Phygital Transformation:

Adding Physical Devices to Digital Products to Improve the User Experience

By

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ABSTRACT

I see bright rectangles everywhere. Or, as Professor Hiroshi Ishii from the Tangible Media Group at the MIT Media Lab describes it, the “Pixel Empire.” Over the two decades, digital screens have taken the front stage in our lives, especially after the advent of the smartphone. While this has enabled incredible experiences that would not have been possible without the digital realm, we have lost tangibility in the process and the myriad of affordances that physical objects can provide and, with it, the richness of human interaction with the physical world. This thesis explores the concept of Phygital Transformation, the process of adding a physical device component to an existing digital product to improve the user experience by bringing back some of the advantages of the physical world to the digital world. It covers case studies of products currently in the market ranging from the fintech world to fitness and healthcare where Phygital Transformation has taken place successfully and analyzes the factors for their success in improving the user experience. It explores the benefits to the user and the business from a phygital user experience. Finally, it offers a framework for other digital products to evaluate their digital-only experience, build phygital concepts, and follow a systematic interdisciplinary process to add physical devices to their digital products where they can map the user experience benefits with the business value gain.

Thesis supervisor: Sheila Pontis

Title: Lecturer, Integrated Design and Management

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The IDM community, with Tony Hu, Andy MacInnis, and my classmates, has given me a once-in-a-lifetime opportunity to learn from the best and grow my expertise in design principles and interdisciplinary collaboration for building human-centered products. So many of my ideas in this thesis are due to the conversations, debates, and exercises we have done through the two years at IDM.

Prof. Randall Davis and Prof. Hiroshi Ishii, whose classes have sparked so much of my interest in “Fighting against the Pixel Empire.” Prof. Amos Winters’ class has helped me think about solving problems out of the box for people in a myriad of circumstances sustainably through business.

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Contents

List of Figures

List of Tables

Chapter 1: Introduction

I see bright rectangles everywhere. Or, as Professor Hiroshi Ishii from the Tangible Media Group at the MIT Media Lab describes it, the “Pixel Empire.” Over the last few decades, digital screens have taken the front stage in our lives, especially after the advent of the smartphone. While this has enabled incredible experiences and new businesses that would not have been possible without the digital realm, in the process, we have lost tangibility and the myriad of affordances that physical objects can provide. Take the humble bookmark; in a physical book, the bookmark does so much more than keep your page; it allows you to see at a glance how much of the book you’ve read and the speed of your reading; it can be customized to represent your personality and take notes. The digital bookmark for eBooks maintains the core functionality of the bookmark, i.e., keeping track of your page, and can add new functionality; you cannot lose a digital bookmark and you could track the digital bookmark of a friend to read together. Still, it loses all the affordances a physical bookmark has. What would a bookmark that combined tangible properties of its physical nature with the convenience and intelligence that digital can offer look like? This thesis aims to provide answers to this question by exploring the world of such combined products.

1.1 What are Digital Products?

The term digital product refers to any software or digitally stored media that is aimed at end users [1], and digital products and services are software-based experiences accessed through the internet on a myriad of devices ranging from large desktop computers to small watch screens. These experiences need the user to focus on a screen to use it, which transfers the user away from the context of the real world and into a hyper-focused region where the screen is the interface to the digital experience.

In this thesis, I refer to Digital Products (including services) as any consumer-facing software experience that requires complete user attention focused on the screen area to use it. Moreover, I add a distinction that the digital product is the primary source of profitability for the business.

1.2 What is Digital Transformation?

Over the last few decades, the world has recognized the value of software and internet-based technologies in improving the lives of people and businesses. Physical mail has been transformed into email; for example, it disrupted how individuals can communicate with each other. With email, they can send mail faster, at a lower cost, and make them more detailed and interactive. We cannot imagine how any business today may not operate with an email account. E-Commerce has allowed sellers to interact directly with customers without needing a physical retail presence. Video Streaming services allow you to watch what you want and when you want to watch it at the click of a button.

Digital transformation is the process of an existing business undergoing organizational changes to adopt digital technologies to achieve optimized day-to-day operations, improved customer experience, or even to build brand new kinds of business models and sales channels never before possible [2], [3]. Nowadays, companies enlist dedicated C-Suite level roles, such as the Chief Digital Officer (CDO), to ensure their successful digital transformation. For example, McDonald's hired its first CDO in 2013 [4], Starbucks Appointed its Chief Digital and Information Officer in 2012 [5], and the CW Network appointed its CDO just this year, 2023 [6].

What does all this mean for a customer and user? There has been an abundance of digital products and services for anything and everything. There are 3.55 Million Apps on the Google Play store and 1.6 Million apps on the Apple Play store [7], [8]. With so many digital products available at your fingerprint, people have started to resonate with Apple's trademarked slogan, "There's an app for that" [7], [8].

With digital transformation and new digital technologies, people could do more, experience more, and have the means to live better lives. Businesses could engage better with their customers and deliver better products and services [2], [9].

1.3 The Impact of Digital Technologies on the User & Businesses

Imagine that you need to go to the grocery store to buy some orange juice. When you reach the store, you learn there is an entire aisle dedicated to orange juice. This sounds great! Options are a good thing, which means that each brand competes to give you the best price possible. Seems like an absolute win for the customer. However, on reaching there, you soon learn that there are too many choices. You now need to compare 30 different types of orange juice. Do I want pulp or no pulp? Should I get the Vitamin D or the Vitamin C option? Which brand should I choose? This leads to choice overload, making it more challenging for the user to pick what they want, leading to higher stress and using up our cognitive capacity [10]. This isn't good for businesses either; having an unhappy customer or a customer that can't pick your product among the sea of others directly impacts the bottom line.

A similar problem exists in the digital realm with the plethora of digital products available. The term "App Fatigue" represents this phenomenon in the digital world [11]. How can your product stand out? An exceptional differentiation can make your product stand out from the rest. However, it is easy for competitors to copy your differentiated features quickly in digital products, making your competitive advantage over a superior product irrelevant. Most digital products and services have no choice but to use Network Effects. Network effects refers to the fact that certain products or services become more valuable with the increase of number of users onto that product or service [12]. Think of messaging apps such as WhatsApp, Signal, and Telegram, to name a few. Signal and Telegram are more feature-packed than WhatsApp; however, due to network effects, WhatsApp remains the number one messaging app globally [13].

Users go through the arduous process of discovering the digital product, evaluating its usefulness, and finally downloading or installing it. Companies spend a lot of money to acquire new customers for their digital products or platforms. As of 2020, the average cost to a company to get a user to download their app was $5. The average cost to convert a user with the app into a paying subscription customer was $65 in the North American region [14]. With such high acquisition costs, it becomes imperative that companies are able to retain their customers on their digital products. Retention rate is the percentage of existing users that continue using the product or service after a fixed period of time, typically measured at 30 days [15]. However, mobile app user retention rates are typically under 5% after 30 days [16]. And for subscription customers, it is typically around 40-45%. A retention rate above 50% puts you in the top quartile of businesses

[17]. The number one reason that users uninstall an app is that the digital product does not solve the pain point it claims to solve effectively enough, and the second likely reason is that it is challenging to use it [18].

With the increased use of digital technologies, products, and services, there is also a social impact on its users. Smartphone addiction has increased, with 50% of teenagers and nearly 30% of parents saying they feel addicted to their devices. Over 50% of people check their phones while driving [19]. Oddly these smart devices capable of social connection beyond physical barriers are keeping us more disconnected from the real world than ever before [9].

1.5 How is the physical world more human?

We human beings are sensory and social creatures that experience the world around us in multifaceted ways. Imagine the last meal you had; what is it that made the meal special for you? Was it the taste, the visual presentation, the aromas, the ambiance, or the company? Or was it all of them together at the same time? [20]

People have strong emotional connections with tangible objects [21]. A family heirloom, for example, may have a strong sentimental value because of what it means to you and who gave it to you. You might even keep mementos and souvenirs from all your travels up on a shelf to remember your adventures and share the stories with others. An interesting study about the value of tangibility in the service industry showed that you could build stronger emotional bonds with customers using branded merchandise [22]. For instance, imagine receiving a shipment from your student loan lending bank with pens, notebooks, and a letter congratulating you on getting into your dream university.

Objects we possess are an extension of our self and represent a part of our identity [23]. For example, some people use clothes, jewelry, and other accessories to express themselves. Alternatively, take something as commonplace as a microwave oven; there are dozens of different microwave designs from several different brands, some have a sleek monolithic all-black design, and some have a modern, sharp look with brushed stainless steel; interestingly, a majority of the microwaves in the world are all manufactured by the same company with the same internal components [24] resulting in the same performance and features. This means people choose a microwave for more than its functionality; they choose it for an aesthetic that matches their taste.

We also place a higher monetary value on tangible products than their digital counterparts [25]. Consider a physical book versus its digital counterpart, an eBook; readers place value on the ability to hold a physical book, feel the paper, turn its pages and store it on a bookshelf, which is why even though eBooks are generally cheaper, a significant number of people still prefer the more expensive physical copy [23].

Affordances are relationships between objects and their user [24]. The physical world around us has numerous affordances that make the experience feel natural. Imagine your favorite coffee cup; not only does it have an emotional connection with you, but you can also use it to hold water, or as a plant pot, you can move it from place to place to change the interior of a room, and maybe use the cup as a paperweight even. The tangible nature of things allows the user to do more than just what it has been designed to do.

The physical world occupies a unique and significant position in our lives as human beings, owing to our innate connection with it. Our ability to perceive and interact with the physical realm through our senses and social interactions allows for diverse and meaningful engagements, facilitating emotional connections and personal expression. We can build sentimental and emotional bonds through the physical nature of objects. Using human ingenuity, we can imagine new affordance and rethink how to use things in the physical world beyond their intended use, which fans the flames for new ideas. These inherent qualities of the physical world contribute to a sense of naturalness and authenticity, perhaps explaining why we often employ expressions such as "drowning in work" or "jumping with excitement" to articulate our experiences.

1.6 The Phygital World

In the Intelligent Multimodal User Interfaces class, I took at MIT, our professor showed us a clip from the famous movie Minority Report set in the future of 2054. The main character, played by Tom Cruise, has a magically choreographed 2-minute sequence of interacting with a futuristic computer using hand gestures and physical objects that hold information. It seemed natural and intuitive to watch the best of what digital and physical have to offer working together; I wondered why we don’t have such products today and what it would take to make that futuristic imagination a reality.

A study comparing the monetary value of physical to digital versions of the same goods found that, overwhelmingly, people were more willing to pay for the physical version of the products. However, when the participants in the study had to choose only one item to buy between the physical and the digital versions of the same product, a 50-50 split was generally skewed towards the digital version [25]. These interesting findings showed that people value the physical version of the product more, but more than half the people still want the digital version owing to the convenience of digital. A product that combines the tangibility of a physical product with the intelligence and convenience of a digital product could solve this gap in a holistic product experience. This thesis explores the world of such physical + digital products.

Phygital combines the words physical and digital, representing the value of having the benefits of both worlds [27]. While the term Physical can encompass the natural and built environment around us and the tangible things it holds, this thesis will focus on physical objects with which the user can interact. The term Phygital, in the context of this paper, is the interaction of physical objects with means to interface with digital products unless otherwise stated.

Additionally, we define two new terms.

1. Phygitization - Refers to combining digital technology and a physical device to build a new phygital version.

2. Phygital Transformation - This is the addition of physical components to an existing or traditional digital product or service-based business to build a phygital version that generates new business value.

These newly defined terms are analogous to their digital counterparts, summarized in Figure *1*.

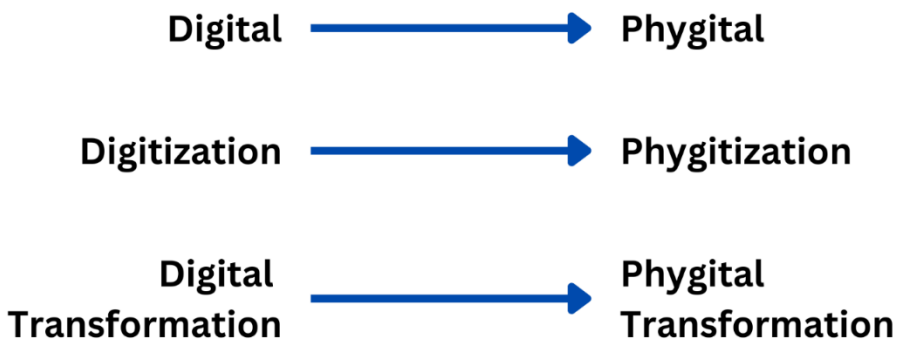


Figure 1: The analogous terms between the digital and phygital worlds.

The Phygitization landscape exists in two ways described below.

1.6.1 Adding Digital to Physical Products & Services

The first category contains traditionally physical products with an added digital layer [26]. Smart Home Automation products, such as the Nest Thermostats, are a great example of this type of phygital. A traditional thermostat is a very simple-to-operate device, you rotate the dial and set it to the temperature you want in the home, and that is it. The Nest Thermostat adds a layer of digital intelligence to this simple form factor device with functionality such as recognizing when you are not at home, changing the temperature to be cost-effective, and allowing you to control your home's temperature remotely. So, it’s perfect when you enter your home [27].

In business-related literature, the term phygital is largely used in the context of retailers, brick-and-mortar stores, and service industries, including a digital element to their product or service offering [28]. For example, ride-hailing services like Uber and Lyft use a digital interface to connect the customer with drivers in the area. Another example is Branded Apps, popular food & beverage chains such as McDonald's, Starbucks, and Chipotle all have a mobile app through which they are able to maintain their brand presence and build brand loyalty through their customer's smartphones while enabling new experiences such as ordering through the app to minimize wait times [29].

It can be argued that these new phygital products and experiences are the outcome of digital transformation efforts by companies to adopt digital technologies into traditional physical products and services.

1.6.2 Adding Physical to Digital Products and Services

Do you own a poster of a musical band you like? A T-shirt celebrating your favorite character in a video game? A mug with your favorite YouTuber’s branding? Although we predominantly experience things like music, movies, and video games through digital media, we still buy merchandise. These can be seen as physical extensions of our digital content that help us feel more connected with the intangible [22]. However, these physical objects do not directly influence the digital product or services they represent and can be labeled as non-interactive.

Connected devices are physical devices and objects that can link with the digital world through the internet [31]. However, this term fails to value the benefits of the physical nature to the phygital user experience. Another term, Tangible Interaction, looks at the representation and manipulation of digital data through the physical world [32]; this focuses only on the physical real-time interaction and fails to account for a holistic user experience. The Human-Computer Interaction field of study looks at a more fundamental approach to human interaction with computing devices, focusing primarily on the human factor's nature of the physical world to interface with the digital world [33]; again, this does not reflect on the combined experience of phygital. None of these lenses shed light on the combined value of physical and digital in the user experience. Nor do they talk about the impact of phygitization on a business.

While it is positive that some work is being done in the space of the combined physical and digital realms in terms of the nature of the interaction itself, there needs to be more understanding of how phygital impacts the holistic user experience. Understanding the phygital user experience is critical for developing phygital products that address user needs and elevate the product experience. Furthermore, there is no unified framework for building phygital products and services to address customer pain points and create value for businesses. To bridge this gap, we require a Phygital Transformation framework that facilitates the transition to a phygital world of products and services. Such a holistic framework needs to be developed, and this thesis aims to build the foundation for this emerging area of phygital transformation.

The goals of this thesis are threefold:

1. Understanding how phygital can improve the user experience.

2. Understanding what business value can be derived from a phygital product.

3. Developing a systematic process for digital product companies to transform into a phygital product company.

To accomplish these research goals, this thesis explores existing literature in this space, conducts primary and secondary research to collect data about commercially available phygital products, and based on this data and analysis, proposes a holistic Phygital Transformation Framework.

Chapter 2: Literature Review

The term User Experience (UX) was defined by Don Norman. It "encompasses all aspects of the end-user's interaction with the company, its services, and its products" [30]. The User Interface (UI) is the medium through which the user can interact with a machine. These two fields are distinct yet interrelated. One way to look at this may be to classify the UX as "What" the user wants to do with a product or service and the UI as the "How" the user can accomplish their task. Digital products and services are delivered to users through a screen as their primary and often the only mode of connection between the user and the product. In this way, the user's UX with the product has been limited by the UI that can be developed using a screen alone; this may be why even though UX is a holistic and encompassing term, it has become labeled more and more as a digital field [31].

To develop a truly holistic and phygital user experience, we must grow beyond the mindset that the user interface can only be digital. In the following sections, we will look at Diana's socially intelligent product framework and the tangible interaction field of study as they offer a perspective on what a non-digitally dominated user interface and user experience may look like. Additionally, we will also look in greater depth into digital transformation; this is important as it may give us guidance on how existing firms can systematically adopt new technologies that may radically alter their business models and operations since this is likely to be true with the adoption of phygital product technologies and product designs as well.

2.1 Tangible Interaction Design

2.1.1 History of Tangible Interaction and early work

Professor Hiroshi Ishii and Bragg Ulmer coined the term "Tangible Bits" in 1997 [32]; it is an umbrella term that refers to physical objects that can represent digital data and enable digital data manipulation directly through physical objects or through their spatial positioning. Subsequent work in this field then developed the concept of Tangible User Interfaces (TUI), which utilized Tangible Bits to create a more intuitive and natural user interface in the physical world that replaced the Graphical User Interface (GUI).

The early literature on tangible interaction focused on three concepts [32] (Figure 2):

1. Using the everyday surfaces surrounding us, such as walls, tables, doors and more, to interact with the digital world.
2. Coupling everyday graspable objects such as mugs and books with the digital data that is related to them.
3. Finally, using ambient media to use human periphery perception by using sounds, air flow, water movement, etc.

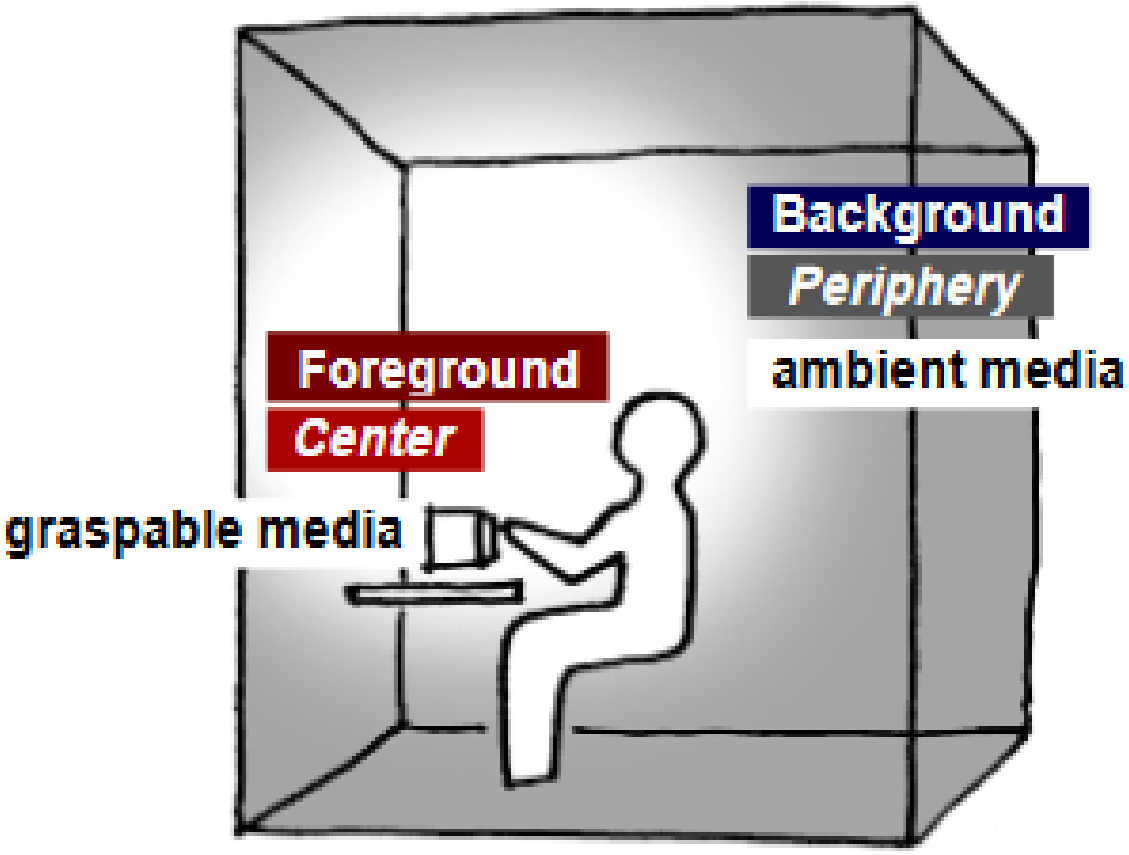


Figure 2: The Early Tangible Interaction Model showing foreground and background media [32].

The concept is best explained through an example. Urp (Figure 3) is a tangible user interface for urban planners. The user can place 3D scaled-down versions of buildings and other structures in

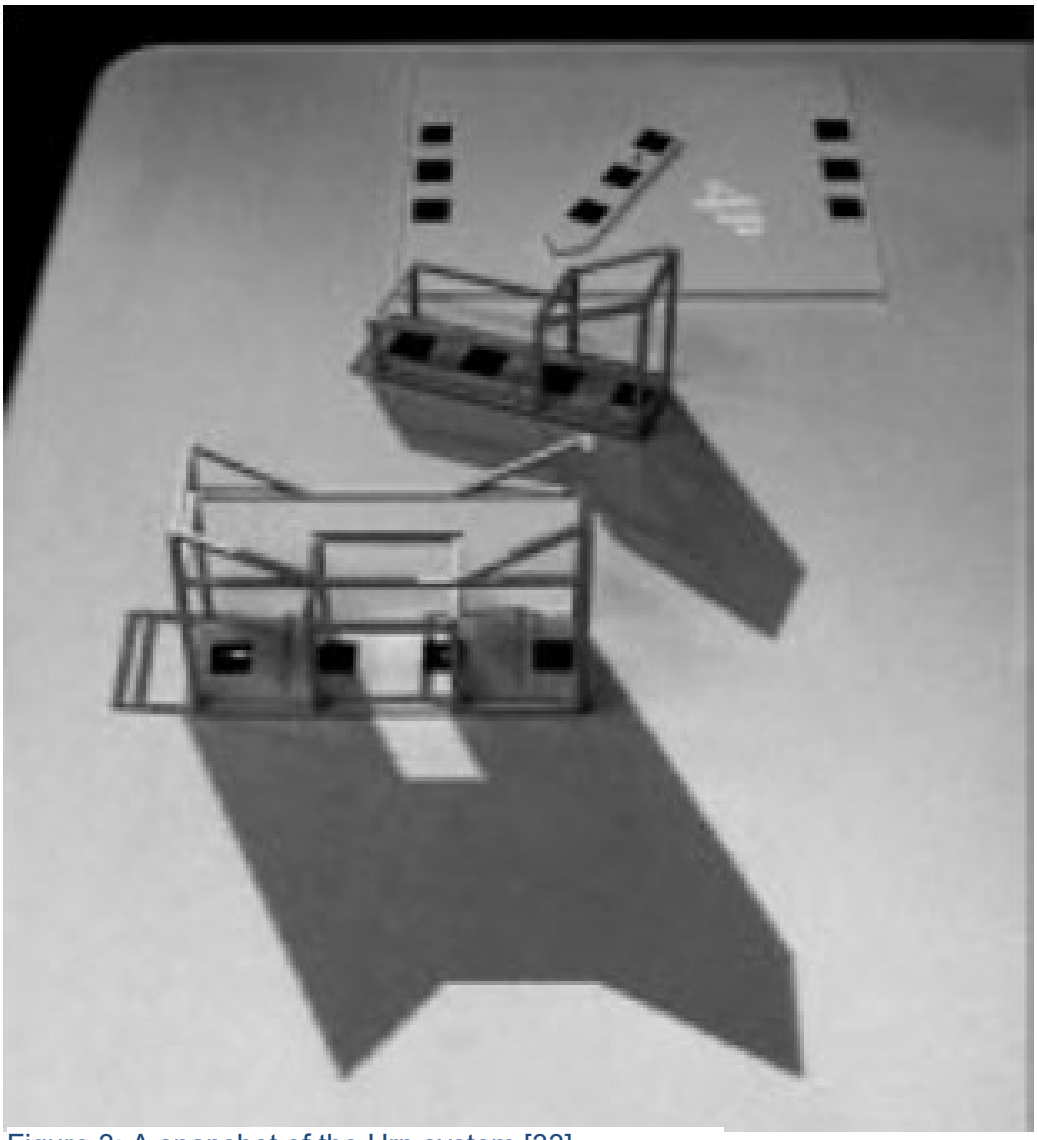


Figure 3: A snapshot of the Urp system [33].

the built environment onto the workbench. A computer then projects a simulated shadow of the objects based on the time of day it is simulating; the result is a more visual understanding of how the building positions can create inter-shadowing problems (when one building's shadow is cast on an adjacent building). Users can then move the buildings and change their orientation simply by picking up and moving the physical objects representing the building structures on the workbench to solve this challenge quickly and intuitively.

Figure 4 shows the difference between a GUI and a TUI. In a GUI, the digital information is controlled via a keyboard and mouse, which has no representational significance to manipulating the data. The user needs to learn how the functionality of the mouse corresponds to manipulating the digital data. Does scrolling the mouse wheel move the virtual building object laterally? Or does it change its orientation? Furthermore, the visualization of the digital data is done through a single screen, making it challenging to understand the three-dimensional nature of the problem that the software is simulating. In the TUI model of the data, the control and viewing of the data are done through physical representations. This makes it more intuitive to understand and use the system. A 3D building block provides affordances to be picked up, moved, and reoriented; your input and output become identical to such a system [34].

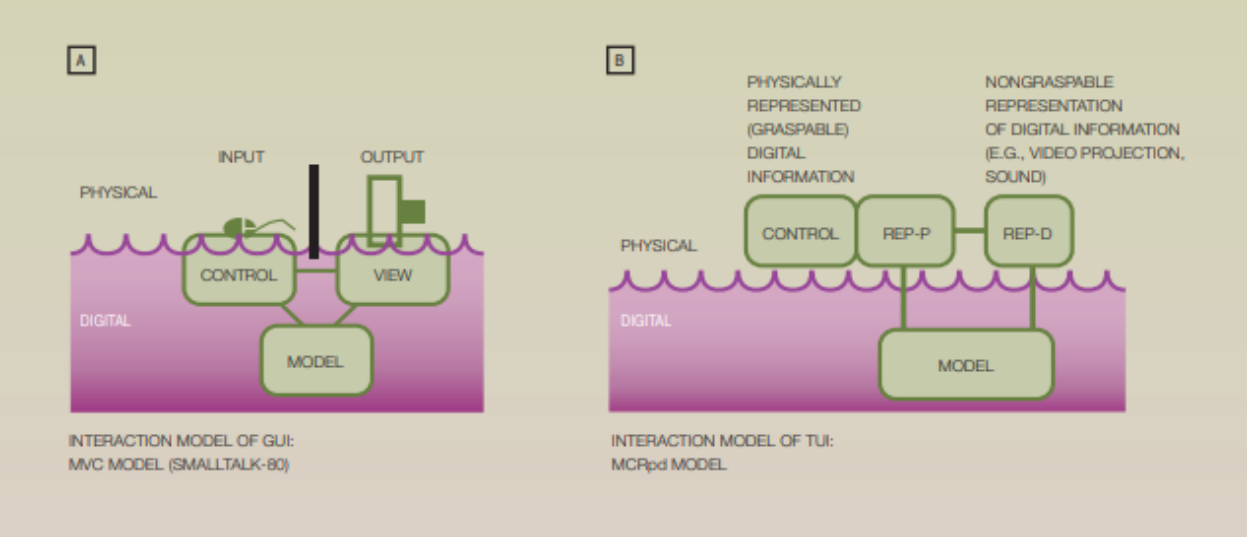


Figure 4: Comparing the GUI and TUI Model [34].

2.1.2 Tangible Interaction Framework

While this early work described in Section 2.1.1 shows the model of a tangible user interface and how to understand it in the context of traditional GUIs, it does not shed any light on its effects on the user. Moreover, tangibility is more than just the physical representation of digital data. A framework introduced by Eva and Jacob [35] attempts to bridge this gap. They have identified four distinct yet interrelated themes of tangible interaction and how the type of interaction can affect the user (Figure 5):

Tangible Manipulation - This theme involves directly manipulating a tangible object of interest, unlike a mouse or a keyboard, which are intermediate physical objects without any direct resemblance to the manipulated data. In Urp (Figure 3), the building objects were used for tangible manipulation of the orientation of the buildings. The user could directly pick up and move the physical building objects on the work surface to alter the simulation results. Compared to a GUI where a mouse and keyboard would be needed to indirectly manipulate the spatial position and orientation of the building icons in the GUI. One of the critical concepts of tangible manipulation is how easy it is for the user to understand the relationship between their actions and their effects (termed Isomorph Effects). To do so, users need feedback initiated from the digital side when they act on a tangible object to understand the implication of their actions.

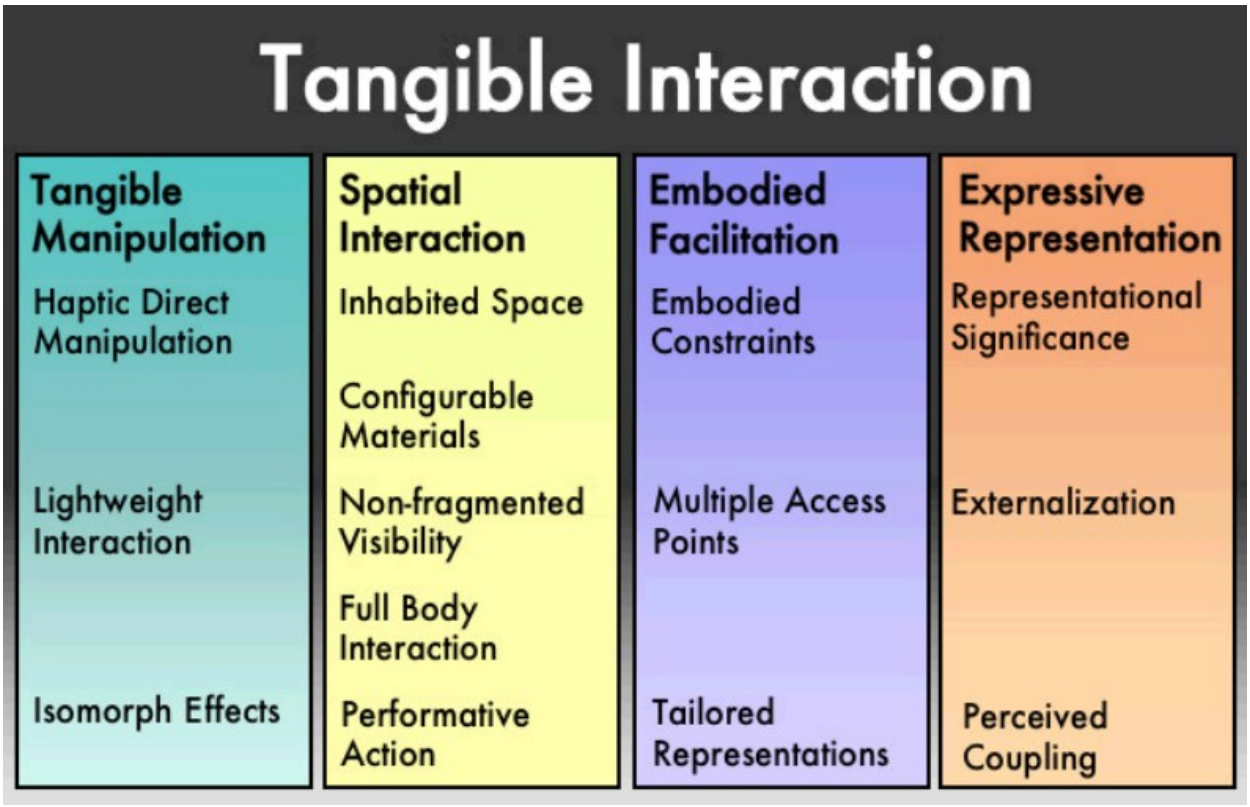


Figure 5: Tangible Interaction Framework by Eva and Jacob [35].

Spatial Interaction - The space we reside in the way it is due to the relative position of objects in it or the relative position of our body with these objects. The spatial organization of multiple objects also has meaning to us. Think of a sandwich; the bread is an independent object, and the tomatoes, onion, and meat are all independent entities. However, unless they are relatively positioned together in a specific way, we don't call it a sandwich and rather just see them as ingredients or components of a sandwich. Thus, tangible interaction can be expressed through spatial interaction.

Embodied Facilitation - The tangible design parameters of the system can influence the behavior of users and groups of simultaneous users as well. A guest speaker for the Innovation Strategy class at MIT Sloan asked the students whether they would use a laptop or a tablet for referring to notes while presenting in front of an audience. An overwhelming majority of the class raised their hand in preference to the tablet. While both devices can house a similar-sized digital screen and are equally capable of showing speaker notes, the tablet appeared to feel more natural to use in such a context. Thus, the tangible nature of the device could influence how the user can use it.

Expressive Representation - A TUI remains an extension of its digital system. The user needs to know how tangible changes are related to digital commands or data. Also, users need feedback from the digital system, letting them know how they have affected the digital layer behind the interface. For this to happen, users need a strong relationship between physical and digital representations or a perceived coupling between that data's physical and digital representations. Interestingly, this happened when we were introduced to the digital world. Files and desktops seen on computers are digital representations of physical objects, and now for TUIs, the reverse must happen to build an intuitive system. Figure 6 shows an example of representing digital entities in the TUI. The representational significance of these objects between the digital and physical worlds makes them more intuitive.

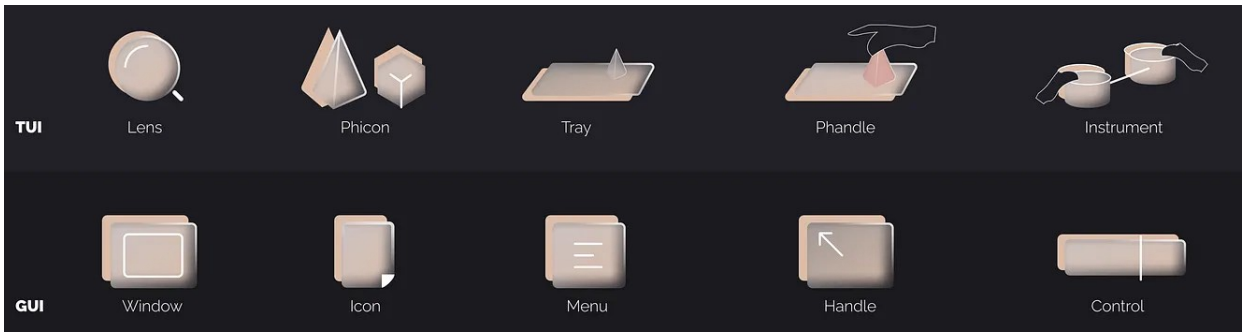


Figure 6: The analogies between GUIs and TUIs for the modes of use of the system [36].

2.1.3 The value of a TUI to the user

While the term tangible interaction may sound novel and futuristic, it is far from that. From the moment we are born, we live in a tangible world and interact tangibly with people and things in our world. We learn very intuitively about the behavior of the physical world, such as letting go of an object means that it will drop to the floor. Over time we have also built perceptions of what tangible properties mean to us. For some categories, expensive and quality products are associated with a higher weight than cheap products, generally perceived as lightweight [37]. A TUI can make the most of people's implicit knowledge about the real world to use the digital world more intuitively.

Tangibility aids learning [40] and creates a stronger emotional connection with the user [22]. Moreover, TUIs give us an opportunity to solve the design principle of form following function for the digital world, that is the form of the object represents its functionality. Think of the stylus as an input device to the computer, it is much more intuitive to use it as a drawing tool, here the form of the stylus has followed the function of a drawing tool which is pen like or paintbrush like structure. On the other hand, a keyboard and mouse can be less intuitive to use as a drawing tool, since the forms of a keyboard and mouse do not resonate with the function of a drawing tool.

Table 1: Tangible Interaction from the Phygital Transformation Lens

Pros	Limitations
● Provides an understanding of the various types of tangible interaction that can be done. ● There exists a technical model with 1:1 mapping from GUI representations and TUI representations.	● Focuses on the replacement of the GUI with a TUI rather than the enhancement of a digital system with physical objects. ● Limited understanding of the specific problems that a TUI can solve in the user journey of a digital product.
Key Insights: ● The user needs to understand the role of the physical and the digital components in a system and how they are coupled; representational significance of the objects can aid this. ● The user needs feedback from the digital system when they interact with the tangible objects to understand how their actions and effects are mapped (Isomorph Effects).	

2.2 The Socially Intelligent Product Framework

Carla Diana, in her book “My Robot Gets Me,” talks about how designers should approach building social products and has built a framework for designing physical products with social intelligence, which is a product that can interact with users based on social relationships and contexts. Diana’s social product framework is split into 5 layers of growing social involvement between the product and the user.

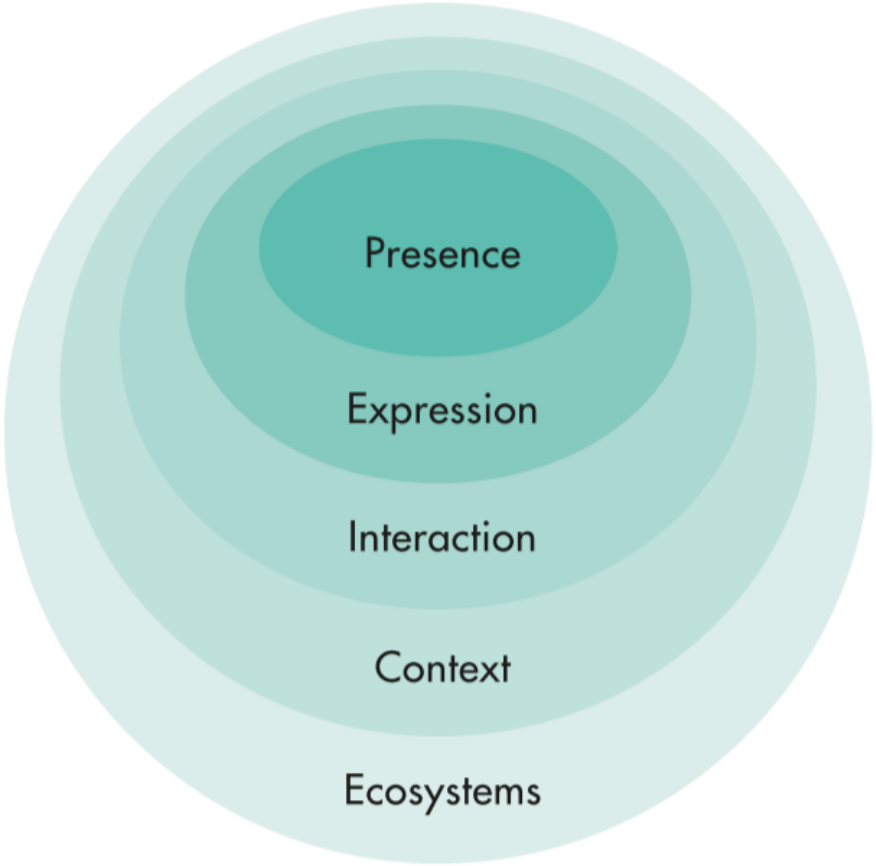


Figure 7: Diana's five social rings in the socially intelligent product framework [38].

2.2.1 Presence

The core of Diana’s framework starts with the mere presence and ownership of a physical object. There are three key concepts under the umbrella of presence, which are covered below:

1. The industrial design of the product and what it communicates:

We have discussed earlier how the nature of a physical object provides affordances that can communicate to the user how to use it. A knob tells the user to rotate it, a key tells the user to insert it into a keyhole, and a switch tells the user to flip it up or down. At a macro level, the entire design aesthetic of the product can make you feel differently about the product. Look at Figure 8 A & B, both are at its core the same product, they are similarly priced Wi-Fi routers that enable the user to connect to the internet. However, the gentle design of A signifies to the user its capable nature, and its intention to blend into the background. The router in Figure 8B, on the other hand, wants to scream its presence, the design shows that this router means business and has plenty of performance to deliver; this is a welcome call to gamers who crave performance. The nature and context of the use of these products are what informed the industrial design of the product; this is called Product Semantics. The presence of these devices has determined what sort of relationship and perception the user is meant to have with them.

A

B

Figure 8: A - Asus Zen WiFi Router [39], B - Asus TUF Gaming Router [40].

2. The Social Role of Products and its User

From a user's point of view, interaction is perceived as intelligence. With this in mind, let's look at the three modes of interactions that users have with their products.

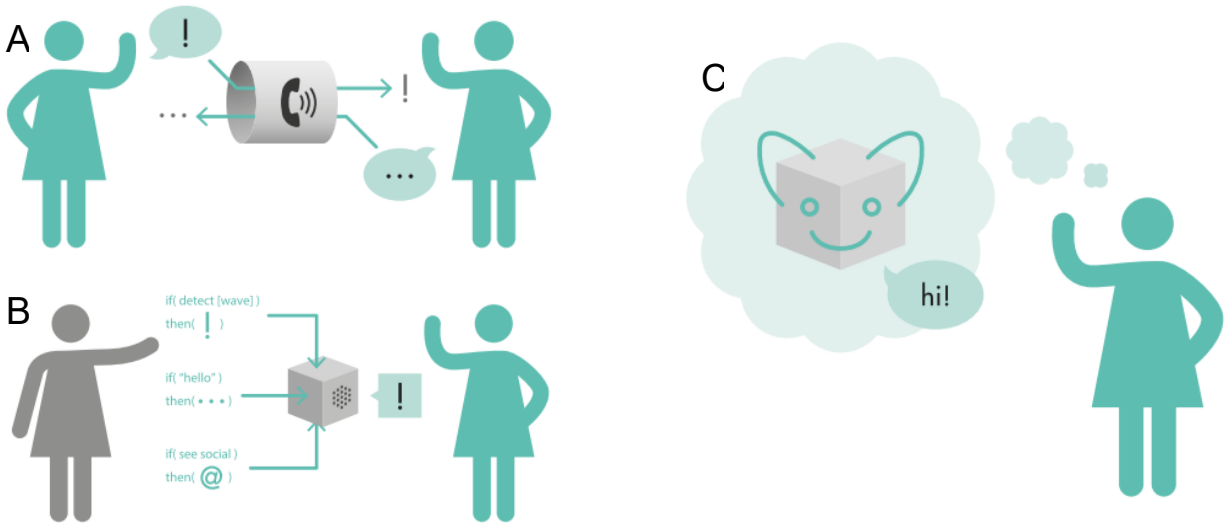


Figure 9: A - Product as a conduit, B - Product as a communicator for embedded Messages, C - Product as an independent Entity [38].

The first mode is a product as a conduit (Figure 9A). We use the medium that the product provides as a means to an end to communicate with another user. A telephone is a great example because our objective is to just talk to another human, and the physical device facilitates it.

The second mode (Figure 9B) is when your product communicates pre-recorded messages to you. In this case, the designer has planned out every possible interaction the user can have with the product. Thus, to the product's user, it is as if another person is telling them information through the indirect medium of the product. The day-to-day appliances that we use in our lives fall under this category. For example, when your phone is charged, an indicator signifies that the battery is full. However, in this type of interaction, the users have an added cognitive burden to interpret and react to these messages.

In the final mode (Figure 9C), the product behaves as if it is communicating the message and not someone else. Here the functionality may remain the same under the hood, but the perceived interaction from the user is that the product itself is talking to you. What if your toaster didn't just switch an LED on when the toast is ready but rather communicated by saying, "Hey! I've made you toast just the way you like it!". In this type of interaction, the cognitive load is much lower since you can use your natural ability to communicate with people to now communicate with physical objects. This is an objective of socially intelligent products as users perceive their natural interaction capabilities as the intelligence of the product.

3. The Emotional Connection with Things We Own.

The objects we own mean something more than just their functionality to us. Souvenirs or *mementos* you have are gateways to memories, for example. Other objects at your home can mean different things based on how you acquired them, who else was involved, and why you purchased them [41]. Just holding an object makes you feel a sense of ownership of the object [42]. We build an identity of ourselves through the items we own [43]; this is an important lever to push for designers as they build products that can create a lasting emotional connection with the product and, by extension, the brand or service it represents.

2.2.2 Product Expression

“The most power-ful aspect of our relationships with our products -will be the split--second, near-- telepathic exchanges that can happen with just a flicker of light, a sequence of tones, or a gestural movement—-the kinds of messages that can benefit from our full attention yet can also take place in our peripheral vision” [38]. To achieve these kinds of responses from the product, there is a two-step process:

1. First, we need to list out all the pieces of information that need to be communicated to the user and what that communication implies.

2. The second step is to communicate this information through the physical world. The most practical modes of communication are using light, sound, and movement to get the user’s attention and then communicate the information to them.

   Light - Can be animated and change its color to show various types of persistent information on the device.

   Sound - Can be used to get information without a line of sight of the product and to share more complex pieces of information through words. However, sound must be heard in real-time; that is, it cannot maintain a persistent state like light can.

Movement - This is the least cost-effective way for products to convey information, as it requires the use of mechanical moving parts such as motors and gears, however, the end result is an action that users perceive as magical and natural. In the real world, living social things use movement as an active part of their communication; seeing them in physical products makes the product seem more socially intelligent.

When you plug in an appliance like a rice cooker to the wall outlet, you see an LED glow, which signals that the device is powered up and is in standby mode, ready for further instructions. A microwave tells the user the food is warmed up and ready by beeping to get the user's attention. A toaster, on the other hand, signals that the toast is ready by moving the bread upwards. Many products use multiple expressions to convey information in redundant ways as well.

I would argue that there could be a fourth mode of expression for a socially intelligent product: sending a communication to the user's mobile phone as a text message, phone call, or smartphone notification. With 86.3% of the global population owning a smartphone and 91.4% owning a mobile phone device [42] (that's 7.33 billion mobile phone users globally), communicating by mobile phone is ubiquitous and a highly common medium through which a person can interact socially with other people. Hence, a socially intelligent product that could talk to its user through mobile phone communication could be another way for the device to express itself and resemble a social entity.

2.2.3 Social Interaction

The previous layer focuses on one direction of communication from the product to the user based on its internal state. The next layer looks at building on top of that to respond based on feedback it receives from sensors and the user. This is where engaging conversations between products and users begin. There are two steps in doing this:

1. Write scripts of all possible conversations between the product (assuming that the product is a person) and the user. This is the "what" that needs to happen.

2. The next step is to figure out how this communication can be realized. Categorize the messages in the script for the product → user messages choose which of the 3 expressions or a combination of them in layer two can be used. For the User → Product, look at the various input sensors or a combination of sensors that can be used to interpret the information.

As an Example:

Table 2: A Conversation between a Microwave and the User

Speaker	**Dialog**	**Input to the Product / Output from the Product**
User	Hey! I'd like to warm up some food, please.	Input: Door open Sensor
Microwave	Sure! How long Should I heat it for?	Output: Cooktop light on
User	For 5 minutes, let me know when it's done	Input: Radial Dial and start button
Microwave	All right, I'll keep track of it for you.	Output: Countdown timer starts.
Narrator	5 Minutes have passed	Output: The countdown timer is running.
Microwave	Hey User! Your food is warmed, have a nice meal.	Output: Buzzer
User	I've got it, thank you!	Input: Door open sensor
Microwave	You're welcome!	Output: Cooktop Light Off

This type of exercise provides an opportunity for the designer to analyze how well the input and output modalities of the system can meet the richness of the conversation between the user and the product.

2.2.4 Contextual Behavior

Let’s consider the example given in Table 2. Suppose you wanted to engage with your microwave in the same way, but now you’re doing it late at night as a sneaky midnight snack and thus don't want to wake anyone else at home up. Wouldn’t it be nice if your microwave knew that and, instead of making an auditory signal that it is done, just flashed the cooktop light to let you know it is ready? Context depends on the individual using it, their personality, location, time of use, and the cultural context of its use. There are a lot of variables here, however, if designers can categorize the different contextual uses of the product, they can design for and build better socially intelligent user experiences.

2.2.5 Product Ecosystems

The Apple AirPods on their own are just a pair of wireless earbuds, but what makes them special is how well you can use them with other Apple devices. Let’s say you pair your AirPods to your MacBook, and you receive a call on your iPhone; the AirPods automatically switch their pairing to the iPhone [44]. This seamless product experience exists because it uses context to base its action, and it leverages the ecosystem of Apple devices and services to make it happen.

Devices don’t need to operate in isolation anymore; they can speak to each other; they can speak with multiple users and can communicate with digital products and services. This unified approach can make the product experience feel more magical and greatly enhances their usefulness, or as Diana says, “the ultimate emotional benefit arises from providing a strong sense of brand through a unified design effort” [38, pp.203].

Carla Diana puts it all very well together in one statement, “to conceive of a product in this holistic way is to map out the product goals, beginning with its physical characteristics (presence); considering its dynamic behaviors (expression); planning out its dialogue with a person (interaction); maintaining sensitivity to location, timing, and state of mind (context); and positioning it within a larger network of related products and services (ecosystem)” [38, pp.39].

Table 3: Social Product Interaction from the Phygital Transformation Lens

Pros	Limitations
● Has a layered framework that looks at building a more social user experience for the customer. ● There is a spectrum for amount of social interaction you want to build into your product, through simple things by changing the way you send messages to the user all the way to creating motorized movement behavior that makes the product feel alive.	● Focuses on products that work mostly independently of a digital product or service. This is briefly covered in the ecosystems stage. ● There is no direct focus on the business value of implementing social interactions into product offerings. ● The product expressions should include mobile phone communication as another practical way for a device to get the user's attention.
Key Insights: ● "Embedding computing power within everyday objects allows us to design products that are more context-appropriate than 'Swiss Army knife' products such as smartphones or tablets." [38, pp.181] ● "the ultimate emotional benefit arises from providing a strong sense of brand through a unified design effort." [38, pp.203]	

2.3 Digital Transformation Frameworks

Digital transformation is adopting new digital technologies into existing business operations and delivering new or improved product offerings. There is a significant focus on the organizational and cultural changes needed for a business to use digital technology and think with a different mindset [2]. This is interesting for phygitization, as hardware-based technologies are not the norm for digital product companies. Some of the same learnings may be transferable from digital transformation to phygitization.

While there is no standardized framework for achieving digital transformation, looking at the frameworks that BCG [45], Accenture [46], Gartner [47], and McKinsey [48] use in their digital transformation consultancy business, we can see some definitive patterns.

The three core pillars at the heart of these frameworks are:

1. **Vision and Strategy** - Companies need to determine what the objectives of digital transformation are for them. Is it to build new products and experiences for their customers, improve operational efficiency, or change how they do business? [2] This goal will keep all the necessary stakeholders aligned to execute and is critical for success.

2. **People and Culture** - Larger organizations have teams operating in silos, making it challenging to adopt a new mindset and company culture. For successful digital transformation, having the executive leadership be on board with the digital strategy is important. Some companies have even created roles such as the CDO to ensure the strategy's success and that the appropriate digital culture is embraced.

3. **Design and Execution** - Companies must evaluate and match the right digital technologies to solve the pain points they are addressing. Finally, pilot projects are used to test the new solution and are iteratively tested and refined for a larger-scale launch.

Interestingly, not all companies can implement and make the most of digital transformation. A McKinsey report states that nearly 70% of digital transformation efforts fail to meet their goals. Common reasons for this failure include poor cross-functional collaboration, insufficient buy-in from management, and lack of accountability [47].

There are four strategies that companies adopt [3] (Figure 10):

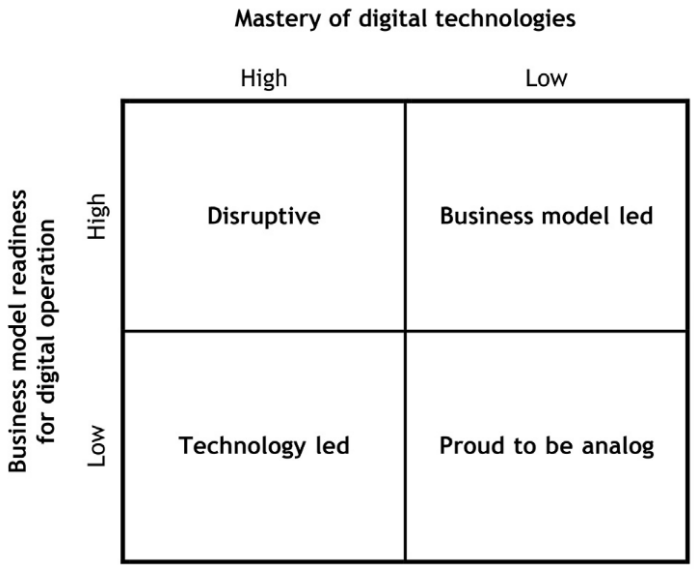


Figure 10: The four types of digital transformation [3].

Disruptive - These companies want to create a substantial change in the value they deliver to customers and change the landscape of the sector they are operating in. Typically, companies in this sector are startups that are poised to make radical changes and experiment fast and fail cheaply to test their hypothesis.

Business Model Led - These companies aim to create new business models and are characterized by a higher risk appetite since failure could prove fatal. General motivators for such companies are the competitive pressure to transform or to perish. These companies focus on proving the business model and then look for technologies that fill the gaps and enable the new business model.

Technology Led - These companies adopt new digital technologies to improve business operations and cut costs. These companies face less risk in digital transformation as they are not undergoing radical changes in their business model. Naturally, industrial sectors are the dominant group in this category.

Proud to be Analog - This group is for companies with the core value proposition of their product due to their tangible nature. Luxury goods and handmade products are top companies here. Hence these groups are risk-averse to digital transformation as it could affect their reputation and perception by their target audience.

Table 4: Digital Transformation Framework from the Phygital Transformation Lens

Pros	Limitations
● The framework looks at the organizational change needed for adopting new technologies into their practices. ● The framework considers new business model opportunities by adopting new technology. For phygitization, hardware carries a higher cost to the customer, implying the need to relook at their business model.	● This framework has a limited focus on evaluating the technology and its impact on user experience. ● The development and scaling process steps suggest a fast development and deployment and look at refining their solution based on data from the field. Due to logistical challenges, rapid deployment and future refinement is not feasible with physical products. ● The framework doesn't account for cross-functional involvement throughout the process from planning to execution.
Key Insights: ● Key decision makers in the company must be aligned on adopting new technology as it requires a shift in its employees' operating mindset and company culture.	

- Just as some companies are proud to be analog, not all digital product companies need to be phygital. The user experience that can be delivered is the key driving factor.

- Startups and B2C companies are best positioned to adopt a phygital mindset and become disrupters in their industry. To do this, cost-effective ways to experiment and test phygital products are needed.

2.4 Summary

In this chapter, we reviewed the role of user experience and its importance in building a product that solves pain points and makes it easy for users to adopt to do so. We then explored two physical product-related frameworks. In the socially intelligent product framework, we saw that customers correlate interaction between the product and the user as social intelligence. We looked at the various levels of social interaction and methods for designers to build social intelligence into their products. However, a limitation of this framework was that the social product operated in isolation from the digital world. The tangible interaction framework shows the concept of the physical embodiment of the digital world. That is the replacement of the GUI with the TUI. This framework gives us a strong understanding of the importance of users understanding the relationship between the physical object and the digital system they interact with. However, it did not share which interactions of the digital system should be phygitized for the best user experience. Finally, we looked at digital transformation; here, we learned about the organizational challenges for a company to adopt a new technology and the need to align all internal stakeholders towards a common goal. It also determined that B2C companies with a risk appetite and early-stage companies are best suited to adopt disruptive new technologies. However, none of the digital transformation frameworks and strategies analyzed accounted for the specific user experience impact of adopting new technology and how to align the key stakeholders to execute it.

Drawing upon the analysis of these frameworks, we intend to leverage these findings to create a new framework tailored explicitly to incorporating a physical device component into existing digital products. This framework would aim to fill the gaps of how the user experience pain-points are addressed, why the business should adopt it, and how all the key stakeholders could stay aligned in a shared process that simultaneously would involve them from planning to execution.

Chapter 3: Research Methodology and Analysis

3.1 Primary Research

For the purpose of investigating the process of Phygital Transformation in companies, this study recruited ten participants through the online professional network LinkedIn. All the participants were selected based on their work experience in companies where Phygital Transformation had occurred, and they held various capacities and roles. These companies exist in the consumer electronics, health, fitness, and fintech domains. To collect data, a standard interview guideline was developed with open-ended questions, which were modified based on the relevancy of each participant's job role and domain expertise. Table 5 lists all the participants who were interviewed. All the interview scripts were then analyzed. First, they were coded to identify key statements and then converted into snippets that were added to sticky notes on a whiteboard tool. At this stage, the notes could only be referenced by participant number, and no reference was made to the participant's personal details; this was done to minimize bias and maintain the anonymity of the participants. The sticky notes were rearranged to find patterns, and insights were derived from the analysis using an affinity diagram. Through this process, the study aimed to understand the Phygital Transformation process better and gain insights into how it can be replicated in other digital products. Figure 11 shows the final affinity diagram after the data synthesis.

Table 5: List of Participants in the Primary User Research Study

No.	Company	Role	A Key Quote from Participant
P1	Domi	Technology Development	"Cannot be confusing, can't be distracting, seems trivial, but it is difficult and important."
P2	Peloton	Product Manager	"Hardware gives a more rewarding experience, the secret sauce is the efficiency of good engagement with members"
P3	PayTm	Product Manager	"Initial focus is to gather max users. Make it credible. Indispensable. Then a revenue model."

No.	Company	Role	A Key Quote from Participant
P4	Domi	Product	“I hired a coach in India who makes sure I stay on Zoom at 8 in the morning to make sure I do it. I don't skip because this guy keeps me accountable. Just an app doesn't do much.”
P5	Domi	Business Development	“Asking people to distance their phone but use the phone for mindfulness is nonsensical.”
P6	Engo	Business Manager	“There's a term device anxiety, which is I have to keep checking this device, and it's making me feel bad.” “Technology products these days, there's a hardware component, a firmware component, and a software component and software is significant.”
P7	AdhereTech	Product Manager	“The point I'd make is that apps are easy to ignore.” “Hardware that performs a real physical function has utility in the real world would drive dramatically higher retention in an app than otherwise.”
P8	Microsoft	Engineering Program Manager	“Stakeholders align a lot more smoothly when there's that shared goal”
P9	HealthifyMe	Product Manager	“By having a physical device, you're actually increasing the customer touch point with your company and the culture.”
P10	HealthifyMe	Product Manager	“it's not difficult to do is if you're integrating with something, it's hard when you're building the hardware on your own.”

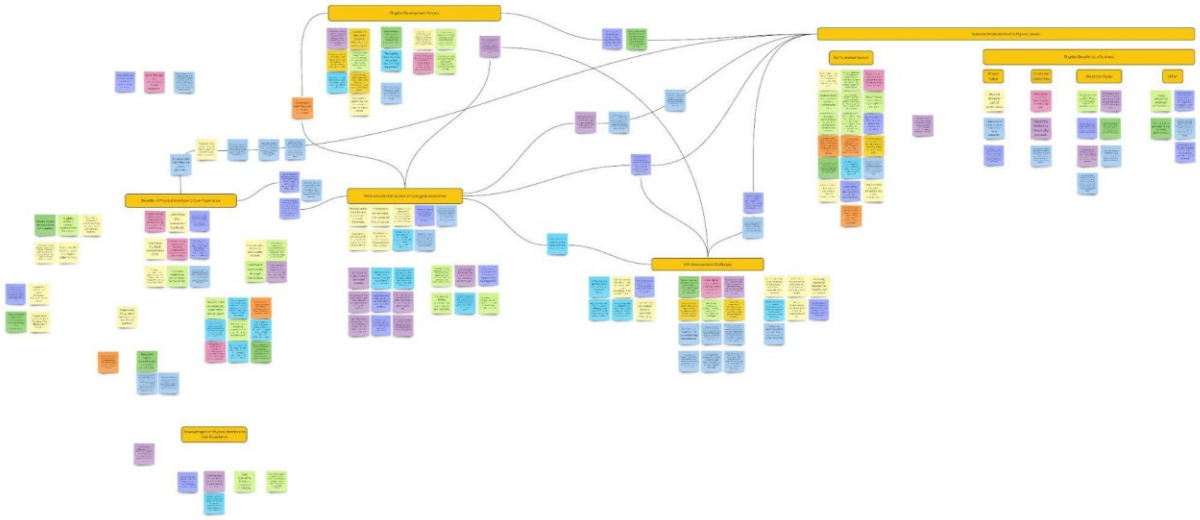


Figure 11: Final result of the affinity diagram.

3.2 Secondary Research & Case Study Development

Commercially available phygital products were analyzed to understand the role of the digital and physical components in the user experience. The products considered are listed in Table 6. App user reviews, third-party data on retention rates, and customer satisfaction data were collected to gain insights into user perceptions. Additionally, company blogs and marketing materials were used to gather more information. The insights gathered through this secondary research helped to substantiate the insights gathered from the primary research. Finally, individual case studies were developed based on secondary and primary research data to understand the phygital product experience and the phygital transformation process to achieve it.

Table 6: Phygital Products Considered in Secondary Research

Phygital Product	Description	Digital Component	Physical Component
Peloton	At-home gym equipment	The Peloton app has media content and performance insights for the user.	The physical gym equipment, such as a rower, treadmill, and bike for at-home use.
Engo Sunglasses	Glasses for runners and athletes to view performance statistics	Garmin and Strava Apps that measure and track user performance during athletic activity.	A pair of sunglasses with a built-in heads-up display to show the user their performance in real-time.
HealthifyMe	Weight loss service company	The HealthifyMe app tracks health metrics and connects the user with wellness coaches and dieticians.	Bluetooth enabled Smart weighing scale and Continuous Glucose Monitoring devices.
PayTm	Financial payments via QR Codes	PayTm App enables cashless transactions between two people.	The SoundBox device audio confirms a financial transaction on the PayTm app.
AdhereTech Smart Pill Bottle	Product to aid medication adherence	Text reminders and phone calls to the user to remind them to take their medication.	A smart pill bottle with multimodal feedback to remind the user when it's time to take their medication and track their adherence.
Unpluq	Product to reduce smartphone usage	The Unpluq app blocks distracting apps on the user's phone.	The Unpluq tag is an NFC device; tapping on the user's smartphone unlocks the distracting apps.
Whoop	Fitness and performance tracking product	The Whoop app is a fitness tracker product. It allows users to gather insights into their performance.	The Whoop 4.0 is a wearable fitness band with onboard sensors to collect performance metrics such as the user's heart rate.
Vaha Mirror	A mirror to see yourself for feedback while exercising	Virtual fitness content, feedback on posture, and health data tracking.	The mirror has a screen embedded within it, the user can use it to check their posture and watch the fitness content simultaneously.

Phygital Product	Description	Digital Component	Physical Component
Clever Kash	A learning product for children to understand money	Digital financial banking services. Specifically, a pre-paid digital card for children.	A tangible toy provides multimodal feedback on the cash left in the child's pre-paid card account.
Amazon Dash Button	A convenient way to make e-commerce orders	Amazon, e-commerce services	The dash button is a single button that can be stuck anywhere at home. On clicking the button, a pre-determined product is immediately ordered from the Amazon online service.
DJ Equipment	Input device for electronic music production	DJ software used to produce music.	Dedicated input hardware makes it intuitive and simpler for DJs to control the software without a mouse and keyboard.
Microsoft Presenter	A tool to help presenters control their slides and audio functions	The Microsoft Teams video conferencing software and PowerPoint presentation software.	The controller allows the user to change slides while presenting in front of an audience and to control video call functions such as muting the mic.
Microsoft Surface Dial	An intuitive tool for graphic designers' workflow	Graphic design software.	The dial can manipulate the artwork by zooming and rotating intuitively, providing quick access to the color palette. It acts as a second input device for the artist to use, speeding up workflow.

Chapter 4: Research Results and Analysis

In this chapter, we will look in detail at the results. They reveal that multiple perspectives contribute to successfully implementing a phygital product experience. They are broadly classified under two areas: how the phygital product experience improves upon the digital-only user experience and what value a business attains from building and implementing a phygital product experience.

After that, we will look at the results of analyzing the phygital user experience of seven products and cover five key areas in which a phygital product can improve user experience. It should be noted that these areas were identified through primary and secondary research studies and cannot be deemed as an exhaustive list.

4.1 Key Insights from Primary Research

Figure 11 shows the result of the affinity diagram analysis. This analysis revealed two distinct perspectives. First, the user perspective on the phygital product experience and what factors influence its adoption. Secondly, the business perspective of implementing a phygital product into their offerings and what value a business can derive from it. Figure 12 shows a summary of these categories, and the following sections discuss the key insights for each category.

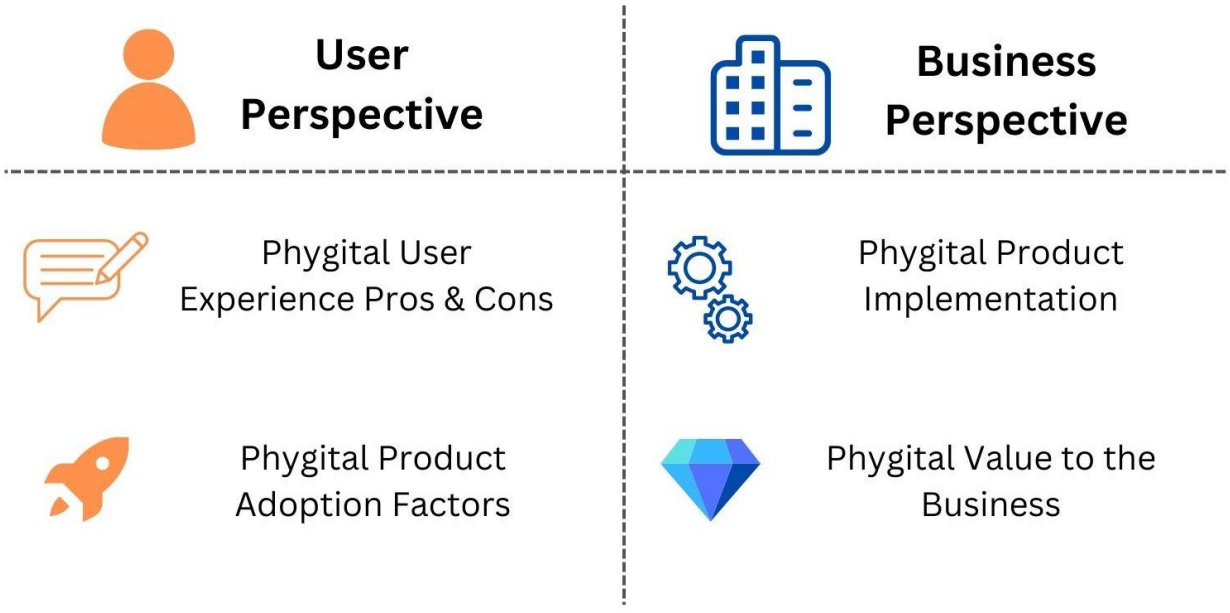


Figure 12: User and Business Perspectives, the two sides of the phygital coin.

4.1.1 Phygital User Experience Pros and Cons

The phygital experience is the holistic experience a user will have due to the product's digital app and physical device components. This section looks at the pros and cons of such experiences based on the insights from product developers interviewed, who are listed in Table 5. These participants understand the impact of their phygital products on their customers, and hence it should be noted that the insights presented here are perceived benefits.

First, we look at the positive insights for how a phygital user experience may enhance a digital-only one:

1. **Feedback** - Multiple participants who work with products related to health and fitness described that a core benefit of hardware is the improved and possible real-time feedback it can provide to its customer. This feedback is particularly important in the early stage of product adoption, as mentioned by Participant 5, “Feedback through hardware solves the problem of ambiguity during early practice and habit forming. It can show the progress and improvement the user is making “.

2. **Habit Forming** - This was briefly mentioned in the previous point. Three participants mentioned that a physical device aids in the habit-forming process. Participant 1 says, “Physical makes it easier to build a habit, vs. digital.” This statement is supported by what Participant 7 says, “Apps are easy to ignore. The user needs to build a habit to use the app and make it part of their daily schedule.”

3. **Faster Access Rate** - Two participants mentioned that a dedicated physical device makes the access rate to that specific activity much faster. This has helped in their case to improve the user experience by making it less cumbersome. Participant 10 said this regarding their phygital product, “the largest feedback that we had is that it's too time taking, I don't want to do this, I don't have this much time, I'd open the app, follow five steps and go and track my weight, it’s too difficult.”

4. **Common Standard** - Two participants (P6, P10) shed light on the software and hardware compatibility of the two firms and how it can be a roadblock to delivering a seamless user experience. Participant 6 said, “Engo partnered with Garmin, but it is challenging to use their SW API as we have a use case they never planned for.” By creating a common standard of what the hardware device should be and the digital component, firms may be better equipped to deliver the experience they plan for. Participant 10 added that “There are many different options for a smart weighing scale. By deciding which one is best for the customer, we can create a standardized experience for our customers and coaches, making it simpler.”

5. **Communicate Information** - An object's physical design can communicate information regarding how it can be used, as discussed in Section 1.5 and explored in the literature review. The ability to convey information can be used to tell the user how to use the device, as put by Participant 4, “Physical makes it easier to start using the product, you see it and can use it immediately.”

6. **Distraction Free** - Five participants stated that a physical device contributes to users staying engaged in an activity for longer. Participant 6 says, “Dedicated physical hardware can ensure you get the distraction-free experience that users want. Runners don't want to slow down and look at their watch.” The sentiment is best expressed by Participant 5, “Asking people to distance from [their] phone for mindfulness but then use the phone for the mindfulness app is nonsensical.”

7. **Emotional Connection** - We have explored earlier that physical objects can create an emotional connection with the user [43]. This was corroborated by three participants who shared that a physical device could make the product experience more tangible as there could be moments of serendipity with the device. The physical device could also communicate the digital value and make it seem more valuable. Participant 1 said, “Physical devices can communicate the value of the digital. Make it palpable.” This was supported by Participant 10, who expressed that “people are much more likely to pay for a tangible object than a digital app.”

Now we look at possible drawbacks of having a phygital experience as described by the interviewed participants:

1. **Dependency** - This is best summarized through Participant 9's comment, "The challenge with physical devices is, if it doesn't work, users feel a huge deficiency of service." In a phygital experience, the value is created for the user due to both the digital app and physical device of the product. If one of them is no longer available, the customer can perceive it as a disruption to their service.

2. **Limited Customization** - Three participants mentioned that the nature of the physical component makes it challenging to customize to personal preferences. Participant 6 explained that with "physical devices, it can be hard to cater to the design preferences of all users. Not everybody likes the single design of the physical device". And Participant 8 added that "due to the complexity of development, we are restricted to a single design that doesn't satisfy all customers."

3. **No Hardware Updates** - Unlike software features, a hardware device will leave the factory with all the features it can possibly have. Multiple participants shared that this was a challenge to the experience they could deliver. Additionally, another participant mentioned that customers view removing the hardware functionality in future releases unfavorably.

4. **Maintenance** - Several participants mentioned the importance of using the physical device in a simple manner. However, the long-term usage of the product includes the maintenance and well-being of the object's physical state [P2], such as cleaning, repairs, and changing batteries.

5. **Footprint** - Physical objects need space in the real world. This may be a hindering factor to some users, particularly for objects that are large in size. Participant 2 explained that "physical has a stronger footprint in the house, but it could be worth it with beautiful aesthetics."

4.1.2 Factors supporting the adoption of Phygital Products

In the previous section, we saw the benefits and challenges that a user might face when using a phygital product. This section explores three factors that could support adopting a new phygital product. These adoption factors may be necessary to maximize the value generated to the users of the phygital product and the company selling the product. The three factors are summarized in Figure 13 and are described below.

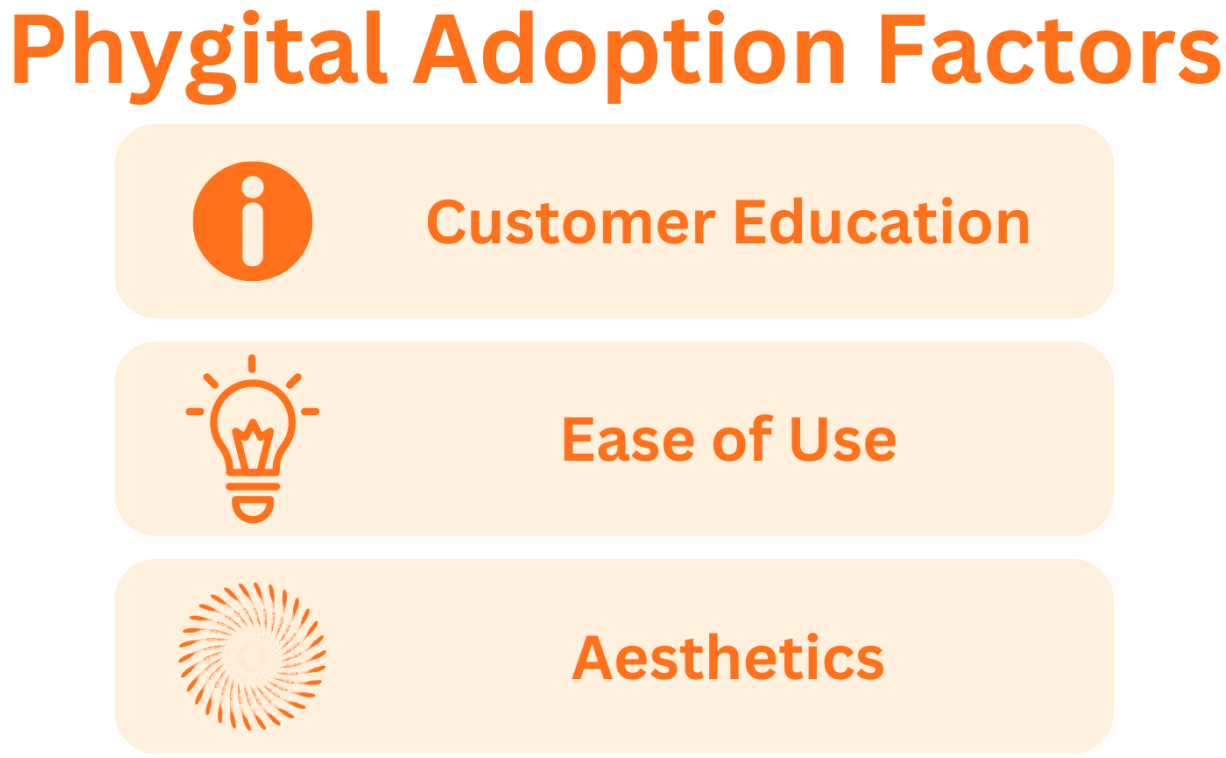


Figure 13: Three factors that could support the successful adoption of a phygital product.

Customer Education

For many users, a phygital product experience could be novel. This means users may need to gain familiarity with the combined value of the physical and digital components of the product [P1] that they can receive. Moreover, if there is a learning curve, the users need to be onboarded and given sufficient guidance on how to use it and where to go if additional help is required. Businesses employ various methods to help users familiarize themselves with the product. A robust 'Frequently Asked Questions' page [P9] and better storytelling [P6] are two such methods that emerged in this research.

“It's important to communicate the value of your phygital product, and you can do that through good storytelling.” - P6

“We added a FAQ section on our app that helped answer questions that people had with the physical devices. For example, how do I change the batteries.” - P9

Ease of Use

Through education, companies can make it easier for users to learn how to interact with their products. It is essential to design a simple and easy-to-use product to increase the chances of customer engagement and long-term adoption. In contrast, a challenging and intimidating product experience could deter users, making adoption significantly more challenging.

One way to do this is to leverage users’ expected behaviors or existing knowledge. AdehereTech’s smart pill bottle looks and functions like a regular physical pill bottle. This familiar physical structure of the device helps the product align with existing users’ behavioral patterns and mental models, requiring no additional learning curve and reducing the adoption barrier. In line with these findings, Josh Stein, the CEO of AdhereTech, shared three design principles that aid in the adoption and ease of use of a phygital product [49]:

1. Devices should work out of the box and require no additional setup by the user.
2. Smart devices should be used exactly like their traditional non-smart counterparts.
3. Products should be designed for extremely long battery life if they are not a plugged-in device.

Point 3 addresses one of the drawbacks of having a physical device: regular product maintenance, wherein the user may be required to change batteries or recharge the device frequently. Maximizing the battery life reduces the maintenance requirements on the user and aids in the long-term ease of use and adoption of the phygital product.

Product adoption could be significantly supported by designers prioritizing product features that address the ease-of-use challenges related to using and setting up a new phygital product in the realm of what is technologically feasible.

Aesthetics

"Aesthetics are very important; it ensures that customers are happy to use their product and keep it in their homes. Not embarrassed to have it." - P2

We have discussed earlier how the ownership of a physical object is an extension of the person's self-identity [43]. Thus, it seems imperative that the physical component of the phygital product has a design that the user is willing to be associated with and, by extension, the brand that provided it to them.

"Physical has a stronger footprint in the house. It could be worth it with beautiful aesthetics" - P2

4.1.3 The Value of Phygital to a Business

The primary research revealed positive outcomes to implementing a phygital product strategy. Four areas of benefits to the business were identified and listed in Figure 14 and are explained below.

Figure 14: Summary of the benefits to a business due to a phygital product strategy.

Brand Equity

Brand equity is the value premium that a company's product commands with its brand name and reputation versus that of a generic brand of a competitor with a similar product [50]. Companies carefully build brand equity because it leads to higher sales, as consumers prefer to use products from brands that imply quality, good value, and trust. Brand equity is developed by consistently delivering good quality products and services, maintaining a positive brand image through marketing and branding efforts, and creating an exceptional customer experience [50].

Phygital product experiences could support the development of positive brand equity by creating delightful user experiences that also solve the real-world needs of the user as expressed by P1 and P2: "Physical has moments of serendipity" and "Tangibility creates a stronger connection with the product." Moreover, having a physical device increases the number of times a brand can interact with the customer, from when the device is received in its packaging to seeing its presence in the physical environment around the user [P9]. This repeated interaction with the product, in turn, seems to support the brand's recognition as the user sees the brand name and its products more regularly [P10]. Finally, having a phygital product could be marketed as being modern and tech-savvy [P10], which could further aid the brand reputation and, in turn, the overall brand equity.

Customer Stickiness

This parameter refers to the fact that a customer will stick with a product from a specific brand and not switch to a competitor's product. To increase customer stickiness, a company should have a unique value proposition and provide a seamless customer experience [51].

Unique software features stay that way for a short time; they are quickly copied onto competitors' digital products. Take TikTok as an example; it gained popularity due to its unique experience of short-form videos that were easy to view. However, this was rapidly copied by other tech giants like Instagram and YouTube. While this does not mean the original innovator will fail, it takes away future customers as there are no unique reasons to try another digital app [51]. Phygital products could be an option for companies to maintain their competitive edge through differentiation, this isn't to say that hardware cannot be copied, but instead, it is more challenging to copy and takes more time to do so [50]. This complexity of copying provides buffer time to maintain the uniqueness against competitors.

With millions of apps [6], it has become the norm for users to expect a digital app from brands; hence, getting a phygital experience could be a unique differentiator compelling users to try or stick with the brand.

Moreover, having a physical component of a product offering fosters the creation of stronger bonds between the customer and the brand [18]. This emotional connection suggests it could become more challenging for a customer to leave the service and switch to a competitor.

"The positive is that hardware creates a strong competitive advantage. It enriches the experience; tangibility strengthens the connection with the product and builds a deeper sense of connection." - P2

Customer Data

Companies want to collect more data on their customers to understand their behavior and needs better. Businesses can use this information to build more compelling products and communicate their value proposition to customers in a manner they can understand, leading to a more personalized product experience. By leveraging consumer data, businesses directly affect their bottom line; thus, consumer data is a strategic competitive advantage [52].

"Physical devices give the opportunity to collect additional data." - P4.

Consider HealthifyMe, a health and fitness app that helps its customers lose weight by providing nutrition and workout plans from fitness coaches. A challenge they face is that customers do not see the immediate benefits of their work and would leave their service. To tackle this, they now provide their customers with a smart Bluetooth-enabled weighing scale that makes tracking the user's weight daily easier and has embedded sensors that can measure body fat, muscle mass, hydration, and bone mass [53]. This extra data is used to build a layer of insights to give their customers more real-time and detailed insights on their progress. Additionally, fitness coaches can now suggest more personalized and effective plans to their customers rather than relying only on general guidelines [P9, P10].

"The smart scale measures weight and other metrics, which gives feedback to the customer on their weight loss journey." - P9

While collecting more customer data may benefit the company, it also raises questions regarding customer privacy and the ethical use of this data. Being truthful and transparent about what and why data is collected and how it will be used and safeguarded may be crucial to fostering a better relationship between the company and the customers [74].

Retention

One of the significant challenges that digital products and services face is ensuring that their customers use the product or service over an extended period since a user who uses the product or service for longer will provide recurring revenue for longer; this is critical for businesses that have a subscription-based business model [15]. Some reasons customers leave are when they no longer get the expected value from a product or service or if the experience of using it is complex and challenging [54].

Why is this important to businesses? Retaining a customer is far more economical than acquiring a new customer [55]; this directly affects the revenues and profitability of the company. Five of the participants indicated that phygital product experiences could address this retention challenge by building a product experience that is more engaging with the customer, which results in higher user satisfaction. Additionally, some participants suggest that phygital products could address customer pain points where a digital-only solution would be less effective.

“The Hardware provides a more engaging experience with higher retention. Naturally aligned with a subscription business.” - P2

“The physical devices help with user retention. If the physical product is sitting in your home, it is much more likely you will use the app that it is connected to.” - P9

“You have a physical product in front of you. And you know that you have to open the app to scan it or to you know, take a reading. Retention rates almost doubled for people who have devices with them.” - P10

“If we had an app, our retention would be 5X of our competitors. Because of our connection with the physical world. It works because of ease of use and zero setup.” - P7

4.1.4 Phygital Product Development and Commercialization

In the previous section, we saw how a phygital product could provide value to a business. This section will explore the insights gathered regarding building the phygital product and how to launch them to the market. The three key areas that emerged are the hardware engineering effort needed to design and build a physical item, the product development process needed for a phygital product to ensure all stakeholders within the company are aligned on the phygital vision, and finally, the methods that a business can explore to launch the physical product to the market. These areas are listed in Figure 15.

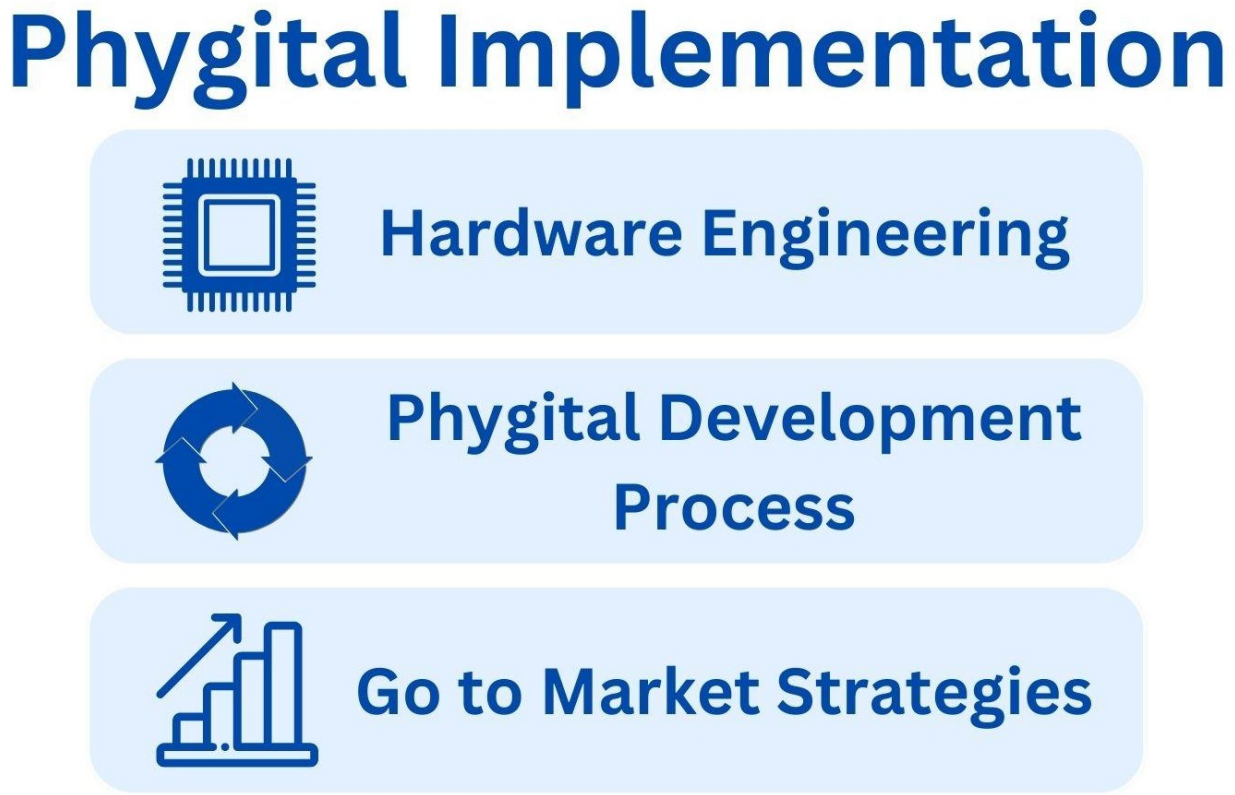


Figure 15: Three components of effectively building and commercializing a phygital product.

Hardware Engineering

Hardware development is challenging due to several factors. It requires a more diverse set of skills, including electrical engineering, mechanical engineering, and industrial design, on top of software engineering. These disciplines have development cycle times that are much longer than software development since they need to be more thorough. New software functionality can be continuously added even after the software has launched and is in the hands of the consumers. In contrast, for hardware, all the functionality that it will ever have must be designed, tested, and made prior to launch. Additionally, there are costs that are not applicable to a software product, such as material costs, manufacturing costs, logistics, inventory, and supply chain management, to name a few [56].

Despite the challenges involved in developing hardware, the primary research revealed strategies to simplify the process for a digital company looking to add a physical component to its product.

> “Hardware is hard to do if you're building the hardware.” - P10

Participants 9 and 10 indicated that if the hardware device that a company needs to add to their digital product already exists, then companies can buy them from a manufacturer, add their branding to it and resell it as part of their phygital product. This is termed White Labeling, when a company resells a product from a manufacturer with their branding [57]. These participants also added that this could be an excellent solution as the company would not need to invest capital in developing the device or the manufacturing costs and could quickly integrate it with their digital product. The ease and simplicity of this strategy may also be its drawback. It could be argued that if this strategy could be simple for one company to integrate and sell the hardware device, it would be just as simple for its competitors to do the same. The other challenge is the customizability to a specific use case; since there is a disconnect between the hardware and software development, the exact needed features or functionalities may not be available, and tradeoffs likely need to be made.

If the white label approach is not feasible for a company, they will need to build the hardware device in-house. Hardware development can be simplified by leveraging existing technologies and not reinventing the wheel. For example, if the product needs to use WiFi, the company does not need to create the WiFi technology; they can purchase and integrate WiFi modules from third-party suppliers into their hardware device [58]. Another way to leverage existing technology is by making use of the hardware that is already available in the environment of the user. For example, as Participant 6 reported, the hardware device can offload some of the processing tasks to the user's smartphone; this means the device needs less computational power and in turn, less expensive parts in the hardware device [P6].

Hardware does not work independently and needs software to make it function. Moreover, the software is needed on the physical and digital components of the phygital product to allow them to interact seamlessly [P6, P9, P10]. Another aspect to consider in a phygital experience is how the digital and the physical components will behave with the user when separated [P1]. Can the physical device perform its function without the digital component, or do both components need constant communication to deliver its functionality? It becomes imperative to involve the digital component software developers in developing the hardware device to ensure that all these questions are answered and that integrating both components results in a seamless experience for the user.

"The software team had to upskill as well to work with hardware. They needed to learn about Bluetooth communication. Previously they knew only app development." - P9

The final guidance revealed through the primary research was the importance and value of detailed design, development, and testing of the physical device. This level of thoroughness could ensure minimal problems after the product launch as it becomes more and more expensive to fix hardware bugs later in the development process.

"Physical interfaces take a lot of time to develop. Can't afford to go wrong, incurs a large monetary cost." - P4

"Need a lot of failure planning and protections with hardware. Cannot fix with a software update later" - P1

Phygital Development Process

One of the open-ended questions asked to the interviewees was what they recommend as an excellent phygital development process. What is the process within the company that allows for streamlined development of a phygital product from concept to integration of the physical device into the digital product? As all participants mentioned, stakeholder alignment is fundamental for successfully implementing a phygital product strategy, particularly between the company's software, hardware, and management teams. The way to achieve this harmony was best put by Participant 4, "Finding metrics that show the value of the physical device will help convince people to add a physical device and its value."

Below is a composite four-step process developed from the ten interviewees' inputs, shown in Figure 16. The process is best understood through the three disciplines comprising the engineering, design, and business efforts that are needed to deliver a phygital product.

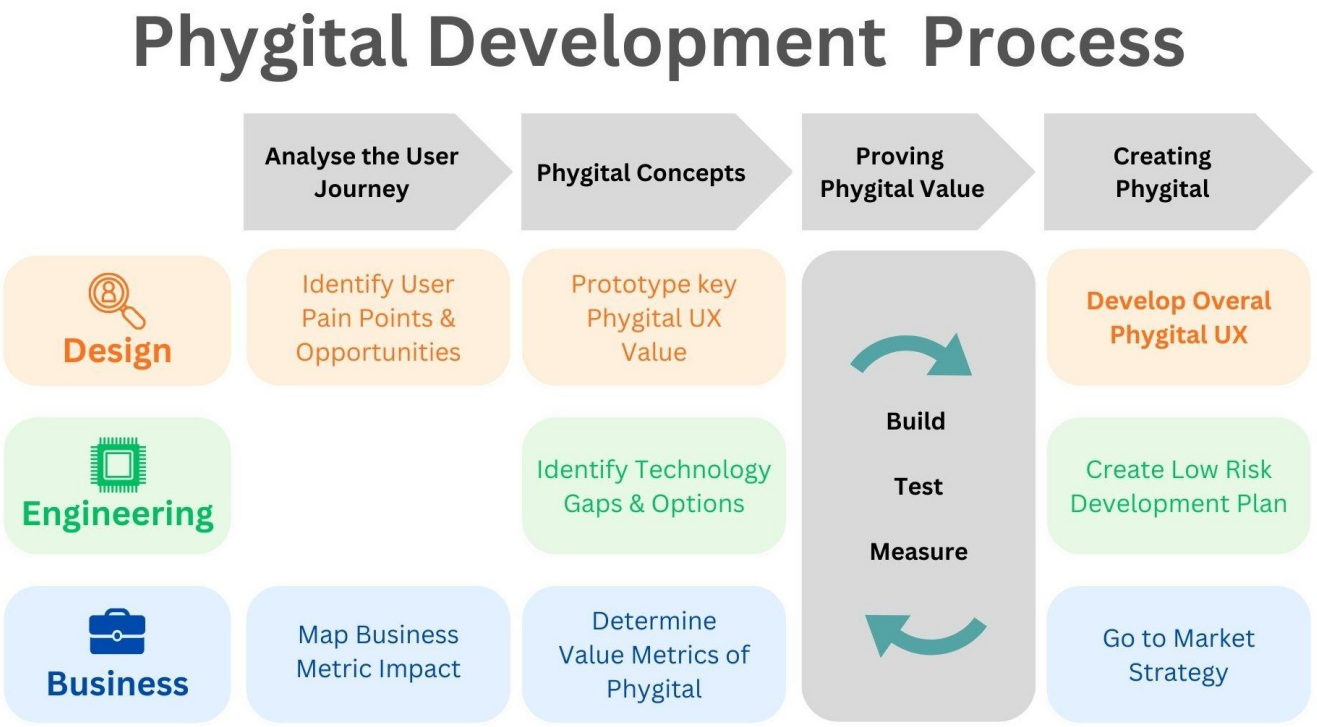


Figure 16: The Design, Engineering, and Business Role in the Phygital Product Development Process.

Step 1: Analyze the Digital User Journey. For Participant 9, the "most important thing for a physical device is the relevance and usefulness to the customer." The first step to do so begins with understanding the current limitations of the digital product. The digital-only product's user journey needs to be analyzed to recognize the customer pain points; as Participant 6 eloquently says, "The leading voice has to be the people who are using the product." An additional perspective to look at this is through the lens of opportunity to build a product that has a stronger connection with its customers due to its tangible nature [P2] and the ability to create moments of serendipity [P1].

However, a better user experience is a challenging sell to the remaining stakeholders, especially the management side, owing to the high cost and complexity of developing hardware products. "Stakeholders need to buy into the hardware vision to make it happen," as said by Participant 1. To obtain stakeholder buy-in, it is necessary to determine the business value obtained by building a hardware device [P8]. Section 4.1.3 presented these potential business values in improving Brand Equity, Customer Stickiness, Retention Rate, and capturing more customer data. The first step to determining the value we can derive from solving a certain customer pain point or addressing an opportunity is to establish how the identified pain point or the improvement opportunity can create business value.

Step 2: Developing Phygital Product Concepts and Prototypes. Having identified possible areas of improvement in the product experience, the next step entails creating concepts and solutions that include a relevant physical component. Multiple participants said their first steps are to build a hypothesis of how the physical device can solve an identified problem and then develop low-cost methods to test the theory. Creating metrics to qualitatively measure the impact of the phygital concept against a digital-only concept helps determine the success of such a prototype.

A vital part of a phygital product experience is delivered through software development, making the experience seamless. Multiple participants mentioned the importance of involving software engineers to be a part of the phygital strategy process as they can identify what software-based dependencies are prevalent for the concept in question as well as the other side of the coin for how the software team can leverage their existing technologies, skills, or knowledge to identify a feasible solution. In addition, Participant 9 mentioned that "the software team had to upskill as well to work with hardware. They needed to learn about Bluetooth communication; previously,

they knew only app development." This statement highlights the importance of having software team members on the table when determining the phygital product strategy. Ultimately, the engineering teams must establish the feasibility of the phygital product concept to decide if the concept goes to the next step.

Step 3: Build, Test, and Measure the Efficacy of the Phygital Product Prototypes. The next step is to test the phygital prototypes to determine if they can deliver business value and improve the customer experience. Three participants (P1, P2, P5) voiced the importance of rapidly and iteratively testing hypotheses using low-cost methods. This step is used to down select the best ideas for delivering maximum value to customers and the business. The importance of this step is stated by Participant 5: "Find ways to de-risk the product market fit to see the viability of the physical device." At this stage, the value of the phygital product would be identified. It is now important to see if these benefits are worth the cost.

Step 4: Creating the Phygital Product Plan. Once the core value of the phygital product is determined, it is time to look at how it will be delivered to the customers. From the product experience perspective, some questions need to be answered, such as how the hardware device will operate independently from the software component and vice versa [P1]. This is also the stage where designers can work on factors discussed in section 4.1.2, such as developing a plan to communicate to customers the value of the phygital product and other design factors that make the product easy to use and industrial design that represents the brand and creates an emotional connection with the customer.

Engineering teams must complete a development and production strategy that weighs the options of leveraging existing technology or hardware devices vs. developing the hardware technology in-house. Participant 8 highlights the challenges in the next stage of product development: "Need stakeholder buy-in and communication between the fast-moving software business and slow-moving hardware business."

The final component of this step is building a go-to-market strategy to distribute the phygital product at scale in order to reap the benefits of the phygital strategy. This component is crucial and is discussed next.

Go-to-Market Strategies

One of the reasons that companies shy away from physical devices seems to be the cost of the product itself. Every unit of the same physical device involves the cost of materials, assembly, and shipping, to name a few. The cost of making one more unit of the same product is next to zero for digital products, as no logistics or materials are involved [59].

Companies must build or modify their business plans to account for these additional costs, which ultimately need to trickle down to the customers. Customers are, however, very cost-sensitive, and businesses need to develop strategies to reduce the cost barrier. Every business is unique, and the way they can approach this will therefore need to be unique. However, some overarching strategies that arose were:

1. Reduce the cost barrier to the customer by amortizing the cost of the device over a period of time.

Peloton's at-home exercise products, like the bike, can be rented instead of purchased, making them more accessible to customers [60].

2. Making the physical device free and recovering the cost through the digital subscription revenue.

Whoop, a health and fitness tracking company, provides Whoop 4.0, a wearable device with health tracking sensors, for free with every membership to their service [61].

3. Bundling and pricing the device and digital product or service together.

HealthifyMe, a weight loss company that connects customers with personalized fitness plans, includes the Smart Bluetooth Weighing scale in all their plans [62]. To the end customer, it appears that every membership includes the cost of the scale, and the scale is not optional to purchase alone.

What is important to note here is that these three companies have recognized the value of the physical device as part of their holistic phygital product experience and hence are focused on disseminating the hardware as much as possible and reducing the barrier to entry for their customers. Most of them have not applied a profit margin on the hardware itself and are looking to recover their costs through a stronger subscription base.

4.2 The Five Lenses of a Phygital User Experience

From analyzing the primary and secondary research data, five lenses were identified to classify a phygital experience. These lenses help understand how the phygital experience improves on the digital-only experience. The lenses are distinct but not mutually exclusive, meaning that a given phygital product can simultaneously express more than one of the lenses. The lens metaphor helps convey that these viewpoints could also be used to guide the brainstorming of new phygital product concepts.

The five lenses are shown in Figure 17 and are briefly explained below, with more in-depth explanations through seven case studies in the rest of this chapter.

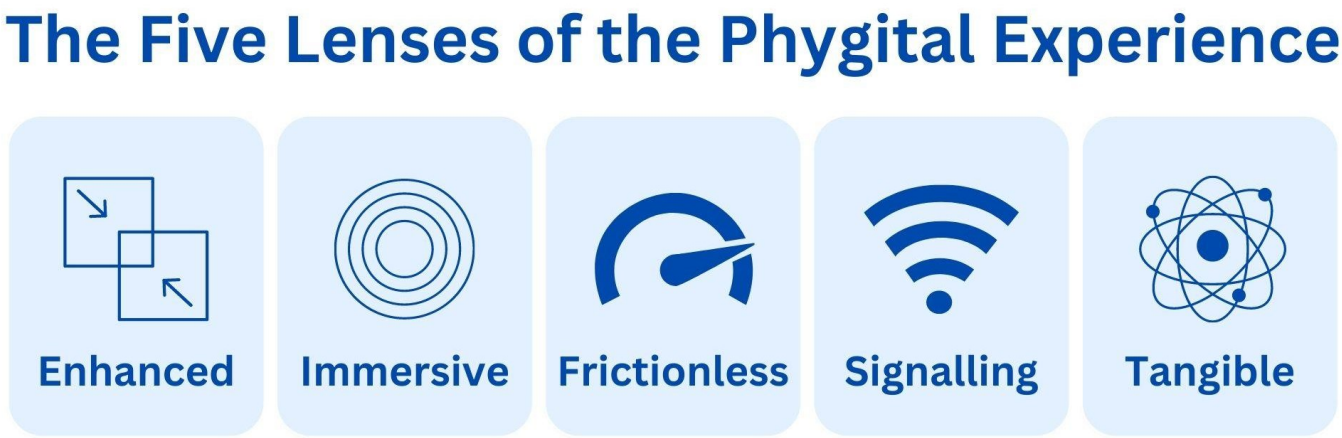


Figure 17: The five lenses of the Phygital Experience.

Enhanced - This lens looks at the combined value of physical and digital components, that each could deliver some value independently.

Immersive - This lens recognizes that through a phygital component, the user can stay in the context of their activity while benefiting from the digital component's features.

Frictionless - Through this lens, we look at the user being able to access the digital component faster or more intuitively via the physical component of the phygital product.

Signaling - This looks at how the physical component can communicate information to the users through static or interactive means at the periphery of the user's attention.

Tangible - The final lens looks at the material nature of the physical component in the phygital product and how that supports the user experience. In general, the material nature of the physical component could communicate information, provide an affordance or double down on the emotional connection that a user has with the object.

The case studies below cover the gamut of lenses expressed for phygital products. These phygital products fall under the health, fitness, finance, or habit-building categories. Only one of the lenses will be explained in each example to better illustrate the impact of that lens on the phygital user experience of that product.

4.2.1 Enhanced Lens Case Study

Description - This lens distinguishes the physical and digital components as independent products with their respective value. However, when the digital and physical components are merged to create a singular phygital product experience, the resulting experience is greater than the sum of its parts.

Product - Peloton is a health and fitness company that creates a phygital product experience. They offer a range of at-home stationary exercise equipment with a large touch screen. The screen displays the media and interactive content for the user while using the exercise equipment, as shown in Figure 18. To illustrate the importance of this lens, we will first examine the role of the digital and the physical components separately and then look at the enhanced value of both.

Digital Component - The Peloton app is the digital component of Peloton's offerings. It hosts numerous video workout classes, tracks the user's health metrics, and allows the user to connect with other Peloton users [63]. The Peloton app is the primary source of profitability; over 80% of their gross profits are generated through their subscription-based business model on the Peloton app [64].

Figure 18: The Peloton Row product for at-home rowing workouts.

Physical Component - The Rower is an at-home exercise device intended to mimic a person's movements to row on a boat. Participant 2 explained that this exercise allows for a full-body workout and is good for holistic health and fitness goals. He also shared that new users experience challenges in maintaining the appropriate posture, pace, and motivation to continue.

Phygital Experience - Participant 2 reported that by combining the physical rower with their digital technologies, the Peloton row product uses onboard sensors to gauge the user's performance and gives actionable real-time feedback to the user for correction. This can enable users to achieve better results. Additionally, the video classes, social features, and a rewarding physical experience seem to lead to better user engagement and higher motivation.

"Physical hardware creates more rewarding experience. The secret sauce is good engagement with members. On average each member uses the product 20 times a month." - P2

This highly engaging product experience helps explain the benefits of combining digital and physical. Peloton products have a retention rate of over 90% due to the user-centered phygital product experience they deliver [65].

4.2.2 Immersive Lens Case Study

Description - A digital screen is the predominant way to interact with a digital product, requiring the user to focus on a screen to use it. However, specific tasks where users need to perform activities in the real world and use the features of a digital product via a screen could pose a challenge. In these situations, the user is expected to repeatedly shift focus from their activity to a digital screen and back, leading to an unpleasant user experience where they cannot stay immersed in their activity. Through the Immersive lens, we look at how dedicated physical devices enable users to perform their activities without giving up their focus and attention to a digital screen to achieve it.

Product - Heart rate, pace, distance, and cadence are some metrics runners can use to track their real-time performance. This data can help them make decisions while running to improve their performance [66]. Smartphones have several onboard sensors which can capture some of this data. However, to make the most of this data while running, the user would have to hold their smartphone in their hand and then change from their running posture to one where they could hold their phone up to glance at this data. This momentary glance at their phone can disrupt the runner's pace and posture. Smartwatches enable runners to capture more data with additional sensors such as heart rate and blood oxygen meters, and the form factor of a watch makes it less burdensome to carry while running. However, the smartwatch still requires the runner to change their posture and hold their hand to read the information.

Engo is a pair of sunglasses designed for athletes (Figure 19), such as runners, that houses a tiny heads-up display. This heads-up display allows users to continue their activity without pausing to look at their smartwatch or smartphone. However, when needed, they can quickly glance at the heads-up display to see their performance metrics, which means that runners can access the data they need when they need it without sacrificing their pace and posture. The runners can stay immersed in their activity and make the most of their digital product via the physical device. The sunglasses communicate with the smartphone and smartwatch to capture the data; this uses less processing power than if the device had to contain all those sensors, thus increasing battery life [P6].

Figure 19: Engo Sunglasses. The red circle marks the heads-up display [67].

Engo sunglasses express the basic tenet of an immersive user experience delivered through a phygital product. This dedicated physical device could help the user stay engaged in what they are doing without needing to give attention to the original digital component hosted on a screen such as a smartphone during the activity.

4.2.3 Frictionless Lens Case Study

Description - The term friction here refers to the user needing to make an effort to interact with the digital product to achieve an objective [68]. This high friction results from a poorly designed, complicated, cumbersome product. A digital product with much user friction could lead to users leaving the digital product [69]. Frictionless, on the contrary, refers to a user experience that is intuitive to use and requires low user effort to adopt it. While some of this friction can be prevented with better digital design principles [69], it falls short due to limitations of what interactions a person can do with a digital-only interface. Dedicated physical devices could provide more intuitive interactions to the users, reducing user effort and leading to higher product adoption.

Product - HealthifyMe is a health and fitness company that helps its users lose weight by connecting them with professional dieticians and fitness coaches via their app and tracking health metrics such as weight and food intake. A part of the daily user journey requires users to capture their weight and enter it on the HealthifyMe app (Figure 20). Let us look below at what the digital-only experience is and what the phygital experience is like.

Figure 20: The HealthifyMe Smart Scale and App.

Digital User Journey - Figure 21 presents steps to capture the user's weight based on the HealthifyMe App user flow. We can see that it takes six steps to complete. Since this process must be done daily by the user, such a flow could feel time taking to the user, as Participant 10 shared: "One of the largest feedback that we had is that it's too time taking, I don't want to do this, I don't have this much time, I need to open the app, follow five steps and go and track my weight it's too difficult."

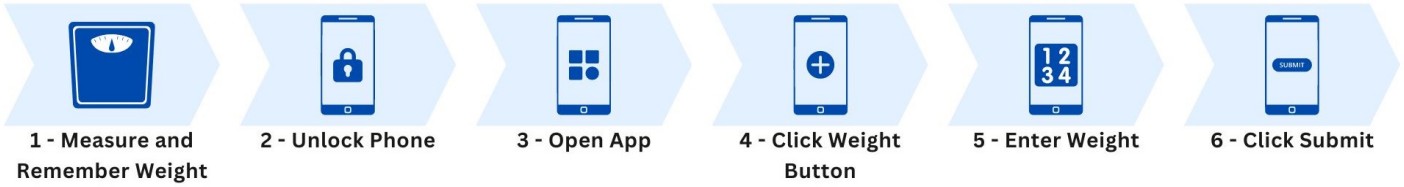


Figure 21: The steps to manually capture your weight on the HealthifyMe app.

Phygital User Journey - HealthifyMe introduced a smart Bluetooth-enabled weighing scale for all their customers in early January 2022 [P10]. With this device, the weighing scale could talk with the HealthifyMe App directly, so the user did not have to enter the data manually. Figure 22 shows the new user journey with the smart scale.

Figure 22: The simplified three-step process to capture the user weight with a phygital experience.

The new user journey is simpler and faster. The user simply stands on the scale, and the data is captured into the app via Bluetooth communication for tracking and viewing later. There is no additional learning curve for using the device, although there is a one-time setup to connect the smart scale device to the user's phone. The simplified day-to-day process reduces the friction of weight tracking. Participant 10 shared that this simplified user experience achieved through a phygital product has doubled the retention rate of users on the HealthifyMe App. Additionally, by intentionally adding the smart scale device to their product offering, they were able to identify additional sensors which could capture even more data, such as hydration and body fat metrics, thereby making their health insights to users more personalized and thorough.

4.2.4 Signaling Lens Case Study

Description - Section 4.2.2 examines how a physical device could create an immersive experience for the user by not using the digital screen in the context of their activity. Here the physical device is used instead of the digital screen and still demands active user attention. The signaling lens is similar to the immersive lens, with the core distinction that the physical device does not command active user attention but works in the user's periphery in the context of their activity. It signals the user via sound, light, or movement to grab their attention momentarily only when needed. This split-second interaction is sufficient to communicate information to the user.

Product Background - India has a large informal retail industry. There are estimated to be nearly 5 million street merchants [70] and 12+ million Kirana stores (Kirana store is a family-run mom-and-pop store) [71]. This industry has generally been averse to digital technologies and banking services owing to a lack of trust in the system and additional overheads. This changed with the advent of QR Code based payment systems and a government ban on high-denomination notes in 2016 [72].

While merchants and customers started getting used to QR Code based digital payments, this revealed new challenges. Many merchants were not digitally literate, owned a feature phone or a smartphone that could house apps, and had low trust in this new system. PayTm is a digital payments and financial services company that built a phygital product to help tackle this problem: the PayTm SoundBox device delivers instant audio confirmation for a financial transaction in a language that the merchant can understand verbally [73]; this is important because many of these merchants may not know how to read or write, and may not know the English language either. Below we will look at the user journey without the SoundBox device and later see how the SoundBox device helps address the problem.

Digital User Journey - Figure 23 shows a typical street merchant in a chaotic market in India tending to multiple customers simultaneously. In such an environment, the following steps occur between the customer and the merchant to make the payment.

1. Merchant confirms the payment amount to the current customer.
2. The customer scans the QR Code of the merchant and makes the payment.
3. Customer shows the payment confirmation on their device to the merchant.
4. Merchant pauses their activity, opens their phone, and awaits payment confirmation.

5. Merchant confirms payment, and the customer can leave.

Figure 23: The vegetable markets of India embracing QR Code payments [72].

While these steps seem rather straightforward, it is important to understand the context. As seen in Figure 23, multiple customers are waiting for the merchant's attention. In this high-stress environment, they are expected to check their phone for a period taking them away from the context of their work, and the period of time could be long enough to agitate the waiting customers due to lack of service. Additionally, merchants cannot rely solely on the customer device's payment confirmation as they fear fraudulent transactions or may not be digitally literate to understand the payment receipts [P3]. Several merchants also use a basic feature phone, where it can be challenging to keep track of payment confirmations via SMSs on a small screen [74]. Solving this problem is important for adopting QR Code-based digital payments long-term.

Phygital Solution - Figure 24 shows the PayTm SoundBox device at a merchant's store. When the code on the device is scanned, and a customer makes a payment, SoundBox delivers a verbal audio message to the merchant stating how much money they have received from the customer. The device has its own SIM card, hence does not need WiFi, and can deliver the message in one of eleven languages ensuring the merchant can understand their native tongue. The discrete steps with this phygital solution are:

1. Merchant confirms the payment amount to the current customer.
2. The customer scans the QR Code of the merchant and makes the payment.
3. The customer and merchant wait for audio confirmation simultaneously.
4. The customer can leave on payment confirmation.

Figure 24: The PayTm Sound Box device is scanned by a customer to make a payment [75].

In this new interaction between the merchant and the customer enabled by a phygital product, the merchant has two fewer steps to do, and step 3 does not require active attention from the merchant. Through this, merchants could maintain their day-to-day mode of operations. They could accept digital payments without the disruption of having to wait for a confirmation message on their phone and rather keep an ear out to listen to the audio confirmation in the periphery of their focus area.

The physical device could help build trust between the merchants and PayTm. PayTm now delivers other digital financial services to merchants, such as short-term business loans, having acquired them onto their platform via SoundBox [74].

4.2.5 Tangibility Case Studies

Description - Throughout this thesis, we have explored the relationship between people and physical objects. Namely, we explored three manifestations of this relationship:

1. Communicating information through the form of the physical component
2. Physical affordances are offered by the form of the physical component.
3. Emotional connection with the physical component

We will further explore these three areas below with a product example.

4.2.5.1 Communicating Information through the Form of the Physical Component

The physical form and visual design of an object can convey information regarding how to use the object, the connection to its brand, and the aesthetic can signify its purpose as well. We have covered this in 2.2.1. Below we look at a phygital product that demonstrates this trait.

Product Example - AdhereTech is a smart pill bottle phygital product that reminds users when to take their medication (Figure 25). The user receives their medication pre-filled in the AdhereTech smart pill bottle, which is pre-programmed with the user's medication schedule. When it's time to take the medicine, the bottle emits audio chimes and has a light ring that flashes to get the user's attention. The smart pill bottle can also send an alert to the user's phone via text to remind them to take their medication. Other products in the market have a similar value proposition for reminding users to take their medication; however, AdhereTech's product

succeeds in user experience through its ease of use. The smart pill bottle looks and behaves exactly like any other pill bottle; this communicates to the user that they can carry the bottle, store the bottle, and interact with the bottle in the same way as a regular pill bottle with no behavioral change resulting in next to zero learning curve to the user. The device also requires zero user setup, further simplifying the product's ease of use from the moment they receive it to its end use [76]. This phygital approach is more effective in reminding users to take their medication as compared to an app, as shared by Participant 7, who claims that AdhereTech has a retention rate greater than 80%, which is five times higher than a digital-only-based reminder solution.

Figure 25: AdhereTech's Smart Pill bottle looks and behaves like a regular pill bottle [76].

4.2.5.2 Physical Affordances

In sections 1.5 and 2.2.1, we saw how physical objects have affordances; a user can interact with the object in certain ways due to the nature and design of its physical features. In section 2.1, we saw how physical objects can be used to manipulate and interact with digital data. However, this

was seen as a replacement for the digital interface rather than a complement. In this lens, one application of tangibility is to use its affordances for having intuitive interactions with digital products. This is best explained by the following example.

Product Example - Unpluq is a phygital product that aims to combat smartphone addiction and overuse (Figure 26). The digital app component of Unpluq is installed on the user's smartphone; this blocks all non-essential apps by the user when activated or on a pre-defined schedule. To use the app, the user needs to tap the smartphone with the Unpluq tag, an NFC-enabled physical object that can be stored separately. This additional physical barrier to the user's device can act as a deterrent to using a smartphone [77]. Notably, this phygital product does the opposite of the Frictionless Lens, as it deliberately adds user friction to achieve its goal. The physical structure of the Unpluq tag provides the affordance to use the tag as a keychain, hook it to a backpack, or store the tag in any way the user deems appropriate.

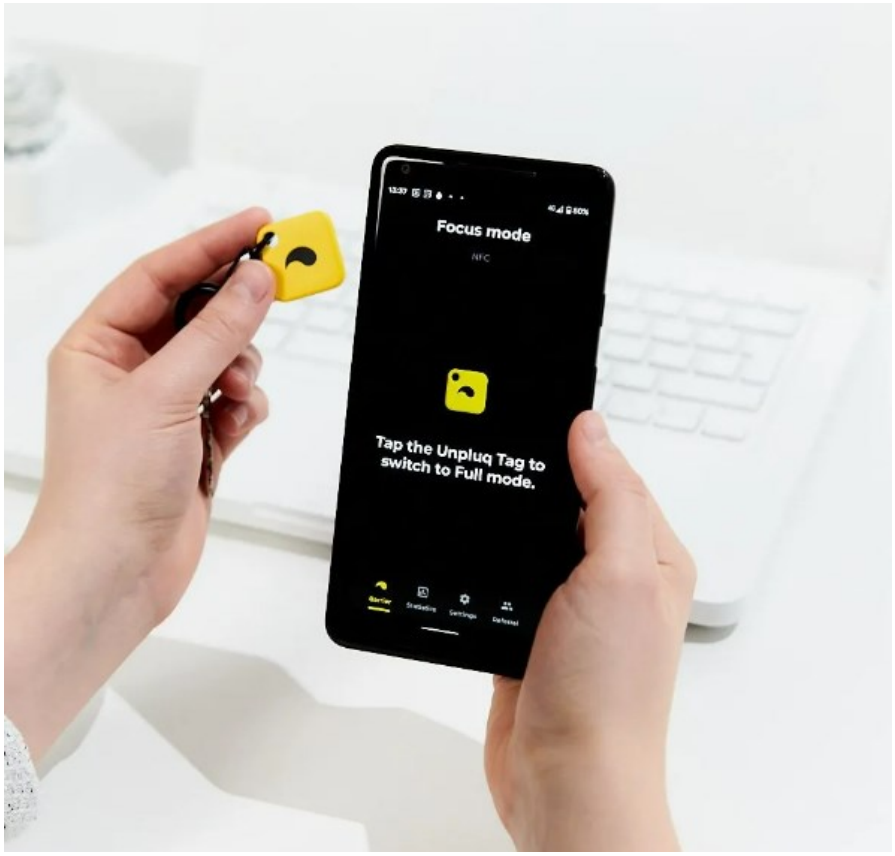


Figure 26: The Unpluq App and Tag [77].

4.2.5.3 Emotional Connection

Finally, we look at the emotional connection that users can develop with physical objects [43]. We have explored this in sections 1.5, 2.1, and 2.2, where we discussed how objects the users own can be an extension and expression of themselves. Designers can leverage this fact to intentionally build phygital products that evoke an emotional connection with the user. One way to do this is through personalization. We saw in section 4.1.1 that customization with physical devices is more challenging, which is why a physical device that can be customized may be viewed positively.

Product Example - Whoop is a health and fitness brand, and their phygital product is an app that tracks health metrics and generates insights based on data captured from their fitness wearable device, the Whoop 4.0. We looked at this phygital product briefly in section 4.1.4. Where we saw that the device is given for free with every Whoop membership plan. They offer a wide array of options to customize the wearable device's design to the user's preferences. This personalized service may create an emotional connection between the user and the brand. See Figure 27 for the customization options that a user can have on the physical device.

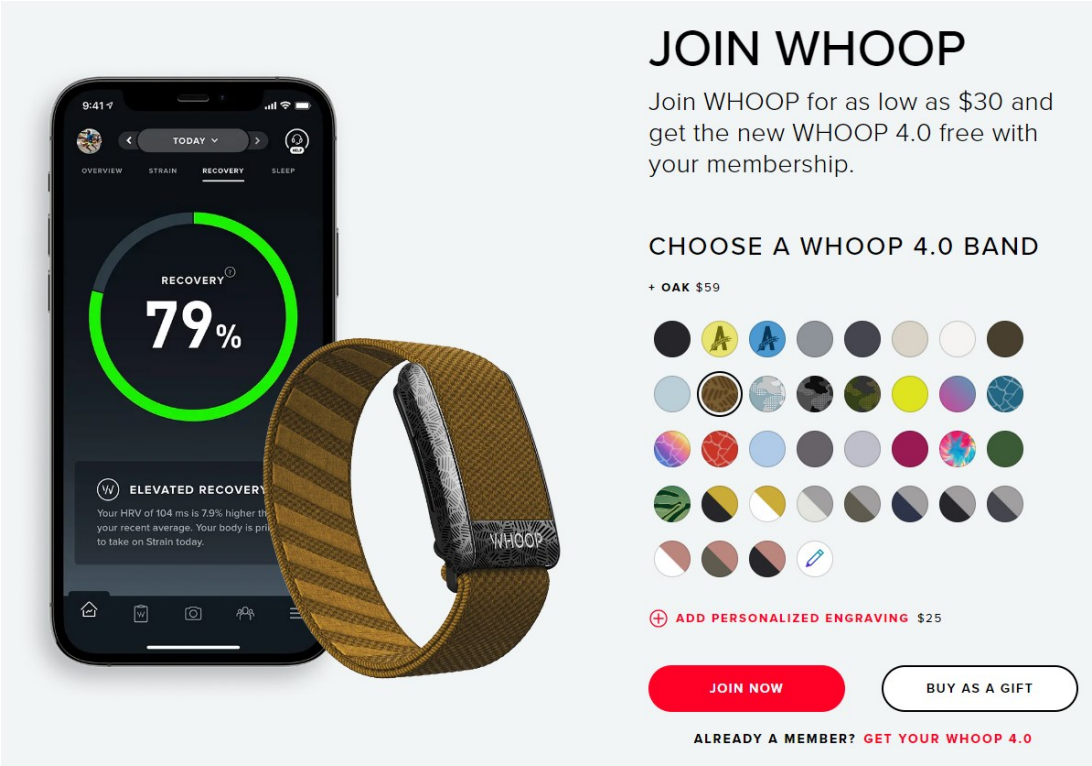
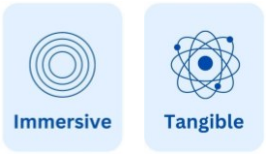
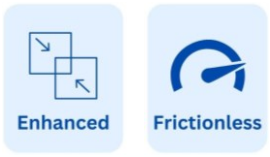


Figure 27: The Whoop Band 4.0 customization screen when buying a Whoop membership [78].

4.2.6 Summary

In this section, we looked at five lenses that help understand the phygital user experience; we then looked at commercially available products for each of these lenses to see them in practice. While these five lenses cannot be claimed as exhaustive, they can provide valuable direction for phygital product designers looking to integrate a physical device into their digital product. A key observation to note here is that the lenses are not mutually exclusive; several of the product examples above simultaneously exhibit more than one of the five phygital lenses. Look at Table 7 to see which lenses are present in each case study. Hence, it could be argued that a successful phygital product should exhibit one or more of these lenses to deliver a phygital user experience that can stand out from digital-only competitor solutions.

Table 7: Lenses Exhibited by each of the Phygital Product Case Studies

Product	Lenses
Peloton Rower	
Engo Sunglasses	
HealthifyMe Smart Scale	
Paytm SoundBox	
AdhereTech Smart Pill Bottle	

Product	Lenses
Unpluq	
Whoop 4.0	

Chapter 5: The Phygital Transformation Framework

5.1 Who is this framework for?

In this chapter, I propose a new Phygital Transformation framework. This framework is a systematic process for analyzing existing digital products and transforming them into a phygital product. Currently, no holistic framework accounts for the value of phygital products and the user experience, and the business value that a phygital product may generate. This proposed framework aims to bridge this gap. It is based on the research conducted for this thesis, including interviews with professionals currently working at phygital product companies and secondary research that encompasses currently commercially available phygital products.

This framework is intended for B2C companies with a digital product looking to transform into a phygital product. While any digital product company can use this framework to develop a phygital product, it may be more applicable for digital products with a B2C business model where the end user can appreciate the value of a better user experience. The research done in this thesis has referenced phygital product examples that are all in the B2C space. All users want a better user experience, consumer or enterprise users. A possible solution to make this framework applicable to B2B products could be by demonstrating how the phygital experience would build a better enterprise user experience and business value to the customer.

Product managers, innovation teams, engineers, designers, and business professionals can use this framework to build phygital products based upon existing digital products. Engineering, design, and business functions are needed to achieve phygital transformation successfully; this is explained in the framework below.

5.2 The Double Diamond Framework

Before the Phygital Transformation framework is presented, we need to look at the Double Diamond design process (Figure 28). This process allows designers and innovators to solve complex challenges and deliver new, improved products, services, or solutions.

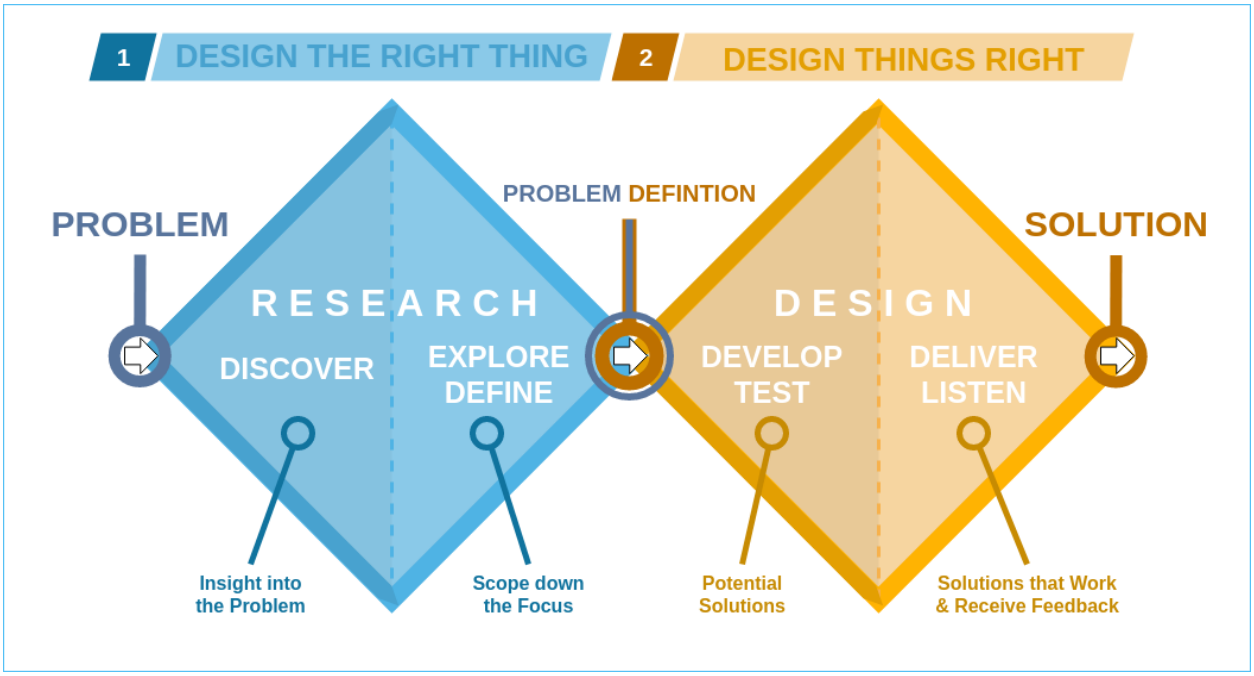


Figure 28: The Double Diamond Design Process [79].

Each of the diamonds represents one stage. In the first stage, the practitioner uses divergent or exploratory thinking to understand the issue more deeply and gain new ideas and concepts. This is marked by the opening of the diamond from a tip to its maximum width. In the second stage, the practitioner uses convergent, or evaluation thinking to narrow the issue and focus on specific areas. This is marked by the diamond's second half, where its maximum width closes towards its other tip. The two diamonds in this process reflect the four distinct phases in this design process [80]:

1. **Discover** - This phase is to understand the problem space better and uses divergent thinking. Here the goal is to gather information rather than make assumptions.

2. **Define** - Here, convergent thinking is used to narrow the problem space and focus on the core challenges to address.

3. **Develop** - The second diamond starts by generating potential solutions for the defined problem space and reusing divergent thinking.

4. **Deliver** - The final phase uses convergent thinking to evaluate the ideas and concepts from the previous phase for their efficacy and select the optimal solution to solve the problem.

The double diamond design process is a general-purpose tool for any problem space. For phygital transformation, a more specific process can give better guidance and direction to the practitioner. The proposed Phygital Transformation framework utilizes the core tenets of the double diamond process, that is, repeated divergent and convergent thinking to move from understanding the problem to delivering a solution. Figure 29 presents the proposed Phygital Transformation framework.

5.3 The Phygital Transformation Framework

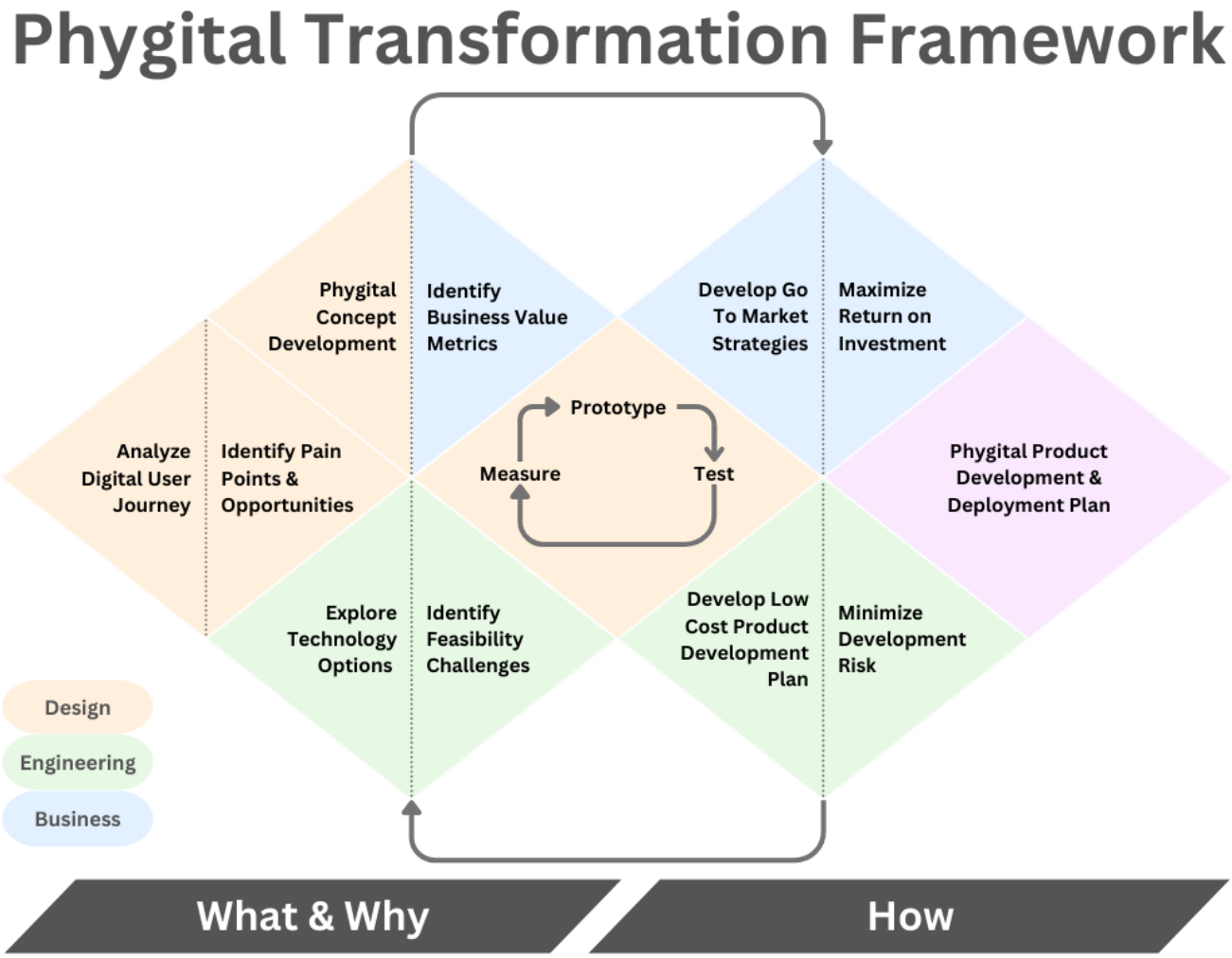


Figure 29: The proposed Phygital Transformation Framework.

5.3.1 Understanding the Framework's Structure

The framework is divided broadly into two sections. In the first section, the framework aims to answer "what" and "why" regarding the phygital transformation. That is, it looks to answer the questions of what problems to solve, what concepts to test, and what technologies to use. The "why" portion aims to answer why to pursue a particular technological approach and why the company should do the phygital transformation.

Having understood the "what" phygital concepts to pursue and "why" to pursue these phygital concepts owing to their anticipated business value and improved user experience, the second section looks to answer "how" to convert the concepts into a product. This transformation includes the technology needed to develop the phygital product and the business challenges of getting the phygital product to the market.

At the same time, each stage is composed of multiple diamonds, each with a divergent and convergent component. These diamonds are color-coded to represent which disciplines among design, business, and engineering are best suited to take a lead role in that part of the process. In all stages of this phygital transformation process, an interdisciplinary team of engineers, designers, and business professionals is necessary; the color code signifies the ownership of that specific part of the overall process to expertise in that particular domain.

The arrows in Figure 29 indicate the iterative nature of the phygital transformation process. Every iteration helps reveal gaps in the solution they have developed to the practitioner and, subsequently, an opportunity to improve the solution. In Section 4.1.4, we looked at the costs associated with developing a hardware device and how impractical it is to make changes to a physical device once it is shipped to the customer [P1, P2]; it becomes imperative to be thorough in the design and development process of the device, as fixing problems early on is cheaper.

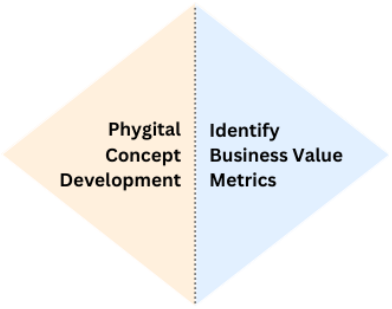
The phygital transformation process is presented from left to right in chronological order. It starts with examining the existing digital product, which is on the extreme left of Figure 29. The output from this framework is the Phygital Product Development and Deployment Plan for the company to execute. The output is marked by a diamond in the color pink on the extreme right of Figure 29. All triangle segments in the same vertical column are activities expected to be performed concurrently by the interdisciplinary team.

5.3.2 Understanding the Framework's Components

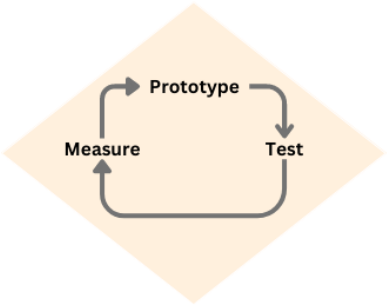
In this section, we will look at the components of the Phygital Transformation framework in more detail. In Table 8, each of the diamonds is examined in detail to understand its divergent and convergent portions. Prior to using this tool, it is advisable for the practitioner to familiarize themselves with the Lenses of the phygital user experience covered in Section 4.2 and the Social Design of Physical Devices covered in Section 2.2 as this will aid in the phygital concept development stage.

Table 8: Components of the Phygital Transformation Framework

Diamond	Divergent / Convergent
	The first step is exploring and understanding the digital product's holistic user journey. To do this, the practitioners must analyze the existing digital app's task flows and the context of the physical world when the user uses it. A strong understanding of the customer, their behavior, and what is happening in the physical world is crucial for the success of the next steps.
	Having understood the landscape of the problem space, the next step is to identify pain points that can be addressed with a phygital solution and opportunities where a phygital solution can improve the user experience. Section 4.1.1 may be helpful to recognize where the phygital experience can benefit the user experience. Also, it is likely that not all pain points and opportunities are recognized in the first attempt; rather, the iterative nature of this process should help uncover the pain points and opportunities in subsequent iterations.

Diamond	Divergent / Convergent
	Concepts need to be brainstormed and developed to solve for the identified problems and opportunities using physical devices and digital interfaces. These phygital concepts can be ideated using the Five Lenses of Phygital User Experience (Section 4.2) and the Socially Intelligent Product Framework (Section 2.3). See Section 5.3.3 for more details on developing the concepts. All subsequent steps in the Phygital Transformation framework build upon the concepts developed in this step, and hence this step is crucial.
	Due to the high costs of hardware device development, it is important that the concept improves the user experience and creates value for the business. In this step, the concepts developed are analyzed to determine the business value the phygital solution can create; see Section 4.1.3, where we discussed the benefits to a business due to a phygital product. Only concepts that can generate business value should be chosen to proceed from this point on. A mechanism to measure the expected business value should be derived for the remaining concepts. This may be done by gauging users' willingness to pay, customer satisfaction surveys and other existing means the company may already have in place to measure these business value metrics.

Diamond	Divergent / Convergent
	The team needs to explore the technology requirements for each concept developed. They can explore options to white label, outsource parts, or build in-house (See section 4.1.4). Additionally, for a given idea, there may be multiple technical solutions to achieve the intended user interaction. Readers may question why this process step parallels the phygital concept development stage. Understanding the technology landscape may support the phygital concept development stage by shedding light on the current technology landscape, its capabilities, and its limitations. This is a divergent phase, and the team should explore all possible technology avenues that could be used to enable the phygital concept.
	In this diamond's convergent portion, the practitioner assesses whether the technology solutions suggested in the previous step are practical to pursue. Practicality may depend on the complexity of the technology, technical know-how, and the maturity of the technology, to name a few. At this stage, the software development teams should provide insights on the challenges arising from a software implementation perspective for a given concept. At the end of this step, feasible concepts with practical means to access the technology and development resources should move to the next steps in the process.

Diamond	Divergent / Convergent
	This diamond lies in the middle of the process, at the intersection of the ideas space on the left and the solution space on the right. Here the team needs to validate the practical phygital concepts they have developed by prototyping them, testing them with real users, and measuring the efficacy of their concepts. The core research question is whether the phygital concept could deliver the intended business value and user experience improvement. This step is an iterative process where the learned insights can inform design changes that must be tested again. The information revealed at this stage may also warrant another pass from the beginning of the Phygital Transformation framework. With every prototype iteration, the prototypes can grow in fidelity, ensuring that resources are spent only on the most promising concepts. Supporting user flows for the core phygital product user experience can also be developed in this diamond. These supporting user flows may include how the physical device will work independently of the digital interface or how a new user is onboarded to the phygital product, to name a few.
	At this stage, the team should better understand which phygital concepts could work to improve the user experience and generate business value. Now we explore how this concept could be translated from an idea to a product. Previously from an engineering perspective, we looked at what technology options were available and which of them were feasible. In this step, the details of converting the technology into a phygital product must be ironed out. The product development plan should include timelines, resource requirements, and manufacturing plans.

Diamond	Divergent / Convergent
	The convergence in this diamond is determined by the technical and operational risks in delivering the phygital product based on the product development plan. To converge on the phygital concepts, each product development plan needs to be analyzed for where the development risk is and then compared. The phygital concepts that are the least risky to develop will move on to the next stage. However, this does not imply that riskier options cannot be pursued. Additionally, strategies can be developed to minimize risk, such as hiring experts and building partnerships with manufacturers.
	This diamond is complementary to the engineering-focused one above. Here we look at how to commercialize the phygital product by exploring various business models. Should the physical device be given away for free? Charged a rental fee? Or merged into a bundled subscription plan? We have discussed this topic in Section 4.1.4. In this step, the goal is to explore all the possible options to disseminate the physical device to the users to derive the business value that the phygital product experience achieves.
	The best business model is the one that maximizes the return on investment made by the company. In the convergence step, we use this as a metric to down-select the optimal go-to-market strategy that maximizes returns and reduces costs and risks. Teams can build metrics to benchmark each go-to-market strategy to determine the optimal choice. Similarly, to the previous diamond, practitioners should not eliminate the other choices but keep them at a lower priority. This will become clearer in the final diamond stage.

Diamond	Divergent / Convergent
	We have reached the final diamond of the Phygital Transformation framework. The outcome of this framework and this diamond is to develop a feasible and viable plan to build a desirable phygital product. In the previous steps, the engineering product development plans and the go-to-market strategies for the phygital product were created in isolation from the other disciplines' perspectives. At this stage, designers, engineers, and business professionals can merge their strategies to build a comprehensive Phygital Product Development Plan, which the company can execute.

5.3.3 Phygital Concept Development

Most of the Phygital Transformation framework looks at how a given phygital product concept is explored, defined, validated, and delivered. The final output depends on the quality of the inputs to the system; that is, understanding the current digital-only user journey first and coming up with phygital concepts that address user pain points in that journey.

In this thesis, we have introduced the Five Lenses of the phygital user experience (See Section 4.2), which predominantly looks at how a user pain point could be addressed through a phygital solution. Another framework we explored was Diana's Socially Intelligent Product framework (See Section 2.2), which states that through a physical medium, products can be intentionally designed to be social, developing stronger bonds between the user and the product.

Figure 30 introduces a tool to aid practitioners in brainstorming and developing socially intelligent phygital concepts to address user pain points. The tool integrates the five lenses of the phygital user experience with the Social Intelligence levels described in Diana's framework.

The tool is divided into five sections, each corresponding to one of the phygital lenses. Each section is further radially partitioned into Diana's five levels of Social Intelligence. To use this tool, the practitioner may frame the brainstorming question in the following way:

How might we integrate [Insert Social Intelligence Level] in an [Insert Phygital Lens] Phygital User Experience to solve [Insert user pain-point]?

For Example: *How might we integrate social contexts in an immersive phygital user experience to solve the background noise in virtual video calls?*

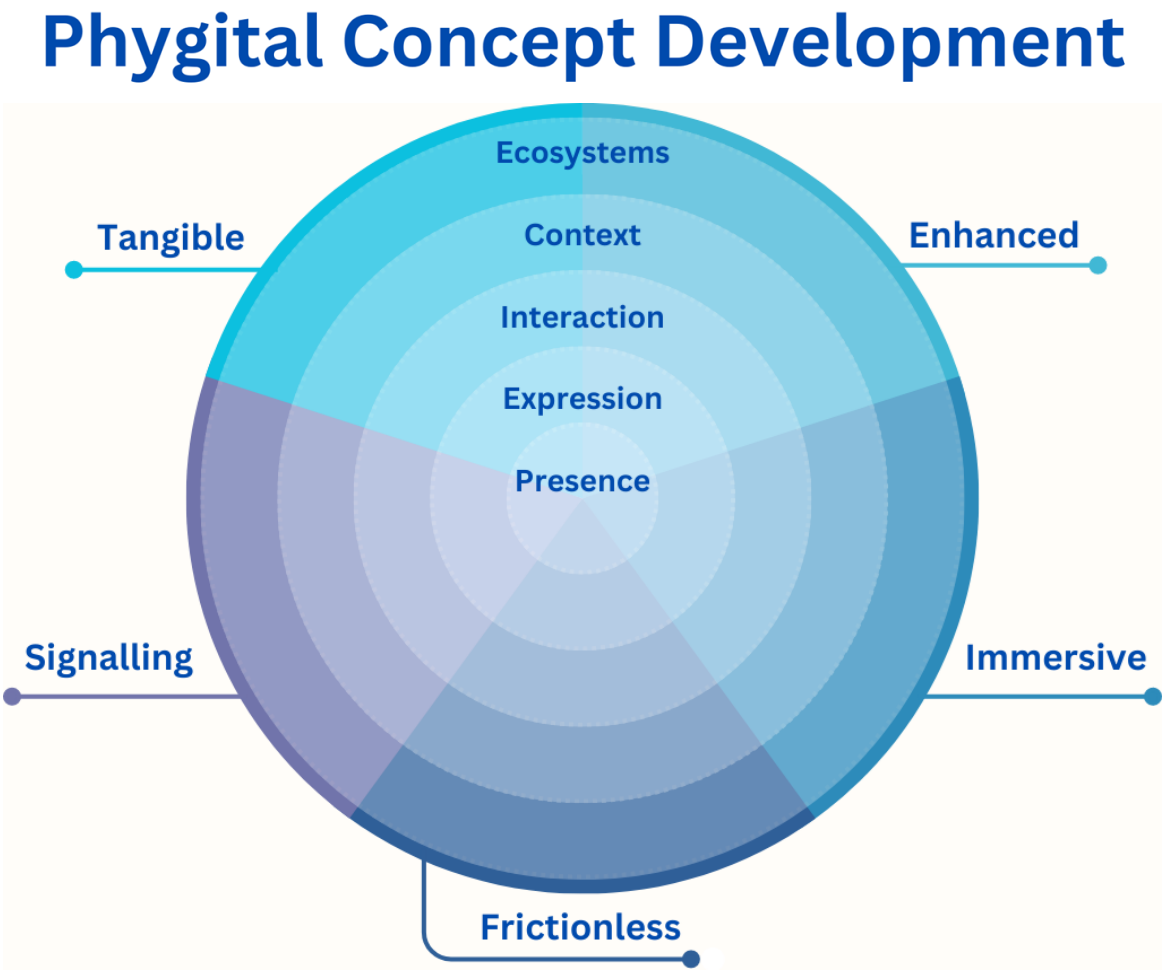


Figure 30: A Phygital Concept Development Tool.

All of the permutations of this tool would lead to generating twenty-five thought-provoking questions for a single user pain point; this may not be practical in terms of the time designers would need to generate ideas for every question. Rather, determining which lenses are more relevant to the problem space and which social intelligence levels are more practical may be prudent, as this would reduce the number of brainstorming questions.

Chapter 6: Conclusion

6.1 Summary

In this thesis, we introduced the concept of phygital transformation, that is, the process of adding a physical device to a digital product to transform it into a phygital product. Before answering the “How?” to perform phygital transformation, we needed to understand the “Why?” to do phygital transformation.

The “Why?” question was answered through primary research, where ten individuals who work at companies with phygital products were interviewed. The data was qualitatively analyzed, organized, and synthesized to identify patterns and themes. The insights showed two sides to the story of a phygital product (Discussed in Chapter 4.1).

1. From the user perspective, we identified what the pros and cons of a phygital user experience could be and what factors could support the adoption of a phygital product experience, such as designing the physical device for ease of use and educating the user on the merits of the device and how to operate it.

2. The second perspective was of the business. Phygital products could generate business value regarding user retention, brand equity, customer stickiness, and additional customer data. It also revealed a set of execution factors businesses must consider to deliver a phygital product.

Through secondary research, phygital products currently available on the market were examined to identify the user journey of the digital-only experience and then the phygital experience. This process revealed five Lenses of the phygital user experience. Each lens is a distinct but not mutually exclusive method by which the phygital user experience could provide value to the customer. The lenses represent an enhanced, immersive, frictionless, signaling, and tangible phygital user experience.

With this primary and secondary research, we could answer the “Why?” question. Phygital transformation could improve the user experience and generate business value. This dual benefit is essential since a physical device is complex and costly to develop versus a digital-only solution wherein the business may be able to afford the improvement of the user experience even with minimal business value benefits. For a phygital product, there should be a strong correlation between the business value of the physical device and the improved user experience.

The question of “How?” to build a phygital product that improves the user experience and generates business value emerged. In the literature review in Chapter 2, we looked at frameworks that exist in the space of phygital and in the space of new technology adoption. Our conclusion was that there appears to be a lack of a unified, holistic framework that accounts for the phygital user experience, the business value, and how to combine the two practices. A new Phygital Transformation framework was introduced in Chapter 5 to address this gap.

The Phygital Transformation framework could allow companies to transform their digital-only product experience into a phygital product experience that could result in business value gains. An interdisciplinary team of engineers, designers, and business professionals would be needed to use this framework. It covers three stages:

1. Analyzing the digital product user journey and developing phygital product concepts that could address the identified pain points and leverage the opportunity to improve the user experience through social intelligence design principles. To aid the ideators, a tool was presented in Section 5.3.3 that combines the five lenses of phygital user experience and the social intelligence product framework.

2. The second stage looked at proving the business value of the phygital concept through iterative prototype development, testing, and measuring processes. It also explores the technology options that may be used to build the phygital product and business models that ensure viable dissemination of the phygital product to the users.

3. The framework's output would be a comprehensive plan to develop and launch the phygital product. This final stage looked at the most promising phygital concepts and focused on how to translate this from concept to product from a business and technical perspective.

6.2 Conclusion and Future Work

A few months ago, I had a magical experience at a restaurant. It seemed ordinary, with ordering through a QR Code and minimal human interaction. After 20 minutes, I saw what appeared to be a white shelf gliding on the floor toward me. It had three trays, each placed above the other, holding several food items. The robot gently stopped beside my table, and the lights near the top tray started glowing. The robot said, “Your food is here, have a nice meal!”. This inanimate object created a surreal and heartwarming feeling. I shared this experience with others and recommended the restaurant for its magical atmosphere. It shows the power of combining physical objects with digital technologies and social intelligence, and I wanted more of such experiences! This experience planted the seeds for this thesis and has now culminated by laying the foundation to enable product developers to create such magical experiences for everyone.

This thesis aimed to learn about existing phygital products and use those findings to develop a repeatable process for transforming a digital product into a phygital one. Using the phygital concept development tool and Phygital Transformation framework developed in this thesis, digital product companies could go through an intentional and systematic approach to building phygital product experiences. Moreover, this thesis expands existing literature on what is considered phygital to include physical devices with digital apps; most previous literature on phygital has been limited to physical retail spaces with digital technologies.

This thesis has laid the foundation for understanding the value of a phygital product experience to the user and the business delivering it. However, this field is nascent. There are many opportunities to build upon the findings presented here for future phygital product experience researchers before we might see a world where a phygital product might replace the norm of a digital product.

This thesis also had limitations. Some of them and future work in this space are listed below:

1. Firstly, the proposed Phygital Transformation framework needs to be validated with existing digital product companies and the outputs with end users. The results of this exercise could shed light on the impact of this proposed framework for building phygital products.

2. The Phygital Transformation framework comprises seven divergent and convergent thinking segments. Although Section 5.3.2 shows what activity needs to be performed in each segment, it does not detail how it should be executed. Future research could test each segment and explore methodologies for each diamond.

3. The insights gathered in this thesis have been gathered only from commercial B2C examples. Future research should be conducted to determine whether the conclusions drawn here would apply to B2B as well. This may change the number of lenses identified in Section 4.2.

4. Finally, in this research work, no end users were interviewed; instead, their voices were channeled through the insights from the employees of companies with phygital products. Thus, their perception of a phygital user experience is an assumption. Future research should explore the insights from the end users' perspective and reassess the structure of the Phygital Transformation framework based on these newfound insights.

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