Proposed Extended Design Process for Sustainable Development and Innovation

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Abstract – The perspective that innovation plays a crucial role in promoting sustainability is generally acknowledged by researchers, professionals in many industries, and government officials. The urgency of addressing sustainable development necessitates prompt action and comprehensive adjustments from governments, industries, and society. The field of design has seen significant transformations throughout the last five decades. In response to the multifaceted challenges of contemporary times, there has been a partial expansion of limits. Various areas, such as social design, inclusive design, codesign, and sustainable design, have evolved as a direct reaction to the shortcomings of the existing consumption and production system. Within this framework, the design of artifacts has been influenced by social, environmental, and cultural trends. However, it is noteworthy that the actual design process has undergone little alterations. In contemporary design processes, there is an increasing recognition of the importance of incorporating criteria beyond economic considerations, particularly when pursuing social and environmental objectives. However, it is noteworthy that the process employed to achieve these objectives remains consistent with the stages and logic traditionally employed in approaches driven solely by economic goals. In this paper, we provide a novel approach to the design process, which encompasses the accountability for the outcomes generated by the artifacts developed, extending beyond the mere supply of solutions.

Keywords – Sustainable Development and Innovation, Extended Design Process, Design Process for Sustainability, Principle of Proportionality.

I. INTRODUCTION

The phenomenon of innovation creation and adoption is often understood to possess three key attributes: complexity, dynamism, and unpredictability. The complexity of the innovation process arises from its inherent involvement with several interrelated aspects that mutually influence one another. When the level of complexity is elevated, it becomes challenging to discern the attributes of the whole system, since there is a greater likelihood of overlooking or misinterpreting the nature and interconnections of the factors involved. The process of innovation is characterized by its dynamic nature, as the many components involved in the process undergo changes and evolution over time. These changes might result in shifting settings that render an invention unfeasible or give rise to unintended consequences within a very short timeframe. The innovation process is characterized by uncertainty, which may be attributed to these two factors. The intricate and ever-changing nature of the innovation process renders it an unclear endeavor with regards to its objectives, motivations, and findings The issue of innovation uncertainty has been extensively examined in the existing body of literature.

The Technological, Commercial, Organizational, And Societal (TCOS) framework, as proposed by Hall, Matos, and Bachor [1], is a valuable tool for managers and researchers seeking to get a deeper understanding of how businesses, supply chains, and communities may effectively navigate the uncertainties and challenges associated with innovation. The framework of TCOS posits that there are four distinct types of uncertainty associated with innovation that necessitate careful consideration. These include: a) technological feasibility, which pertains to the existence and potential development of the technology needed; b) commercial viability, which concerns the potential creation of a market for the innovation; c) organizational appropriability, which refers to the ability to capture the advantages of the innovation and the difficulty for competitors to imitate it; and d) societal acceptability, which encompasses the potential acceptance of the innovation by society, taking into account its societal implications such as environmental, social, cultural, and political factors. The concept of innovation for sustainable development (SD) is very recent, and its progression and execution are similarly intricate, dynamic, and unpredictable, similar to other types of innovation.

The current corpus of scholarly literature substantiates the proposition that achieving enhanced sustainability performance is reliant on the use of new methodologies. The achievement of enhanced sustainability performance requires the execution of changes and alterations across several dimensions, including processes, goods, management strategies, and governance structures. Hence, the concept of change has significant importance for enterprises, communities, and supply chains as they progress along their path towards sustainability. The adoption of sustainable innovations contributes to the enhancement of both individual organizations and the overall sustainability trajectory of the supply chain, therefore enabling them to attain exceptional sustainability performance. Sustainability trajectories refer to the courses of action that businesses, supply chains, and communities undertake in order to enhance their sustainability via the implementation of innovative practices. Regardless of whether an innovation is considered radical or gradual, whether it pertains to processes or goods, and whether it is novel to the company, industry, or the globe, it is always constrained by what economists refer to as path dependency.

This article provides a comprehensive analysis of the significance of design in both the corporate and societal contexts. It also delves into the potential need of reevaluating the design process to align with the imperative of fostering a more socially responsible approach to design for the sake of innovation. The field of design has seen significant transformations throughout the last five decades. The expansion of boundaries has been undertaken in part to accommodate the multifaceted nature of contemporary challenges. Researchers and professionals in the field of design agree that design plays an important role in both the problems that plague society and the possible solutions to those problems [2]. Furthermore, there has been a noticeable presence of institutional pressure aimed at redefining design's current understanding as a more progressive and active agenda. Several British organizations, such as the Design Council, the Sorrell Foundation, NESTA (National Endowment for Science Through the Arts), and the Royal Society of Arts, have experienced this occurrence.

By consciously rejecting ideological neutrality and actively engaging in value-based activities, these groups want to legitimize the use of design as a technique for tackling global challenges. Social design, sustainable design, value-sensitive design, inclusive design, and participatory design are only few of the subfields of design that have worked to alter the profession's social role [3]. By drawing insights from the responsible innovation frameworks, it is possible to categorize all these domains together as "responsible designs". The term "responsible designs" encompasses a broad and diverse spectrum of design domains, methodologies, and undertakings that aim to determine the ideal state of design, as opposed to its existing state. The duty in question is conceptualized as a tripartite notion, drawing upon the research conducted by Martovetsky [4]. This idea has three key components: (a) the responsibility to prevent damage, (b) the obligation to promote good, and (c) the management responsibility of the process of design. It is said that various manifestations of responsible design fundamentally embody the need to reassess the benchmarks of effective design in light of worldwide concerns, as well as the accountability of designers in attaining such accomplishment.

Within this particular framework, many social, environmental, political, and cultural tendencies have had an influence on the manner in which artifacts are conceived and fashioned. However, it is noteworthy that the design process itself has remained largely unaltered. In contemporary design processes, there is an increasing recognition of the need to consider criteria beyond economic considerations when pursuing social and environmental objectives. However, it is noteworthy that the process employed to achieve these objectives adheres to the logical framework and same stages as cultural approaches that are solely driven by economic goals. For example, when a product is developed with the intention of achieving sustainability, the conventional method involves incorporating ideas and concerns from the field of sustainable design, preferably from the outset of the design process. Various tools have been created to assist designers in addressing these ideas and issues. However, the fundamental nature of the process of design remains unaltered. This scenario may be extended to include social design, participatory design, and inclusive design, and the majority of the aforementioned "responsible designs."

In this study, we provide a novel approach to the design process, which encompasses not only the creation of solutions but also the consideration of the repercussions resulting from the developed artifacts. It is acknowledged that there are several models that include the design process. Several models have been built by engineers, while others have been created by designers and architects. Additionally, some models have been established by practitioners, and there are even models that have been developed by business consultants. These models exhibit several sources of variability that are linked to the discipline from which they originate, their orientation towards users, and the extent of the process. Nevertheless, it is important to note that there are some shared components that form the foundational framework of the design process. The features included in the process consist of iterative rationality, the incorporation of divergent and convergent thinking within the several phases, a focus on actionable steps, and the adaptability of the process to accommodate a range of potential outcomes. Among these often-seen aspects, none of them alone embodies the responsibility that the process of design should uphold in order to ensure responsible outcomes.

The subsequent section of this article has been structured in the following manner: Section II presents a discussion of the design process and its role in business and society. In Section III, a critical review of previous literature has been done. Section IV presents a detailed description of the extended design process, defining its pre-delivery process, and extending the scope of implementation in terms of delivery. More discussion of this concept is provided in Section V. Lastly, Section VI presents a conclusion as well as future research directions.

II. OVERVIEW OF THE DESIGN PROCESS AND ITS ROLE IN BUSINESS AND SOCIETY

The design process, in a more particular context, may be characterized as the systematic approach of creating a design solution that meets external requirements or specifications. The present publication delves into the aforementioned description by examining design as a cyclical process. In order to engage in a comprehensive analysis of the aforementioned inquiries, it is important to cultivate a more expansive comprehension of the design process. The design cycle model proposed by Sebastian [5] has three distinct stages, namely the post-design phase, the design phase, and the pre-design phase.

The fields of design and business are inherently interconnected. The emergence of contemporary design in the mid-nineteenth century was driven by the need to cater to the demands of the industrial economy. Consequently, the interconnection between design and business has persisted throughout history. Designers in the early stages of the profession emerged from many backgrounds, having been drawn to the field due to their aesthetic or constructive aptitude in meeting the industry's need for product advertising and development messages. Over the course of time, with the progression of business models, the area of design has also seen a transformation. Designers have transitioned from being mere stylists to assuming the role of proficient "problem solvers" in a professional capacity. Over the course of time, several prominent enterprises have come to realize that only focusing on the production of identical products and services is insufficient to ensure success inside the fiercely competitive worldwide market.

According to Youssef and Awad [6], it is argued that a sustainable design strategy should go beyond the immediate economic advantages of conventional approaches and instead use a holistic perspective when considering the design. Authors in [7] provide additional distinction between two models of design: the transitional approach and the traditional-linear process. The linear model often assigns more importance to factors such as monetary expenses, quality, and limitations of scheduling. The model of transition incorporates a GBRS (Green Building Rating System) and facilitates the integration of technical information at an earlier stage in the design process, fostering enhanced levels of engagement and feedback among all relevant stakeholders. Previous studies have examined the use of digital technologies for the purpose of facilitating sustainable design and analysis. Hence, in the realm of modern architecture, there is a growing inclination towards prioritizing sustainability and relying on evidence-based design, such as Building Environmental Science (BES), to inform and justify design choices. Based on the data obtained from the interviews, it can be seen that a design process aimed at achieving sustainability has a sequence of processes that may be categorized as follows: (a) operations (b) programming, (c) construction, (d) site analysis, (e) analytics, (f) goals definition, and (g) design refinement.

Cohen [8] primarily examined the application of factors (a) through (e). Typically, the participants begin by doing an investigation of the climate, location and orientation, in addition to the rural and urban settings. This data serves to guide designers in the selection of certain passive design solutions. A rudimentary study of massing simulation is conducted in order to evaluate various design choices during the schematic design phase and to enhance the overall building shape. By the time the design reaches the improvement stage of design, a significant portion of the simulation has already been completed and the design has undergone refinement. The subsequent phase involves the use of Building Information Modeling (BIM) and collision detection for the purpose of coordinating. BIM has the potential to be used for the purposes of commissioning and facility management, therefore offering valuable insights into the operation of a building and facilitating the acquisition of new knowledge and lessons.

The consensus among participants is that sustainable design requires a comprehensive strategy, which entails promoting collaboration across several disciplines and embracing a transformative shift in processes. Post-construction assessments are not yet universally embraced, despite the fact that many Green Building Rating Systems (GBRS) are mandating their implementation. The complete realization of BIM’s capabilities remains largely unrealized inside the majority of organizations. Building Energy Simulation (BES) is being increasingly used within the design process to forecast and enhance the efficiency of buildings. The integration of Integrated Design Process (IDP) is widely recognized as a crucial element within modern design frameworks aimed at promoting sustainability. It seems to have a synergistic relationship with BES (Building Energy Simulation) and BIM techniques. Many businesses saw BIM as a crucial tool for enhancing communication and coordination among stakeholders, namely via the inclusion of BES (Building Energy Simulation) and IDP (Integrated Design Process).

Consequently, a new phase of corporate innovation has emerged, with a primary emphasis on the creation of immersive experiences and the development of comprehensive systems that cater to all aspects of daily life, including living, working, and entertainment. This necessitated the emergence of novel lines of thought that would question established business models, employing a strategy now known as "disruptive innovation." This entails a radical transformation within a given sector, product, or market, achieved by substituting intricacy and exorbitant expenses associated with SCM (supply chain management) and product development with affordability, straightforwardness, accessibility, and convenience. Many firms have started to turn to the process of design as an inspiration source in their quest for the next significant disruption. Following the emergence of notable design-driven advancements like Nintendo's Wii game console and Apple's iPhone, design has swiftly ascended to a prominent position on the corporate agenda. However, a fundamental distinction exists: design is now seen as a realm of cognitive processes rather to only focused on physical creation.

III. RELATED WORKS

Oliveira and d’Aquin [9] argue that models play a crucial role in extracting knowledge from domain specialists and ensuring accurate comprehension of the system. Models may be used to address questions pertaining to the system, such as the

maximum quantity of products that can be present in a single order. Is it possible for one order to have many customers? What transitional phases does an order undergo over its lifespan? Which course is accountable for managing orders that have been cancelled? The first two inquiries may be addressed by examining the multiplicities present in the class model, whereas the remaining problems need the use of other models. If inquiries of significance are unanswerable or provide inaccurate responses, it is imperative to make adjustments to the model until it becomes accurate. One advantage of using modeling in problem-solving is the facilitation of answering inquiries more effortlessly compared to employing code, since models tend to possess a reduced number of superfluous intricacies.

Matsumoto, Watanobe, and Nakamura [10] argue that correcting a flawed model is notably less challenging compared to rectifying erroneous code. Models may also serve the purpose of generating code for programming languages, databases, or specialized languages. The use of a class model facilitates the generation of class declarations in various object-oriented programming languages with minimal challenges. In cases when the target language does not include certain aspects, it is possible to establish a correspondence between those features and those present in another language (a process akin to the compilation process used for any programming language). For instance, in the event that a certain target language does not include the feature of inheritance, other methods might be used to provide similar functionality.

Steiner, Helm, and Maack [11] argue that given the escalating complexity of customer demands and the expanding need for enhanced product development capabilities in industries such as aviation and space, it is evident that the conventional approach to product development is no longer adequate. Model-based system engineering (MBSE) is a methodology that facilitates the creation of intricate goods via a novel approach, enabling the prediction of product behaviors and ultimately enhancing the efficiency of the product development process. It may be argued that the advancements in aviation and space systems, which are widely recognized as highly intricate cyber-physical systems (CPSs) within the industry, have embraced the Model-Based Systems Engineering (MBSE) approach to streamline the execution of all stages of the product lifecycle. The extensive use of Model-Based Systems Engineering (MBSE) has resulted in a notable change in focus from data management to model management over the whole of a product's lifetime.

According to Henderson and Salado [12], Model-Based Systems Engineering (MBSE) refers to the structured use of modeling techniques in order to facilitate various operations such as system analysis, design, requirements, and validation and verification. This approach begins during the conceptual phase of design and persists throughout the subsequent stages of development and the system's lifespan. The result of the Model-Based Systems Engineering (MBSE) activities is a cohesive system model, with a focus on the iterative development and improvement of the model via the use of model-based techniques and technologies. Hence, the model assumes a paramount significance in every phase of the product's lifespan.

Upon conducting an analysis of the data obtained from Marseglia [13], the identified similarities have been consolidated into a systematic procedure that could potentially be implemented uniformly across various organizations. This proposed framework, referred to as the DEPROSU (Design Process for Sustainability), aims to provide a standardized approach. The DEPROSU model is a flexible and performance-based design approach that aims to accurately represent the observed reality in advanced design organizations. The system is specifically designed for a multidisciplinary design team (IDP) that has superior skills in using BES and BIM. The model of DEPROSU consists of three primary phases, each of which is further divided into two sub-phases, referred to as A and B. Each phase A signifies a process of obtaining information in preparation for phase B, which involves analysis and synthesis. The procedure throughout the sample is simplified and shown in **Fig 1**.

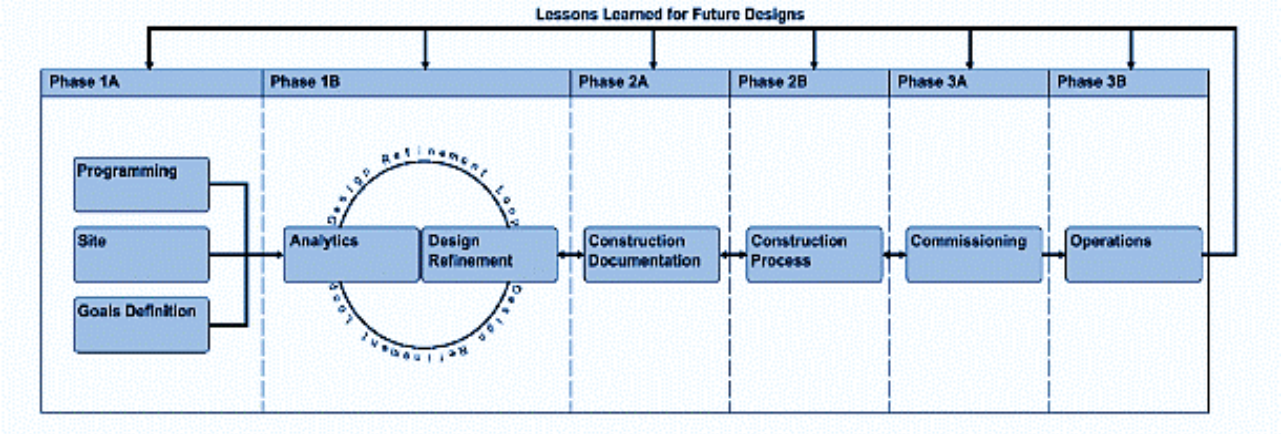

Fig 1. Simplified Process Flow Diagram for the Sustainable Design Process

During the conceptualization and design stages, it is essential to establish a unified system model that facilitates the seamless transfer of information across diverse domains. Thus, the system model in question functions as the central model inside the system, serving the purpose of delivering information and ensuring coherence with domain-specific models. Among the several models available to depict the design process, particularly those focused on solution-oriented design, we have selected the double diamond model produced by the Council of Design as the framework to illustrate the concept of an expanded process of design in this article. The rationale for choosing this model as the foundation for our proposal is rooted in its ability to effectively depict the many phases often used in a conventional design process.

IV. EXTENDED DESIGN PROCESS

In their article titled "Sustainability Driving Innovation and Value Creation," Berg and Hack [14] emphasize the significance of establishing an appropriate company culture in order to effectively tackle environmental and social challenges. López and Oliver [15] emphasize five crucial components that leaders and managers must possess in order to foster innovation with a sustainability focus. These include the ability to provide a clear vision and effectively communicate goals to employees, ensuring sufficient allocation of resources such as budget, space, time, and training. Additionally, leaders should create an environment that encourages collaboration, allowing employees to engage with different departments within the organization or collaborate with external stakeholders such as suppliers and customers. Recognizing and reinforcing the efforts of all employees involved in sustainability-oriented innovation projects is also essential. Lastly, implementing measures accountable, that prioritize the creation of habitat and social value is crucial for promoting sustainability-focused innovation. The ideas put out by Nicolopoulou and Ozkan [16] are derived from their empirical investigation of seven prominent global corporations, namely AkzoNobel, Johnson & Johnson, Pearson Education, Koninklijke Philips, Unilever, UBS, and Interface.

According to Geradts and Alt [17], the concept of social intrapreneurship offers these corporations a means to fulfill their sustainability obligations while also generating enduring value for both communities and consumers. In the 2018 publication titled "Cultivating the Social Intrapreneur," Jenkins provides a definition for the term "social intrapreneur" as an employee who exhibits entrepreneurial qualities and undertakes the development of a financially viable model of business, service, or new product that generates value for both society and the employing organization. However, it is not a straightforward task. Damayanti and Nurasik [18] identify many prevalent issues, such the emphasis on the expansion of established enterprises, the consideration of opportunity cost in investment decisions, and the existence of talent gaps. According to Berzin and Pitt-Catsouphes [19], organizations that prioritize innovation sustainability and engage in social intrapreneurship exhibit three key properties. These include allocating financial resources, emphasizing skill development, and fostering collaborative networks.

The suggested design process incorporates components that are often seen in several solution-oriented models that have been developed throughout the years. The model of double-diamond was chosen not only as a reference, but also due to its ability to include the many phases of the process of design often used in company, taught in educational institutions, and utilized in several process of innovation. Instead of presenting a completely novel and disruptive concept, our objective is to modify existing practices by leveraging familiar actions and language. The proposal is structured into two distinct sections: pre-delivery activities pertaining to the artefact (solution), and post-delivery activities concerning the artefact usage. In the following section, we provide a comprehensive analysis of the ramifications associated with an elongated process of design at these two specific junctures.

Pre-Delivery

The design of Double Diamond concept posits a sequential framework consisting of two diamonds, with each diamond including a divergent stage followed by a convergence stage. The method has four parts, namely explore, deliver, develop, and define. The first assertion presented, while it may seem inherent in the model, is that the initial two stages inside the first diamond pertain to the articulation of the design challenge, while the subsequent two stages within the second diamond align with the progression of the solution's creation, as seen in **Fig 2**.

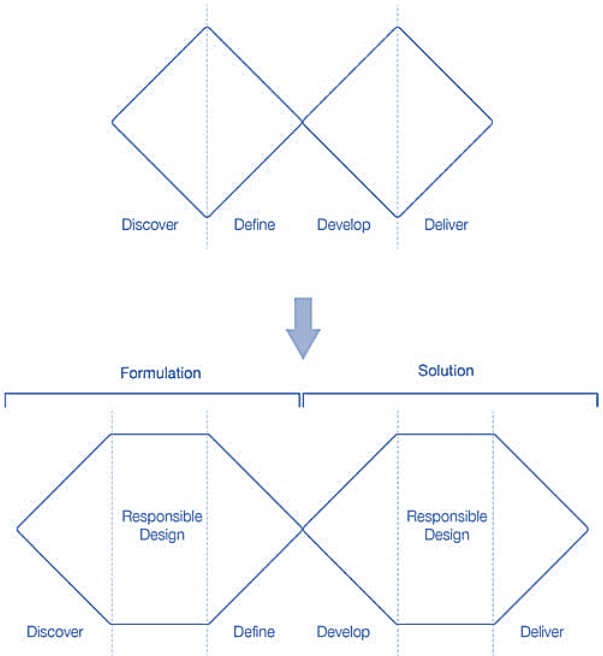

Fig 2. Responsible Design in Pre-Delivery

The primary modification involves creating an aperture inside the center of each diamond shape to accommodate a novel stage. The aforementioned phases are not characterized by either divergence or convergence; rather, they serve as integral components for review and reflection within the process of design. Instead of incorporating inclusive design and criteria for sustainability at one of the initial 4 stages, we suggest incorporating dedicated moments within the process of design to conduct a comprehensive evaluation of the solutions and context. This evaluation will consider the elements that we believe effectively embody the concept of the design responsible, namely pertinence, transparency, and distributed agencies.

During the first phase of reflection and assessment in issue formulation (represented by the first diamond), it is essential to consider the inclusion of transparency and pertinence as key factors. Transparency should be prioritized in order to ensure that all relevant players, stakeholders, and interactions have been thoroughly considered in order to establish the framework within which a region of opportunity will be delineated. As discussed by van der Molen, Sluiter, and Frings-Dresen [20], it is important to examine all the stakeholders involved in providing and accessing data throughout the design and implementation phases. It is essential to establish a comprehensive mapping of all conceivable connections among the people involved, while also proactively identifying and addressing any potential conflicts that may arise.

The concept of pertinence entails the assessment of the significance and purpose of the context established in accordance with a predetermined set of criteria outlined by the domains that include design that is responsible, such as safety, inclusiveness, sustainability, and other relevant factors that vary based on the specific circumstances. The evaluation of the importance of the design context for Smart Labels should include not just economic issues but also arguments from social and environmental perspectives. The use of distributed agencies is evident in the approaches employed to include various stakeholders in the process of identifying and framing problems. This kind of distributed agency is closely associated with the advancements and methodologies derived from participatory design and codesign.

During the second stage of review and reflection in the solution improvement process (referred to as the second diamond), it is essential to include the qualities of dispersed, pertinency, and transparency agency. In this particular instance, transparency pertains to the dissemination of data by the designers to all relevant stakeholders and actors who will be engaged in the implementation of the proposed solution. This information encompasses the methodology used in creating the solution, the consequential effects seen during its construction, as well as the potential implications that may arise throughout its utilization and ultimate disposal. Additionally, it encompasses the data needs necessary for the solution to function effectively, among other pertinent considerations. The pertinence refers to the significance and effectiveness of the solution in achieving its intended aim. One possible approach to assess this is by using the questionnaire developed by Ratcliffe, R. Takundwa, Sen-Nikitas, Hirst, and Malmenas [21], which encompasses several dimensions such as necessity, appropriateness, cost-effectiveness, progressiveness, autonomy, usability, empowerment, and interdependence.

Additionally, it is advisable to include inquiries pertaining to sustainability and inclusiveness. In the aforementioned instances of Smart Labels and Door Lock, the current phase of assessment and reflection should prioritize the critical examination of the generated solutions prior to their market release. This inquiry should encompass any potential issues that may arise during the utilization of the solutions, such as the requirement for users to disclose data they may be unwilling to share, as exemplified in [22]. Additionally, it should consider any potential data misinterpretation provided by the Smart Labels, which could lead to misuse that may have detrimental effects on the user or other parties involved. In conclusion, we contend that the incorporation of scattered agencies is a crucial addition to the second phase of assessment. The term refers to the allocation of duties among all the entities that will be engaged in the resolution process. The agents included under this framework consist of communities, designers, users, producers, and any other individuals who may be impacted either indirectly or directly by the proposed solution.

Extending the Scope of Implementation in Terms of Delivery

There seems to be a constraint on the capacity of our imagination to accurately forecast or foresee the future ramifications of our design ideas. Moreover, this assertion encompasses not only the proficiencies, competencies, and resources that might enhance professionals' capacity for anticipation, but also pertains to the inherent characteristics of the design challenges at hand. Crombez [23] posit that designers frequently encounter intricate problems that cannot be adequately resolved through conventional problem-solving approaches applicable to scenarios structured, like engineering optimization problems, finite solutions games like chess, and natural science experiments, with clear-cut solutions. Design difficulties can provide challenges to rationalistic methods due to their inherent characteristics, which include indistinct boundaries, contradicting knowledge, and intricate systemic complexity. Marier and Van Pevenage [24] used the term "wicked problems" to distinguish them from "tame problems" often associated with areas like the hard sciences.

“Wicked” challenges are characterized by their unpredictable effects on the systems in which they are implemented. According to Walls [25], it is argued that there is no immediate or final criterion to evaluate the effectiveness of a solution for a wicked situation. In contrast, tamed issues have a higher degree of predictability, allowing for the possibility of conducting impact evaluations to assess their effects. The design of solutions for wicked issues has diverse repercussions that manifest throughout many timeframes, including long term, medium, and short-term periods. Hence, given that a comprehensive assessment requires the whole unfolding of all repercussions and lacks a rigid temporal constraint, the evaluation of impacts emerges as a complex and challenging issue. Two contrasting conclusions may be drawn from this situation. One perspective suggests that the negative effects of design solutions make it difficult to evaluate their influence, however this viewpoint contradicts the adoption of a more responsible design approach. An alternative perspective involves

approaching this challenge in a more comprehensive and design-oriented manner, aiming to evaluate the effects of our design solution while acknowledging the likelihood of unforeseen and unpredictable outcomes during its implementation. It is important to note that all assessments should be regarded as provisional. The contention put out is that in order to attain this objective, it will be necessary to expand the design process beyond its current scope of delivery and to delineate the specifics of how this review is to be carried out.

Nevertheless, what are the ramifications of design? According to Chew [26], designers have the ultimate objective of effecting behavioral change. Designers employ various strategies to modify user behaviors, employing mechanisms like seduction or invitation (e.g., the use of a fly sticker in airport bathrooms to encourage correct pointing during urination by biological males) or through coercion and inhibition (e.g., the implementation of mandatory seatbelts in automobiles). In this context, the acquisition of knowledge and skills, often known as learning, may be seen as the immediate consequence of design. Designs, meanwhile, possess not just a direct influence on the user, but also on the broader habitat and social system. According to Bradshaw and Sparrow [27], the impacts of technology may be classified into two distinct concepts: Hard and Soft impacts. The hard impacts refer to quantitative effects that may be seen in terms of risks and advantages experienced by individuals or entities within the system as a result of adopting the technology. Conversely, soft effects refer to nuanced alterations in the allocation of social duties and obligations, moral standards, social identities, and values resulting from the integration of technology.

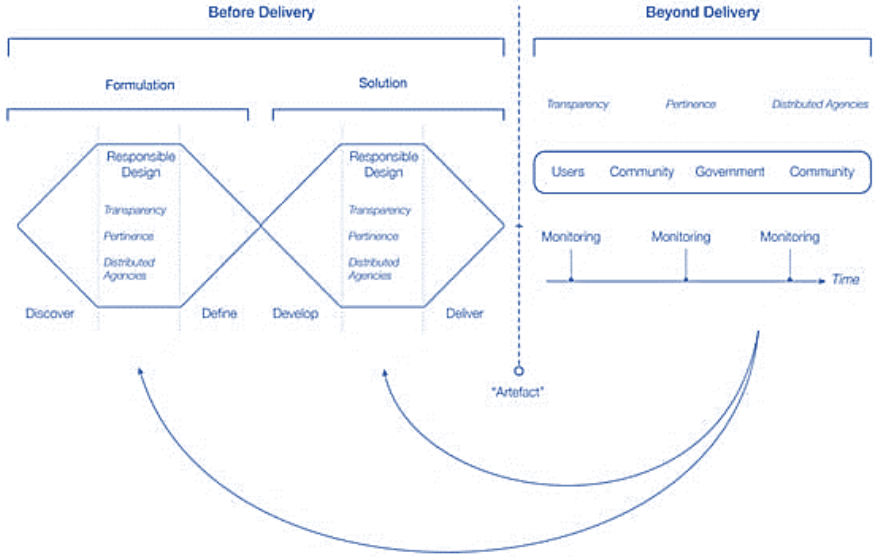

Fig 3. Responsible Design Process Before Delivery

These two categories may also be widely used in the field of design. The assessment of design solutions may be pursued in order to evaluate their effects on user behavior as well as the tangible and intangible consequences they generate within the broader system. Nonetheless, it is not feasible to accurately predict the extent of this effect during the solution's creation phase, since the complex and multifaceted nature of these issues would only reveal their repercussions after actual implementation and over an extended period. Therefore, we argue that a more conscientious design process should include more than just the final delivery of the solution, since many existing designs process models tend to conclude at this stage. The objective of an extended design process is not to generate a definitive assessment of the solution, as this appears to be unattainable. Instead, it focuses on observing and gaining insights from the design's effects within the system. This serves as a basis for determining whether it is appropriate to continue with the current design, expedite its progress, alter its direction, rectify any issues, reassess its viability, or in rare cases, terminate it.

The criteria used for assessing our design solutions may fundamentally align with the criteria we establish for relevance. As previously said, we posit that the comprehensive collection of inquiries put out by Thayer [28], which we have elaborated over in the preceding section, might potentially function as a framework for conducting this review. Designers may also consider the potential unexpected outcomes of their solutions in practical application, including both good and bad effects. They should reflect on what insights and knowledge may be gained through watching the influence of their designs on behaviors and the various alterations within the system, whether they subtle or substantial. The need of transparency at this stage should also be emphasized. The concept of transparency extending beyond the mere act of delivery facilitates the establishment of accountability.

Designers are need to establish and effectively convey the methods through which the artifact will be monitored, as well as the strategies for managing the feedback received. The concept of dispersed agencies beyond delivery pertains to the allocation of responsibility for monitoring tasks. A distributed monitoring initiative may include the participation of several stakeholders, including individual users, communities, non-governmental organizations (NGOs), universities, and governmental bodies, contingent upon the intricacy of the undertaking. For example, the monitoring of the effects of projects like IBM's Smart Cities should include several stakeholders, such as the corporation itself, independent accessors,

governmental agencies, and perhaps the individuals who are impacted by the consequences of this process of design. The aforementioned collaborations are intricately intertwined with power dynamics and political factors, hence contributing to the intricate nature of the design process.

It is believed that the design team must independently choose the specific approach for conducting the learning and monitoring process after the delivery. It is believed that irrespective of the specific format chosen by design teams, they will need to consider a minimum of three inquiries: What is the quantity of learning and monitoring instances that will be incorporated? At what point in the use of the design would it be deemed satisfactory? Lastly, it is important to consider the players who will be engaged in the learning and monitoring process.

Ultimately, the comprehensive plan shown in **Fig 3** illustrates the cross-cutting components that we advocate for including into an expanded design process that is focused on the creation and advancement of socially responsible solutions. In addition to the aforementioned aspects, namely pertinence, transparency, and scattered agencies, there are additional significant observations to be made in this proposal. The notion that the monitoring of solutions should provide input to the process of design and influence the advancement of the same solution or its iterations is a significant consideration. Furthermore, the post-delivery monitoring of the solution (artefact) should occur at various intervals. The assessment process does not necessarily occur in a continuous manner, nor does it occur at regular intervals of time. One significant concern within the context of this protracted design process, as previously said, is to the delineation of the responsible party or parties tasked with conducting monitoring activities, as well as the determination of the appropriate timing and duration of such monitoring efforts subsequent to the implementation of the proposed solution.

An additional significant aspect of this proposal for an extended process of design involves the delineation of two distinct phases: post-delivery and pre-delivery. The assessment and contemplation conducted during the initial phase, prior to solution delivery, should inform the subsequent monitoring activities carried out during the latter phase, after solution delivery.

V. DISCUSSION

There exist several subjects that we want to explore in relation to the proposition of an innovative and elongated design process, as well as its depiction. Given the breadth of the document, we shall condense the content into two key focal points. Initially, we want to engage in a discourse around the constituent components that we see as effectively embodying the principles underlying responsible design. It is important to note that these aspects are not inherently comprehensive in nature. Furthermore, we would want to discuss an additional factor that we deem essential to be taken into account throughout a prolonged design process: proportionality.

In relation to the three components included within our proposal for an expanded design process, namely dispersed agencies, transparency, and pertinence, it is our contention that they effectively encapsulate the fundamental principles behind the notion of responsible designs. However, it is worth acknowledging the potential existence of other factors that might contribute to this concept. This implies that we acknowledge the possibility of including more aspects into the phases of reflection and assessment inside the two diamonds of the process of design model used for elucidating the additions. Any additional components included into the expanded design process should adhere to the principles of being foundational aspects rather than addressing specific subjects within specific settings. In the realm of sustainable design, a critical concern is to the avoidance of hazardous substances. In addition to its significance in assessing sustainable design, it is argued that this particular problem does not constitute a fundamental aspect that universally embodies the concept of responsible design. Consequently, it is suggested that it is not supposed to be included as one of the foundational components of the extended process of design.

Secondly, it is our contention that the concept of proportionality should be duly considered in the progression of an expanded design procedure. Prior to and subsequent to the delivery, it is contended that design teams will be confronted with several inquiries and choices that need their own resolution in order to actively participate in a more conscientious design procedure. Our objective is not to give definitive solutions, but rather to propose a set of essential inquiries that we believe might aid in the facilitation of the decision-making process. It is important to consider the notion of proportionality while making these judgments. Proportionality pertains to the use of a design model, such as the double diamond framework introduced by the council of design, which is employed universally to steer the process of design of many entities, ranging from chairs to cars, and even services like financial loans. These three artifacts exhibit inherent differences among themselves and possess distinct implications in terms of their production, use, and ultimate disposal. In the current context, it is posited that a model aiming to depict a conscientious design process ought to take into account both the magnitude of the process itself and the magnitude of the resultant solution.

From our perspective, the application of a concept of proportionality entails designers taking into account the level of complexity involved in their design process. This includes factors such as the sensitivity of the issue at hand, the magnitude of the solution being proposed, and the anticipated influence on the system after implementation. We suggest that there is a positive correlation between complexity and responsibility. Naturally, as to other heuristics, this principle is not a precise discipline and every instance is unique, just as the designers themselves vary. At now, we are uncertain about the appropriate method of incorporating this feature into our proposal. Consequently, we provide this issue as a potential avenue for further investigation, inviting input and suggestions from other academics engaged in this field.

As previously suggested, the influence of design remains inherently uncertain. This should not engender despondency or foster the inclination to relinquish all efforts towards the conscientious administration of the design process. Genus and

Stirling [29] introduced the concept of a "dilemma of control" in the context of technology, which may also be extended to include a wide range of complex design challenges. The Collingridge paradox, as posited by Gee, Palmer, Friel, and Collingridge [30], is based on two fundamental premises. Firstly, it asserts that the prediction of impacts stemming from a technology is a challenging task until the technology has been deployed and extensively adopted. Secondly, it argues that exerting control or governance over a technology becomes more difficult after it has gotten deeply embedded inside the system.

Both of these premises seem to be accurate, and despite the negative implications for design responsibility, we might view it as an opportunity for design innovation. It is important to establish a well-defined design process to enhance our capacity for making informed assessments and projections about the consequences of our solutions. Additionally, this approach should provide strategic planning for learning and adaptation throughout the implementation phase within a given system. Our argument in favor of an extended design process challenges the prevailing assumptions that including foresight and reflexivity alone is sufficient for establishing accountability in the context of innovation. It is important to acknowledge the significance of these concepts; yet, it is crucial to emphasize that their implementation necessitates their integration into the very fabric of the process. Furthermore, it is important to note that establishing boundaries is an integral aspect of this process. For instance, it should be acknowledged that the act of monitoring cannot be entirely substituted by anticipatory exercises alone.

In conclusion, the creation of a unique extended design process requires careful evaluation of and resolution of substantial sociotechnical and ethical design challenges. What are the extra aspects of responsibility, such as pertinence and transparency, that would need to be included, for instance, (a) Dimensionality? (b) Timeliness: When does the process of design come to an end? (c) Agency: Which participants in the extended process of design should take on certain duties? (d) Tooling: What design tools will be needed to mediate and promote the growth of the process of design?

VI. CONCLUSION AND FUTURE SCOPE

It is important to consider the limits of this plan. As a conceptual piece, our primary objective was to analyze the limitations of representations of mainstream process of design and provide an alternative model that demonstrates the potential for reimagining this process. Therefore, this article is deficient in the systematic empirical data required to substantiate a more conclusive expansion of the design process. It is anticipated that this preliminary investigation will stimulate more elucidations on the origins and justifications for the adoption of the current procedure, as well as empirical data highlighting strategic and holistic approaches for integrating responsibility into the fundamental aspects of the process of design. The latter stages of our study include the further development of our recommendations pertaining to pertinence, transparency, and dispersed agencies. This implies that our objective is to translate these concepts into practical actions, tangible instruments, and measurable benchmarks to guide each subsequent phase of the expanded design process. Subsequently, our objective will be to evaluate these preliminary concepts by conducting an analysis and documenting the execution of a real-world implementation involving design teams. This article examines the ethical considerations within the design process. However, it is important to acknowledge that there are additional adjacent aspects that warrant further investigation. These include the influence of politics and power, the designers' aspirations education, and the interplay between technical expertise and ethical considerations throughout the process of design. It is anticipated that via the contextualization of responsible design difficulties and the exploration of preliminary ideas to expand the design process, there would be a stimulation of fresh confrontations and discussions on the present condition of the process of design.

Data Availability

No data was used to support this study.

Conflicts of Interests

The author(s) declare(s) that they have no conflicts of interest.

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