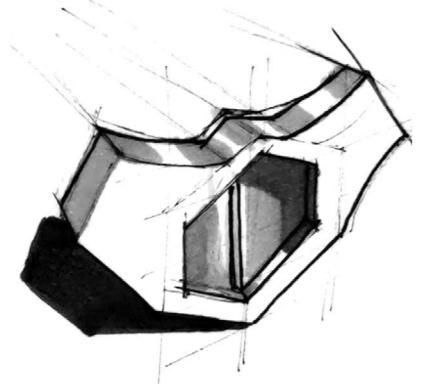


Choose

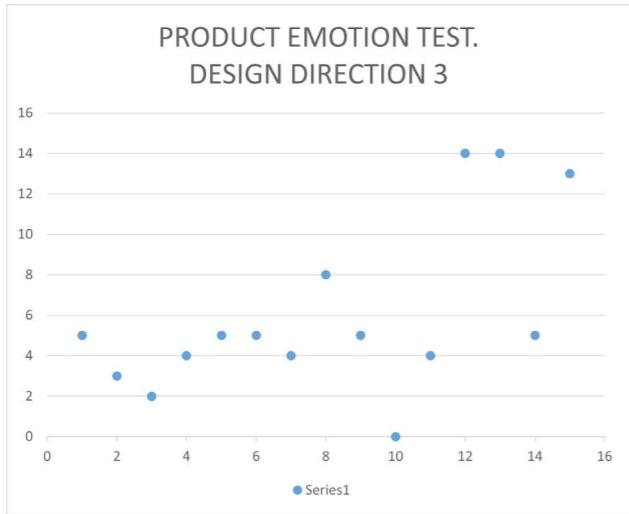
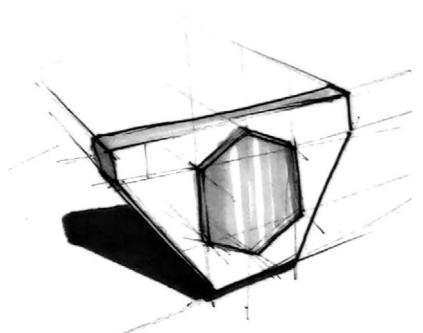
## Appendix 16. Product Emotion User Test. Results



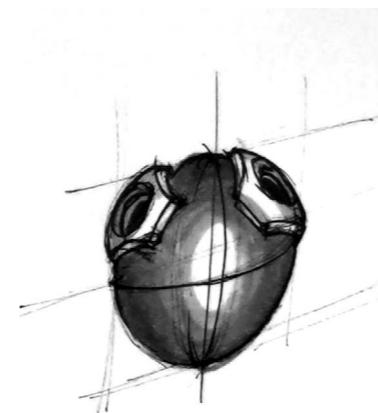
Ap.Fig. 101. Product emotion test. Design direction 1 result



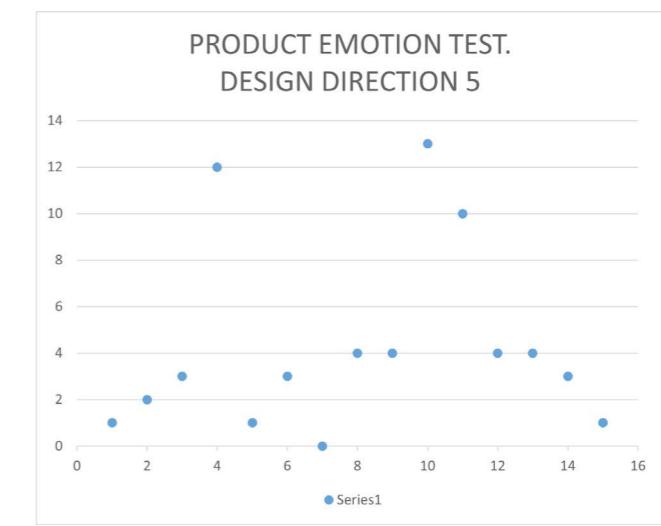
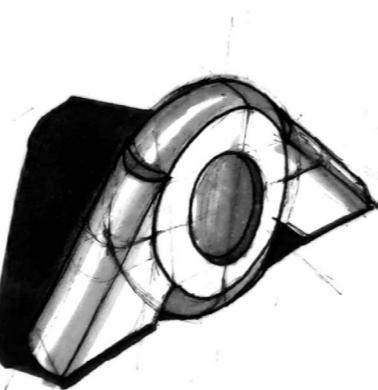
Ap.Fig. 102. Product emotion test. Design direction 2 result



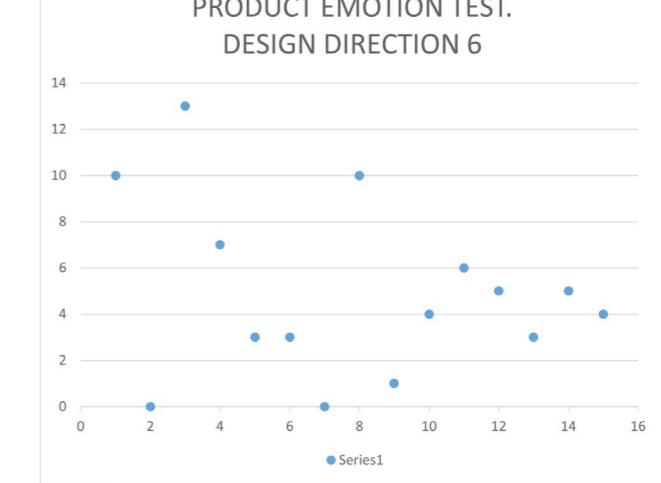
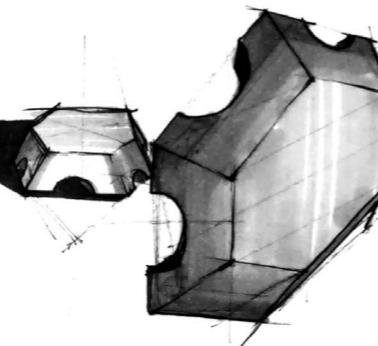
Ap.Fig. 103. Product emotion test. Design direction 3 result



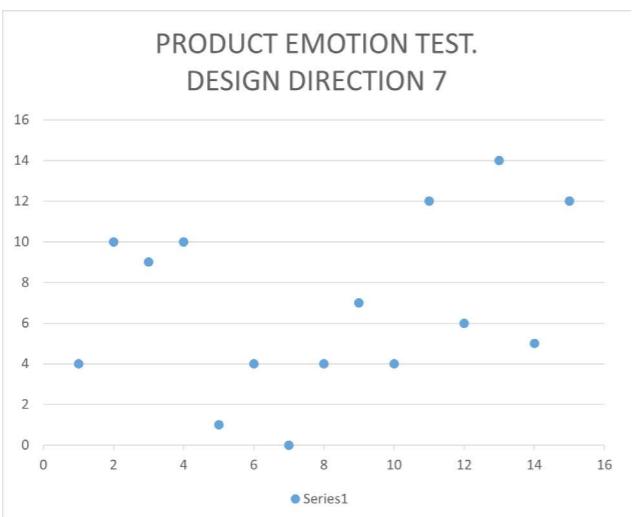
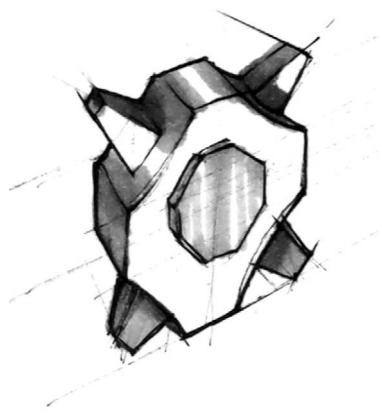
Ap.Fig. 104. Product emotion test. Design direction 4 result



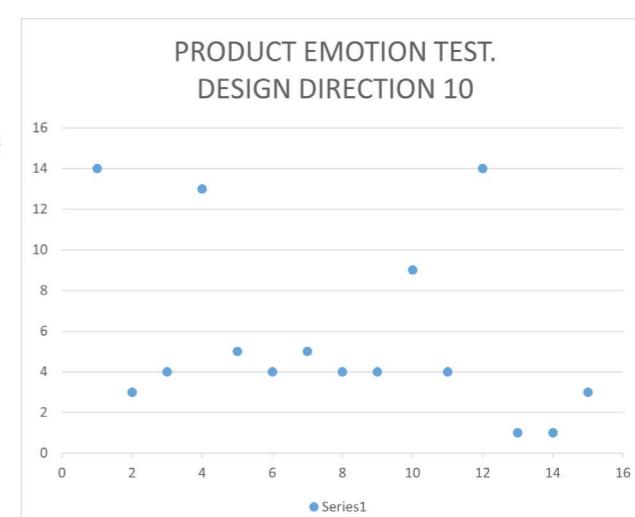
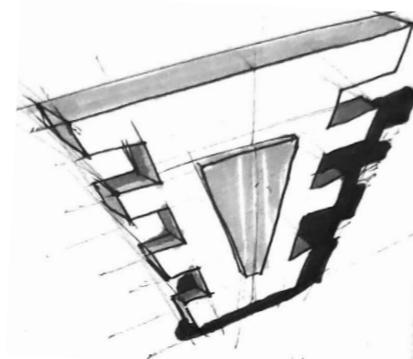
Ap.Fig. 105. Product emotion test. Design direction 5 result



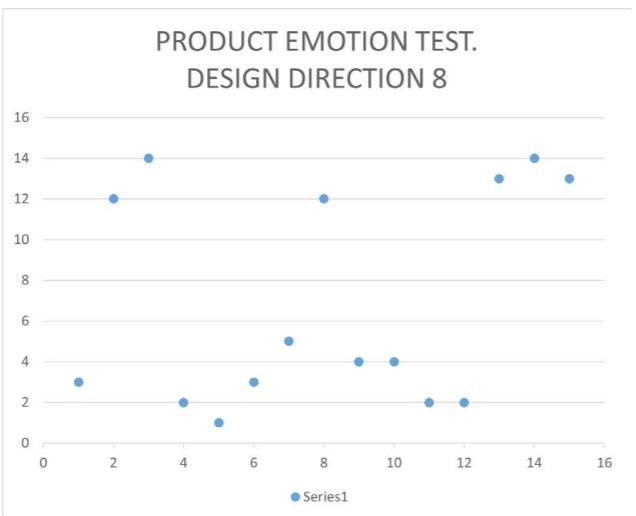
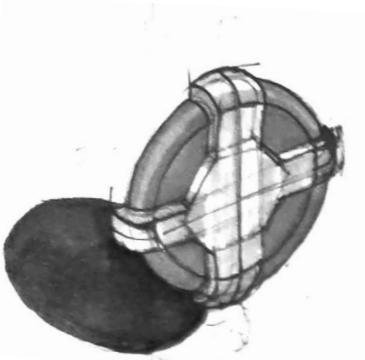
Ap.Fig. 106. Product emotion test. Design direction 6 result



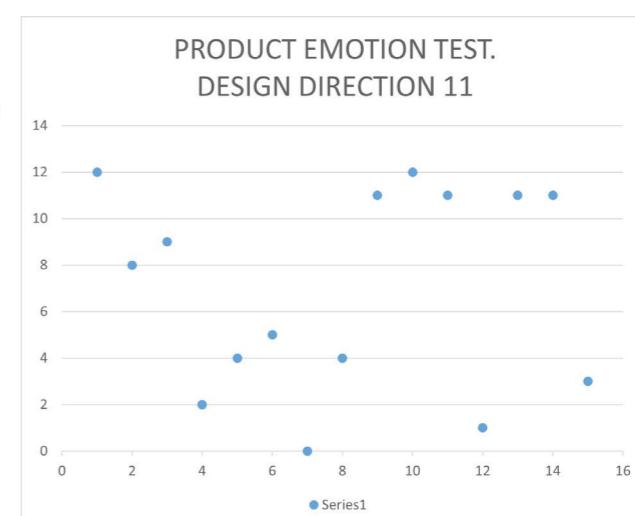
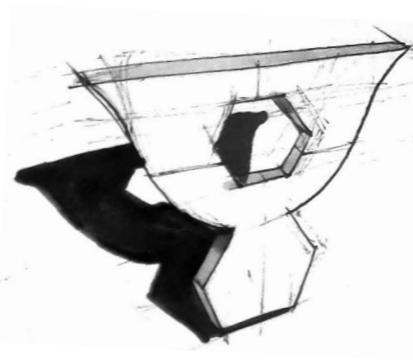
Ap.Fig. 107. Product emotion test. Design direction 7 result



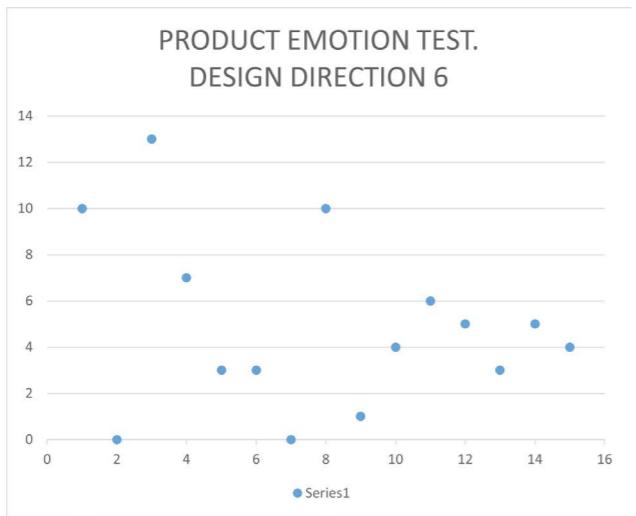
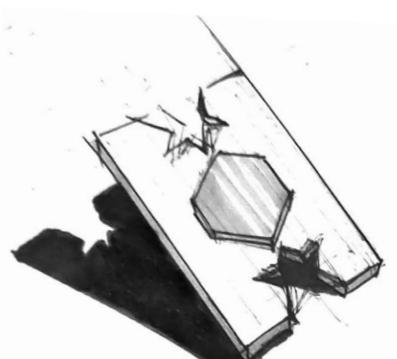
Ap.Fig. 110. Product emotion test. Design direction 10 result



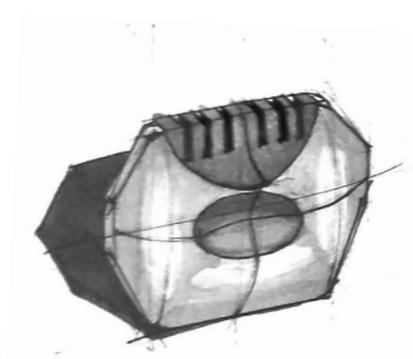
Ap.Fig. 108. Product emotion test. Design direction 8 result



Ap.Fig. 111. Product emotion test. Design direction 11 result

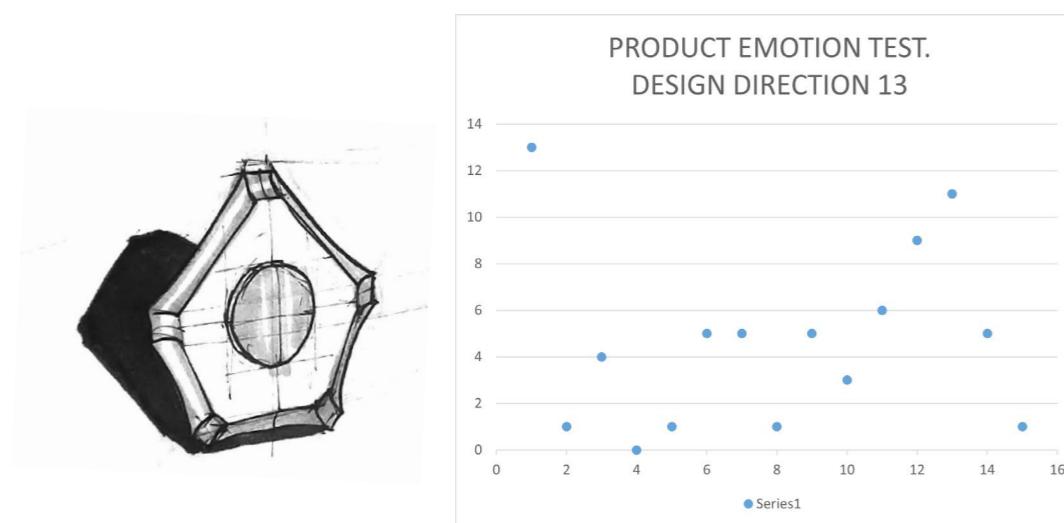


Ap.Fig. 109. Product emotion test. Design direction 9 result

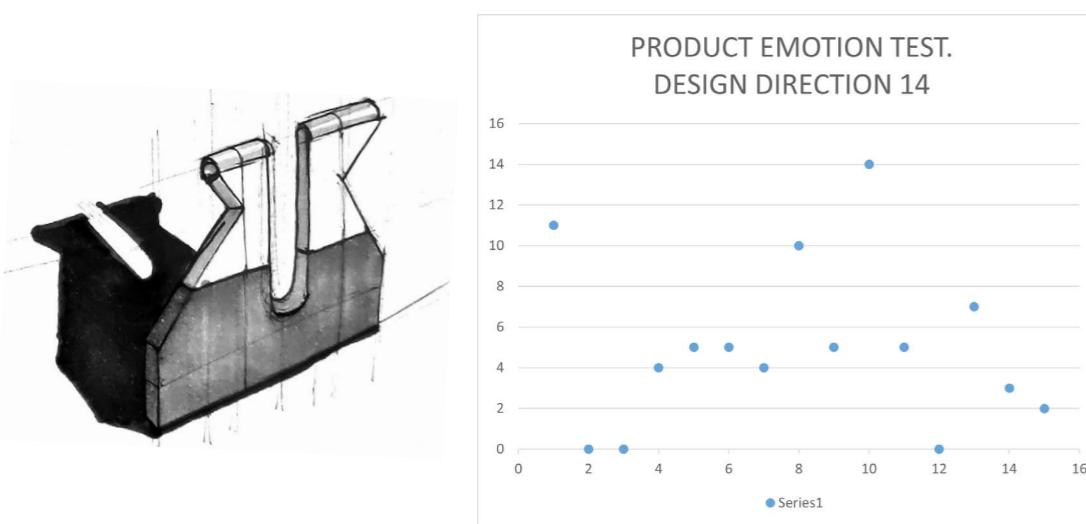


Ap.Fig. 112. Product emotion test. Design direction 12 result

## Appendix 17. Retrieving & Displaying NFTs. Scripts



Ap.Fig. 113. Product emotion test. Design direction 13 result



Ap.Fig. 114. Product emotion test. Design direction 14 result

For this code to work, it is necessary to install Web3 and Newtonsoft packages for Unity

```
using Newtonsoft.Json;
using System.Collections.Generic;
using UnityEngine;
using UnityEngine.Networking;
```

//Used by metadata class for storing attributes

```
public class Attributes
{
    //The type or name of a given trait
    public string trait_type;
    //The value associated with the trait_type
    public string value;
}
```

//Used for storing NFT metadata from standard NFT json files

```
public class Metadata
{
    //List storing attributes of the NFT
    public List<Attributes> attributes { get; set; }
    //Description of the NFT
    public string description { get; set; }
    //An external_url related to the NFT (often a website)
    public string external_url { get; set; }
    //image stores the NFTs URI for image NFTs
    public string image { get; set; }
    //Name of the NFT
    public string name { get; set; }
}
```

//Interacting with blockchain

```
public class BCInteract : MonoBehaviour
{
    //The chain to interact with, using Polygon here
    public string chain = "polygon";
    //The network to interact with (mainnet, testnet)
    public string network = "mainnet";
    //Contract to interact with, contract below is "Project: Pigeon Smart Contract"
    public string contract = "0xb68bCe041c7DDbA9d03AFD13BFeCf9d89aB8ba65";
    //Token ID to pull from contract
    public string tokenId = "0";
    //Used for storing metadata
    Metadata metadata;
```

```
private void Start()
```

```
{
    //Starts async function to get the NFT image
```

```

        GetNFTImage();
    }

async private void GetNFTImage()
{
    //Interacts with the Blockchain to find the URI related to that specific token
    string URI = await ERC721.URI(chain, network, contract, tokenId);

    //Perform webrequest to get JSON file from URI
    using (UnityWebRequest webRequest = UnityWebRequest.Get(URI))
    {
        //Sends webrequest
        await webRequest.SendWebRequest();
        //Gets text from webrequest
        string metadataString = webRequest.downloadHandler.text;
        //Converts the metadata string to the Metadata object
        metadata = JsonConvert.DeserializeObject<Metadata>(metadataString);
    }

    //Performs another web request to collect the image related to the NFT
    using (UnityWebRequest webRequest = UnityWebRequestTexture.GetTexture(metadata.image))
    {
        //Sends webrequest
        await webRequest.SendWebRequest();
        //Gets the image from the web request and stores it as a texture
        Texture texture = DownloadHandlerTexture.GetContent(webRequest);
        //Sets the objects main render material to the texture
        GetComponent<MeshRenderer>().material.mainTexture = texture;
    }
}

```

Credit (Francis, 2021)

## Appendix 18. Requirements Fulfilment

Technical Requirements	Fulfilment method
<b>(1) Connectivity.</b> The solution must have access to NFTs to visualise them. Therefore, it should be able either to gather the NFTs by itself (internet connectivity) or be able to communicate with a device that is capable of it.	The use of the phone enables the access to the NFTs thanks to the possibility they must access the internet.
<b>(2) Mass production possible.</b> All components should be able to be adapted to mass production	All materials selected are applicable for mass production.
<b>(3) Durability.</b> Minimum life expectancy of 5 years of all the components.	The materials selected have a life expectancy superior to 5 years. The technologies applied (smartphone and NFC tags) also meet this requirement.
<b>(4) Portability.</b> Users must be able to comfortably carry the product with them. This is traduced in a compact size (maximum 7cmx15cm in the largest sides) and lightweight (maximum 250g).	Final size of the product: 6cmx4cm in their largest sides. Total weight <20g.
<b>(5) Environmentally friendly.</b> Referring to avoid e-waste (1% of the maximum weight, 2.5g), and recyclability (minimum 90% of the whole product should be recyclable).	E-waste of the solution: 1g (NFC tag weight). The rest of the materials used (ABS, TPU and stainless steel) are 100% recyclable.
<b>(6) Safety.</b> The product should not be a risk for the user in any way: no skin, muscular, brain, respiratory, eye or ear threats of any kind. Allergies and ingestion issues are not contemplated. A note in the final device should inform the users not to ingest it and the material composition.	The materials used do not cause harm or reaction to the body when fabricated. ABS is toxic.
<b>(7) Resistance to different environments.</b> Exterior use intended. Temperature operating range: -15 to 40°C. Water and dust resistant (IP54), corrosion resistant.	Operating temperature: -40°C to +85°C. IP54 resistance: tested spraying water to the product. The operation afterwards was successful. Corrosion resistant: materials selected have high resistance to corrosion.
<b>(8) Visualisation possible for all types of NFTs.</b> Images, GIFs, videos, 3D, and music should be able to be displayed.	Expert validation.
<b>(9) Acceptance of all types of standards.</b> ERC-721 and ERC-1155	Expert validation.
<b>(10) Acceptance of all blockchains.</b> Limited to NFT blockchains.	Expert validation.
<b>(11) Technical upgradability and adaptability to a fast changing environment.</b> It should be possible to include new blockchains and standards	App uses an API system to gather the information. Therefore, it can use information from multiple servers, which cover all possible blockchains.

(12) <b>High security levels.</b> Technical impossibility of fulfilling money or exchange requests.	Expert validation.
(13) <b>Blending physical and digital worlds.</b> Must be an integration of both environments in the visualisation.	AR technology and the use of a smartphone with a compatible app meets this requirement.
(14) <b>Optimised visualisation.</b> Minimum resolution display HD (1,920 x 1,080 pixels).	Smartphones suitable for AR display meet this requirement.
(15) <b>Centralisation.</b> One unique platform for visualisation.	App designed.
User Qualities	Fulfilment method
(1) <b>Pride.</b> Should be the emotion that evokes to users. Measured with a Product Emotion Test.	Product Emotion Test validation
(2) <b>NFT essence: ownership, authenticity.</b> Should convey these qualities in any way. For example, shape or capabilities. Depending on how it is conveyed, the validation would vary	NFT embodied with the metal sheet. The hexagonal shape refers to them. Ownership and authenticity are represented with the polished finish, where the user can see him/herself reflected.
(3) <b>Adaptability to any type of user (uniqueness, self-expression, communities).</b> Flexible design. Users must be able to customise the product at least in one way. For example, colour, shape, or additional features	Self expression achievable with different colours possible thanks to the materials selected and customization of the metal sheet by laser-engraving simple icons or letters.
(4) <b>Usability.</b> Simple to interact with. Users must learn how to use the product in 3 or less tries. Measured with usability test and lightweight (maximum 250g).	Usability test validation. Weight of the product <20g.
(5) <b>Seamless interaction.</b> No awkward transitions, interruptions, or indications of disparity. Measured with engagement test	Engagement test validation
(6) <b>Desirability.</b> How attractive could it be for early adopters. Must follow the general aesthetics of products used by the target group. Measured following the guidelines of a study of the look and feel	Design for emotion guidelines. Look and feel study results adapted to the design direction.
Economic Requirements	Fulfilment method
(1) <b>Competitive price. Less than 80% of the cost of its cheaper competitor. This is an estimate sale price of 80€</b>	Use of materials and production processes that permit a consumer sale price of 15€.
(2) <b>Technology simplicity. Avoid complex technological solutions that create a heavy impact on the price</b>	Solved with the integration of the smartphone, which handles all the technologically complex elements (AR, high resolution, internet connectivity, wireless connection, and programmability capabilities). The economic impact is 0€.

Ap.Table 01. Requirements fulfilment

## Appendix 19. Security Validation Interview. Questions & Results

### Questions

Q1. I have sent you the architecture of the app I want to develop. Do you have any question regarding the explanation?

Q2. Are the steps followed correct?

Q3. How does the security in a bank app works in comparison to the method proposed?

Q4. What is the level of security in your point of view of the solution proposed?

### Results

Q1 and Q2. The architecture proposed was incorrect. The expert proceeded to explain the correct way in which the technology works. The information received was the following:

There are two different approaches: Encryption and digital signatures. Encryption is based on public key, and the digital signatures in the private key. Furthermore, there are entities called certification authorities who act as trusted third parties to verify the identity of the agents interchanging information.

In this process it is important to distinguish between 3 key concepts (Ap.Fig. 115):

Identification: know who you are establishing contact with

Authentication: confirm that the identified entity is in reality who it says

Authorisation: give permissions

Q3. Bank apps do not use this type of technology. It would be very complex to create a digital certification for each individual, therefore they use other methods to strengthen the security apart from the password. They use double verification system, in which they usually sent a message to the phone, to validate that the person trying to connect is who they claim (authentication).

Q4. Usually the issue with phone apps is not that they are insecure, but the connection between them. When apps interchange information, the most vulnerable part is the communication between them.

Therefore, a product that avoids exchange of information between apps is intrinsically more secure.

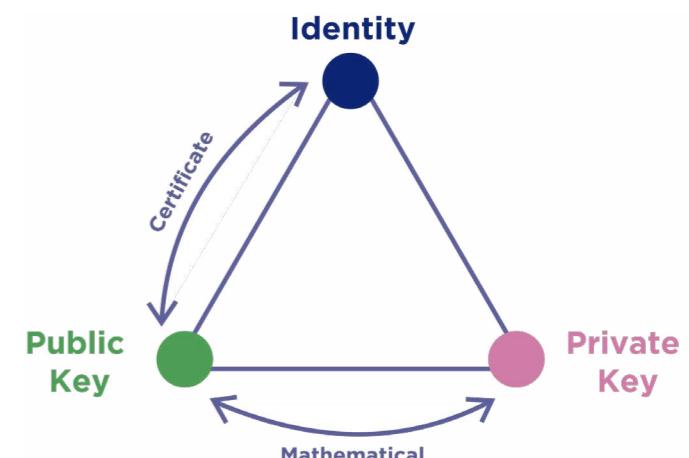
***“It is clear the relevance of what you are trying to solve”***  
(Cybersecurity expert)

Furthermore, about the use of this technology, the expert stated:

***“Public key technology is more than 10 times more secure than just a password”***  
(Cybersecurity expert)

***“If you use public key technology in your app it is almost impossible that someone will hack it”***

(Cybersecurity expert)



## Appendix 20. Physical Product. Cost Calculation

### Small Scale Production

Total pieces	25,000
3D print. Cost (€)	3,000 (Ultimaker, 2022)
3D print. life (yr)	3
3D print. Consumption (W)	221 (Ultimaker, 2022)
Days	249
Days/month	20.75
mins/day	360
N (needed) parts/day	100
Post-proc. tool cost (€)	20
Post-proc. tool life (yr)	0,5
Energy cost (€ per MW/h)	306.86

*Ap.Table 02. Physical product input for small scale production calculation*

NFC tag. Outsourced. Bulk price: 0.38€ (NFC Tagify, 2022)

Core metal sheet outsourced. Bulk price: *Ap.Fig. 116.*



TU Delft		Attention of:	Ignacio
		Date:	13th September 2022
		Quote No.:	GN334122EP
		Your Ref.:	
Tel:	34669171943	Fax:	
Email:	ignacio96@gmail.com		
Current Lead Time <b>TBA</b>			
LONG NARROW PARTS MAY BOW - FLATTENING COSTS ARE NOT INCLUDED UNLESS STATED			
Drawing Number	Issue	Description	Material
28mm x 28mm Hexagon		Laser cut, Material Supply & Delivery Included	Our Supply, 2mm Stainless Steel 304 DP1
			5000 £1.06 <b>£5,300.00</b>

Cutting Technologies Ltd  
Zenith Park, Whaley Road, Barnsley,  
S7 1HT, UK  
Tel: +44 (0)1226 283322  
Fax: +44 (0)1226 283355  
accounts@cut-tec.co.uk  
www.cut-tec.co.uk

Prices subject to stock remaining unsold, prices exclude VAT at 20%. Payment terms are pro-forma for the first order. We should emphasise that this Quotation is not a tender document and as a result any order which is placed by you will be subject to our formal acceptance confirmed by an appropriate order acknowledgement. We also confirm that this quotation and any subsequent contract entered into will be governed by our Terms and Conditions of Sale, a copy of which is available on request. All parts are supplied on the basis of our Technical sheets in the appropriate section on the website.  
All Mild Steel, Stainless Steel and Aluminium will be supplied to BS EN 1090-1 Eco Class 2, unless otherwise stated. Any untoleranced drawings or dimensions will be subject to our standard achievable tolerances as published on our website, or are available on request.

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*Ap.Fig. 116. Budget for core metal sheet*

## Appendix 21. Physical Product. Cost Calculation

### Large Scale Production

Total pieces	50,000
Injection machine cost (€)	40,000 (Alibaba 2022)
Injection machine life (yr)	5
Injection machine cons. (KW)	221
Days	249
Days/month	20.75
mins/day	360
N (needed) parts/day	201
Energy cost (€ per MW/h)	306.86
Mould cost (€)	10,000 (Formlabs, 2022)

*Ap.Table 03. Physical product input for large scale production calculation*

Gate trimming considered part of the injection moulding machine.

Total pieces mass production	50,000
Total pieces small scale production	25,000
Number of workers	2
Developer salary (€)	70,000 (SalaryExpert, 2022)
Play store fee (€)	25 (Girdhar, 2021)
App store fee (€/year)	99 (Girdhar, 2021)

*Ap.Table 04. App input for production calculation*

## Appendix 22. Break Even Point Calculation

Small scale		Large scale		App	
Total pieces	25,000	Total pieces	50,000	Time to develop app (days)	125
3D print. Cost (€)	3,000	Injection machine cost (€)	40,000	Number of workers	2
Total 3D print	10	Number of machines	2	Daily cost per worker (€)	281
Total post proc. tools	10	Mould cost (€)	10,000		
Post-proc. tool cost (€)	20	Number of moulds	2		
Units per day	100	Units per day	201		
Material costs per day (€)	160	Material costs per day (€)	358		
Energy costs per day (€)	150	Energy costs per day (€)	1		
Labour cost per day (€)	215	Labour cost per day (€)	326		

*Ap.Table 05. Input for break even point calculation*

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## IDE Master Graduation

### Project team, Procedural checks and personal Project brief

This document contains the agreements made between student and supervisory team about the student's IDE Master Graduation Project. This document can also include the involvement of an external organisation, however, it does not cover any legal employment relationship that the student and the client (might) agree upon. Next to that, this document facilitates the required procedural checks. In this document:

- The student defines the team, what he/she is going to do/deliver and how that will come about.
- SSC E&SA (Shared Service Center, Education & Student Affairs) reports on the student's registration and study progress.
- IDE's Board of Examiners confirms if the student is allowed to start the Graduation Project.

! USE ADOBE ACROBAT READER TO OPEN, EDIT AND SAVE THIS DOCUMENT

Download again and reopen in case you tried other software, such as Preview (Mac) or a webbrowser.

#### STUDENT DATA & MASTER PROGRAMME

Save this form according the format "IDE Master Graduation Project Brief\_familynamne\_firstname\_studentnumber\_dd-mm-yyyy". Complete all blue parts of the form and include the approved Project Brief in your Graduation Report as Appendix 1 !

family name Jiménez  
initials I given name Ignacio  
student number 5394732  
street & no. \_\_\_\_\_  
zipcode & city \_\_\_\_\_  
country \_\_\_\_\_  
phone \_\_\_\_\_  
email \_\_\_\_\_

Your master programme (only select the options that apply to you):

IDE master(s):  IPD  Dfl  SPD

2<sup>nd</sup> non-IDE master:

individual programme: - - (give date of approval)

honours programme:  Honours Programme Master

specialisation / annotation:  Medisign

Tech. in Sustainable Design

Entrepreneurship

#### SUPERVISORY TEAM \*\*

Fill in the required data for the supervisory team members. Please check the instructions on the right !

\*\* chair Kortuem, G.W dept. / section: SDE/IoT  
\*\* mentor Brand, D.I dept. / section: HCD/DA  
2<sup>nd</sup> mentor Peter Warman  
organisation: Newzoo  
city: Amsterdam country: Netherlands

comments (optional)  
Newzoo will only participate in the initial stage of the project, as their expertise lies on the research, not the product development. However, Peter Warman will be mentor through the whole project.  
A second company might be included for the second part.

Chair should request the IDE Board of Examiners for approval of a non-IDE mentor, including a motivation letter and c.v..

! Second mentor only applies in case the assignment is hosted by an external organisation.

! Ensure a heterogeneous team. In case you wish to include two team members from the same section, please explain why.

**Procedural Checks** - IDE Master Graduation

**APPROVAL PROJECT BRIEF**

To be filled in by the chair of the supervisory team.

 chair Kortuem, G.W

 date 01 - 03 - 2022

 signature 
**CHECK STUDY PROGRESS**

To be filled in by the SSC E&amp;SA (Shared Service Center, Education &amp; Student Affairs), after approval of the project brief by the Chair. The study progress will be checked for a 2nd time just before the green light meeting.

 Master electives no. of EC accumulated in total: 21 EC

 YES all 1<sup>st</sup> year master courses passed

 Of which, taking the conditional requirements into account, can be part of the exam programme 21 EC

 NO missing 1<sup>st</sup> year master courses are:

List of electives obtained before the third semester without approval of the BoE

 name K. Veldman

 date 11 - 3 - 2022

 signature 
**FORMAL APPROVAL GRADUATION PROJECT**

To be filled in by the Board of Examiners of IDE TU Delft. Please check the supervisory team and study the parts of the brief marked \*\*. Next, please assess, (dis)approve and sign this Project Brief, by using the criteria below.

- Does the project fit within the (MSc)-programme of the student (taking into account, if described, the activities done next to the obligatory MSc specific courses)?
- Is the level of the project challenging enough for a MSc IDE graduating student?
- Is the project expected to be doable within 100 working days/20 weeks ?
- Does the composition of the supervisory team comply with the regulations and fit the assignment ?

 Content:  APPROVED  NOT APPROVED

 Procedure:  APPROVED  NOT APPROVED

comments

 name Monique von Morgen

 date 29/3/2022

 signature MvM

## Development of a product that showcases 3D Non-Fungible Tokens

project title

Please state the title of your graduation project (above) and the start date and end date (below). Keep the title compact and simple. Do not use abbreviations. The remainder of this document allows you to define and clarify your graduation project.

start date 28 - 02 - 202209 - 09 - 2022 end date

### INTRODUCTION \*\*

Please describe, the context of your project, and address the main stakeholders (interests) within this context in a concise yet complete manner. Who are involved, what do they value and how do they currently operate within the given context? What are the main opportunities and limitations you are currently aware of (cultural- and social norms, resources (time, money,...), technology, ...).

#### Background:

With the reveal of the Metaverse a new era begins, in which digital and physical stop being separate aspects of human lives. The tremendous amount of time and resources that Meta (most known as Facebook) is willing to invest in this project already sets a historic precedent in the relevance of digital communities, communication and sharing. Within this scope, certain aspects are gaining extreme relevance in the digital world, which make this project so attractive in the time being. These are: blockchain, Non-Fungible Tokens (NFTs), gaming and remote work. All these aspects have gained relevance due to the 2019 Covid pandemic.

Therefore, a whole new field focused on merging these worlds has emerged. The field of study and implementation is extremely broad, as the fusion of 2 different "worlds" is very complex. To mention some, bringing real life perception to Virtual Reality, transforming physical environments with the use of Augmented Reality, bringing digital communities and events together in a more realistic way, decentralization (web based) of many aspects of real life, being blockchain the basics for the change (web 3.0), and so many others. In all of these new fields, many interesting new concepts are emerging such as VR trainings, VR expos, NFTs, super immersive gaming, remote control of real objects in immersive environments and many others.

In this scenario one could say blockchain and VR/AR/XR technologies are the core. Within the blockchain there are many challenges that still need solution. Nowadays, part of the most mainstream are sustainability, NFT legitimization, and scalability of the blockchain. All these 3 challenges play a very important role in the NFT environment, and therefore it is a relevant field of focus for a graduation project.

#### Project:

In this project I aim to improve legitimization and provide new ways of sharing 3D assets in the form of NFTs. These digital assets are widely used in the gaming and metaverse communities and serve as identifiers for the collectives as well as being part of the interaction between the members. They are also a "marketing window" for other potential users. The focus is placed on showcasing technology in a new and interesting way, combining digital assets and Augmented Reality.

#### Stakeholders:

The final outcome of the project is a product that is marketed towards consumers. The NFT communities have shown deep interest in getting to be known and building environments in which they feel part of a group, not only online but also in real life. An example can be seen in Image 1.

However, other parties involved will also benefit from the result. The increment of exposure inevitably benefits the creators of the communities, this is, gaming companies, artists and third parties linked to them. The benefit doesn't only come by the hand of greater exposure, but also by the minimum level of involvement in terms of time, resources, and infrastructure from the third parties. It is the members of the community who take most of the action.

space available for images / figures on next page

## Personal Project Brief - IDE Master Graduation

introduction (continued): space for images



image / figure 1: Bored Ape Yacht Club's (NFT community) membership party

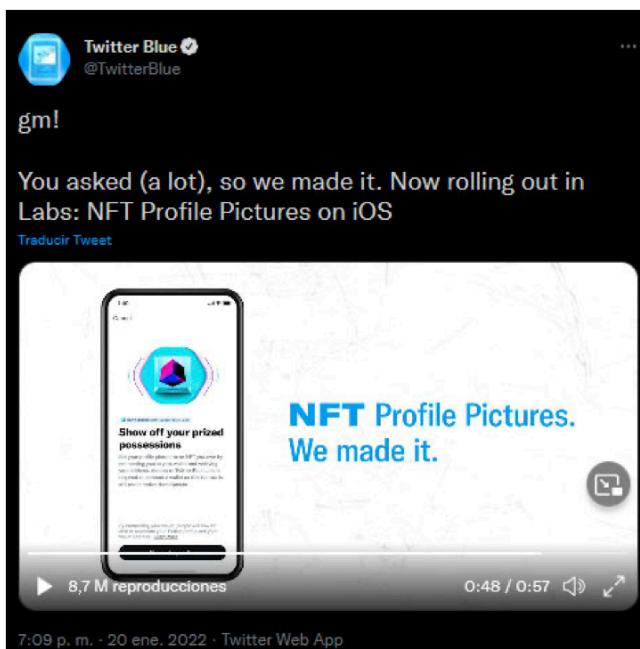


image / figure 2: Twitter's solution to NFT profile demand solving legitimacy: hexagonal profile picture.

## Personal Project Brief - IDE Master Graduation

### PROBLEM DEFINITION \*\*

Limit and define the scope and solution space of your project to one that is manageable within one Master Graduation Project of 30 EC (= 20 full time weeks or 100 working days) and clearly indicate what issue(s) should be addressed in this project.

In the past year 2021 the volume and interest in NFTs, in particular collectibles, has increased exponentially (+4500% in December 2021). The increment came majorly thanks to the exposure through social media, in particular Twitter, Instagram, TikTok and Reddit. They have been the showcase scenario for NFTs and a space for communities to grow. These platforms have been the drivers of the impact due to the nature of the vast majority of NFTs: images, videos and GIFs. These formats make it easy for NFTs to adapt to social media content.

Very recently (20th of January 2022) Twitter signed a partnership with Opensea (the biggest NFT marketplace) in which they enabled using NFTs as profile pictures in the social media platform. The partnership was created due to the high demand of users that wanted a solution for the legitimacy of the profile pictures. The main issue was that the images could be easily saved and used as profile pictures, without any proof of the user being the owner. Their solution addresses this issue by showing all relevant data of the NFT as shown in the marketplace.

However, the legitimization and ease of sharing tackled by social media is only limited to JPEG and PNG formats and belonging to the Ethereum blockchain. The variety is not broad but it covers most of the spectrum. Nevertheless, it seems necessary for other formats like 3D assets, also very present in the NFT community and with a very big relevance in the future thanks to the Metaverse, to have the same legitimization, as well as exposure (only visible in game platforms or NFT markets).

Knowing this, the project will try and solve two main problems:

1- Can 3D NFT assets be showcased out of their native market or in-game platforms? What would be a possible design solution using relevant technologies in this scope?

2- How can the legitimacy present in markets and in-game platforms of 3D NFT assets remain as it is out of this environment?

### ASSIGNMENT \*\*

State in 2 or 3 sentences what you are going to research, design, create and / or generate, that will solve (part of) the issue(s) pointed out in "problem definition". Then illustrate this assignment by indicating what kind of solution you expect and / or aim to deliver, for instance: a product, a product-service combination, a strategy illustrated through product or product-service combination ideas, ... . In case of a Specialisation and/or Annotation, make sure the assignment reflects this/these.

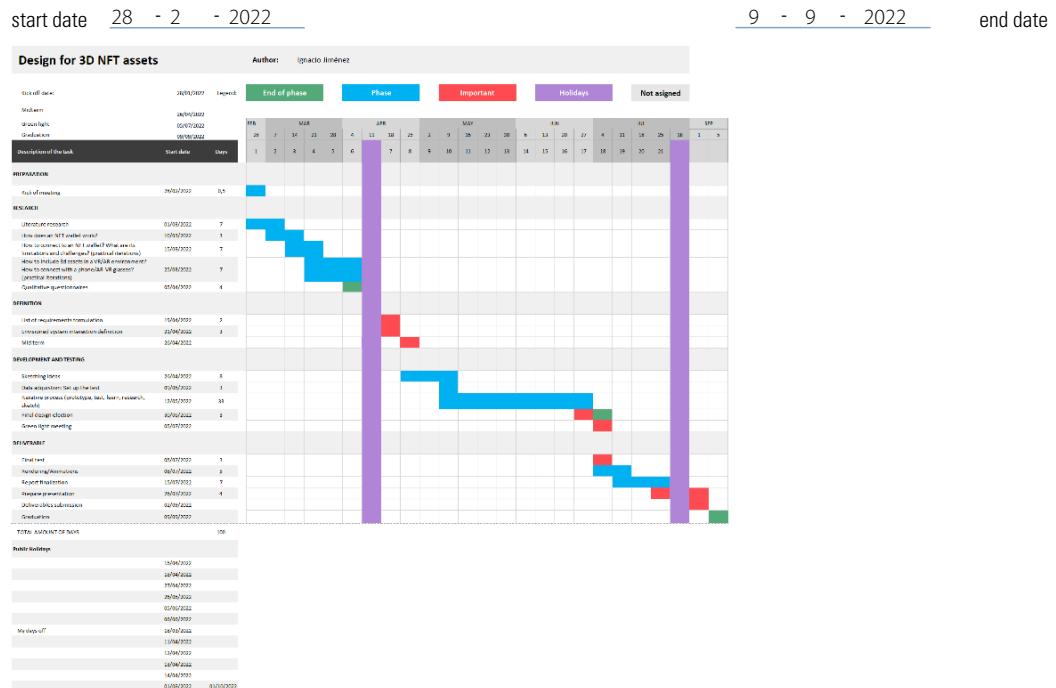
I am going to create a physical product that, with the help of state of the art technologies relevant to the metaverse, showcases 3D NFT assets out of their conventional environment. This will be done maintaining the legitimacy present in those environments by extracting the NFT metadata information from its storage site and displaying it with the asset.

The expected solution would be envisioned as a wearable that NFT users carry with them. With this product they will be able to show their assets with all the data associated to them. In the envisioned interaction a phone will be used as interface and Augmented Reality technology as the display medium.

## Personal Project Brief - IDE Master Graduation

### PLANNING AND APPROACH \*\*

Include a Gantt Chart (replace the example below - more examples can be found in Manual 2) that shows the different phases of your project, deliverables you have in mind, meetings, and how you plan to spend your time. Please note that all activities should fit within the given net time of 30 EC = 20 full time weeks or 100 working days, and your planning should include a kick-off meeting, mid-term meeting, green light meeting and graduation ceremony. Illustrate your Gantt Chart by, for instance, explaining your approach, and please indicate periods of part-time activities and/or periods of not spending time on your graduation project, if any, for instance because of holidays or parallel activities.



#### Research Phase:

Focused on gaining as much knowledge as possible related to working with NFTs. It is necessary to understand as much as possible how they function, to be able to develop different approaches that could solve the issues. In this phase, some prototyping will take place to guide the research and obtain meaningful information, avoiding getting lost in the vast field of the NFTs and the metaverse. Once the knowledge is obtained, it will be easier to clearly define requirements and create concepts.

#### Definition Phase:

Critical stage that will set the ground for the upcoming solutions. It is very important to pay attention to details when creating the list of requirements. Here, it is also important to envision an interaction with the user, following the requirements needed. At the end of the phase, the Mid Term evaluation will take place, where it is expected to have a confirmation on all the previous work and have green light for the development phase.

#### Development and Testing Phase:

Iteration process in which it is intended to find and develop a definitive solution. Here, research will also happen as new information will be needed to progress. At the end, the Green Light meeting will take place, in which the solution is validated, and only finalising details and final testing is missing.

#### Deliverable Phase:

Finish the report, preparing the presentation and hand in all the necessary documents 1 week before graduation.

**Personal Project Brief** - IDE Master Graduation**MOTIVATION AND PERSONAL AMBITIONS**

Explain why you set up this project, what competences you want to prove and learn. For example: acquired competences from your MSc programme, the elective semester, extra-curricular activities (etc.) and point out the competences you have yet developed. Optionally, describe which personal learning ambitions you explicitly want to address in this project, on top of the learning objectives of the Graduation Project, such as: in depth knowledge a on specific subject, broadening your competences or experimenting with a specific tool and/or methodology, ... . Stick to no more than five ambitions.

My motivation to focus my graduation project in the scope of the metaverse, VR/AR technology and the NFTs is due to my interest in gaming and the blockchain. My approach as a designer is to create products that provide users with new experiences by giving them the possibilities to create and imagine their own worlds. In this regard gaming is a very powerful tool and when combined with technologies like Virtual Reality or Augmented Reality the interest increases.

On the other hand, I find the possibilities unlocked by the blockchain technology fascinating. The wide variety of projects and applications make this technology a revolution in the virtual environment. Also, the multiple challenges and future development are very attractive aspects for me as a designer as I am problem solving driven.

I believe that the NFTs are a very promising concept within this context. Orienting my graduation project to try and solve some of the issues they have, from a product designer's perspective, while involving new immersive technologies is a challenge that enthuses me. It is also very adequate also to learn more about all these concepts and orient my designing expertise towards this field.

With this graduation proposal I aim to learn how to merge virtual and physical worlds, a complex task in the field of industrial design. Here, very few methodologies are clearly defined and I want to explore ways of approaching the new challenges, yet very relevant for the near future. While doing it, I hope to gain new skills that will make me stand out from the typical industrial design engineer and hopefully help me dive into this exciting and interesting field. Furthermore, I aim to learn more practical skills such as VR/AR game engines and workflows, wearable design (with focus on 3D modelling and aesthetics) and also communication. I am aware that this topic is not conventional for an industrial designer, which will challenge my communication skills in an adequate level.

**FINAL COMMENTS**

In case your project brief needs final comments, please add any information you think is relevant.