THE ADVANCEMENT OF CUSTOMIZATION EXPERIENCE THROUGH WEB-BASED CONFIGURATORS FOR MODULAR HOUSING INDUSTRY

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ABSTRACT

THE ADVANCEMENT OF CUSTOMIZATION EXPERIENCE THROUGH WEB-BASED CONFIGURATORS FOR MODULAR HOUSING INDUSTRY

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Although the mass customization paradigm, which reflects the production philosophy of the 21st century and offers the most suitable products and services for the current market demands, has been adopted and sustained by many companies across a wide range of industries, it has found minimal application within the construction industry. Despite numerous research and development efforts and pioneering attempts to adapt mass customization services to the industry, these services have found only a small application area within modular house manufacturing. Even though significant strides have been made and considerable success achieved in adopting this strategy in modular housing since the beginning of the 21st century, crucial factors for success, such as customer guidance and personalization experience, have been overlooked in the process. As a result, the level of mass customization in this area has yet to reach its ideal level. At this point, product configurators, which are the most effective reflection of these factors in practice, have been described by experts as an insurmountable challenge. Herein, based on this, the research first identifies the qualification criteria for web-based

configurators developed for mass customization applications in modular homes. Through interviews conducted as part of the research, the impact of these identified criteria on the personalization experience was examined by evaluating the customers' approaches to existing web-based configurators. Drawing from the data obtained, a new guidance methodology and a framework guide for modular home configurators, which is the aim of this research, have been proposed.

Keywords: Mass Customization, Modular Homes, Choice Navigation, Configurators

ÖZ

WEB TABANLI KONFIGÜRATÖRLER İLE MODÜLER KONUT SEKTÖRÜNDE ÖZELLEŞTİRME DENEYİMİNİN GELİŞTİRİLMESİ

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Yüksek Lisans, Yapı Bilimleri, Mimarlık
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21. yüzyılın üretim anlayışını yansıtan ve günümüz pazar taleplerine en uygun ürün ve hizmetleri sunabilen kitlesel bireyselleştirme paradigması geniş bir endüstri yelpazesinden pek çok firma tarafından benimsenen ve sürdürülen bir üretim strateji olsa da inşaat sektörüne adapte edilmesi noktasında pek çok sıkıntı ile karşılaşılmıştır. Bunun neticesinde, her ne kadar pek çok araştırma-geliştirme çalışması ve öncü denemeler ile sektöre adapte edilmeye çalışılsa da, kitlesel bireyselleştirme hizmetleri günümüzde inşaat endüstrisinde modüler ev imalatı ile küçük bir uygulama alanı bulabilmiştir. Bu alanda da 21. yüzyılın başından bu yana bu stratejiyi benimsemeye yönelik önemli adımlar atılmış ve pek başarı elde edilmiş olmasına rağmen, müşteri yönlendirmesi ve kişiselleştirme deneyimi gibi başarı için önem arz eden faktörler bu süreçte göz ardı edilmiş ve neticesinde bu alanda kitlesel özelleştirme seviyesi halen ideal düzeyine ulaşamamıştır. Bu noktada, bu faktörlerin uygulamadaki en etkili temsili olan konfigüratörler (oluşturucular) ise otoriteler tarafından henüz çözülememiş bir problem olarak tanımlanmıştır. Buradan yola çıkarak, bu çalışma kapsamında ilk olarak modüler konutlarda kitlesel bireyselleştirme uygulamaları için geliştirilen internet tabanlı konfigüratörlerine ait yeterlilik kriterlerinin belirlenmiştir. Çalışma kapsamında yapılan görüşmeler

aracılığıyla mevcut internet tabanlı konfigüratörler üzerine müşterilerin yaklaşımlarını değerlendirerek belirlenen kriterlerin kişiselleştirme deneyimi üzerine etkisi incelenmiş, elde edilen verilerden yola çıkarak çalışmanın amacı olan modüler konut konfigüratörleri için bir kılavuz çatkı ile birlikte yeni bir yönlendirme metodolojisi önerilmiştir.

Anahtar Kelimeler: Kitlesel Bireyselleştirme, Modüler Konut, Konfigüratör (Oluşturucu), Tercih Gezinimi

To my family…

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CHAPTER 1

INTRODUCTION

Today, the alteration of comprehension and dynamics of the industry is highly related to its relevance with technology and satisfying the expectations of the market. As customer existence and integration become a growing aspect of the successful product placement and introduction in the developing market, the rule of fulfilling customer specification through flexibly offering product families with many variants is the main market strategy, and customers' demands of verity is also accepted and started to be applied also for the construction industry and its offerings (Jensen, Nielsen, and Brunoe, 2018). However, the construction industry, as it's shown no significant improvement in terms of productivity in manufacturing while other industries have doubled since 2005; the progress should be elaborated more on the wider aspects of production methodology (Alex, 2022).

Herein, the economic paradigm shifts leading to the differentiating production systems and making a major impact on the fundamentals of the markets are stepping forward as further-discussed topics for the market and literature starting from the post-war period with the intention of consolidating both practice and theory-based aspects of it. Considering the condition of current changes and developments in today's market, the literature of Alvin Toffler, an American futurist writer, called "*The Third Wave"* presents a huge significance in highlighting the integration of customers and their will within the process of production. In his book, he discusses three significant waves that humankind encountered throughout history. The First Wave refers to the settled agrarian community which replaced the hunter-gatherers in the history of humanity and renormalized the first true social order in a community leading to the specification of professions and their existence in the market. The Second Wave emphasizes the shift introduced with the Industrial Revolution which

brought the terms of the modern economic order in a primitive way such as centralization, standardization, mass production, mass consumption, and mass education. The Third Wave is the period ascribing the current market and conditions with the highlight of individualization, data, and information (Toffler, 1980).

As can be understood from the highlighted subjects at this point, the shift experienced with the Third Wave is a transition driven by increasing intellectualism and individual consciousness, along with advancing technology. Therefore, the fundamentally transformative aspects of terms like standardization and mass production, which came with the Second Wave, are not as apparent in the Third Wave. Indeed, the production paradigm known as mass customization, which emerged with the Third Wave, inherently combines the ability to meet customers' demands for personalization and firms' demands for information, while also retaining the capabilities of the Second Wave, such as producing cheaply and in large quantities. Due to this characteristic that promotes a considerably smoother transition and supports the adoption of every beneficial qualification, the mass customization paradigm was recognized by many companies as the business strategy of the future even before the 21st century began and was attempted to be adapted into production.

In contrast to industries that witnessed and adapted to many changes throughout the 20th century, the construction industry lagged and only began to catch up with these transitions a few decades later. In this context, the very first responses seen within the construction industry were to adapt the industrialization fundamentals to the manufacturing and servicing namely industrialized building systems, prefabrication of architecture, or off-site fabrication of sub-assemblies and their emergence has stemmed from the rapid augmentation in the population and mass marketing (Eid Mohamed & Carbone, 2022). The driving ideology behind the introduction of these terms was directly linked to the outline of the market depicted in the Second Wave's description. Fast production and supply were the main targets considering the conditions of the period; Gann (1996) associates this specific period with its inspiration from Ford's assembly line of cars to reflect the pure intention of focusing on the main targets. At this point, these targets did help to achieve certain qualities

such as lowering the unit costs and shortening the production and assembly time; yet the achievements are not found as substantial as before when the war period was over, and the demands of the customers did exceed beyond the vital need of sheltering (Anson, Ko, and Lam, 2002). A certain level of specification and customization is included within the process of production thereafter with the initiative of architects and engineers dedicating their effort to the subject of architectural manufacturing, specifically modular construction. Starting from the General Panel House Corporation's initiative to employ Walter Gropius and Konrad Wachsmann to architecturally glorify the concept of modular houses by reconfiguring the stereotypic form by adding or subtracting the components employed within the modules, the early examples of mass customization seen in the industry but rather stayed niche which is found to be extravagant and belonging to specific type and understanding of life (Herbert, 1984). Conversely, the faith of the construction industry shifted from following the paths of others in an unfavorable way of standardizing the main components of the building process and advertising the need and ability of customization way after the completion of structures which determines the possibility of updating the idea of housing as a product that meets the market's expectations. As a result, while other industries were already examining and integrating the mass customization paradigm brought to the forefront by the Third Wave into their production schemes, the construction industry shelved this concept. It would take decades for mass customization to re-emerge as a relevant topic.

At the beginning of the 21st century, the preliminary studies regarding the suitability and applicability of mass customization in the fields of construction and architecture started to re-emerge, with a standout focus on the theoretical framework of manufacturing in general. Within the scope of these early studies, it was revealed that mass customization for construction production is indeed possible. However, after a few unsuccessful attempts, this trend dissipated, and mass customization applications in architecture became limited to modular construction, particularly modular housing, which is already closely associated with industrial production in

the industry. Although many companies today try to implement mass customization strategies in the modular houses they produce, a proven case has yet to emerge globally. Upon investigating the reasons for this, it has been discovered that, while modular house manufacturers have made significant progress in terms of production, they have fallen behind in customer integration, a critical aspect of mass customization. When configurators are examined, the most used customization and choice navigation tool for customer integration by companies offering mass customization services, this deficit becomes apparent even today. To address this deficit and enable the provision of successful mass customization services within the industry, this research has focused on developing a customer/choice navigation model tailored to the industry and modular homes as a product, while meeting the current market's demands. This model, developed for configurators, offers a choice navigation methodology and the necessary features to ensure this methodology works most effectively, thereby establishing a foundation and a reference.

1.1 Research Problem

Towards the end of the 20th century, the production paradigm in the market evolved from mass production at low cost to a focus on individual needs and desires in products (Bressani, 2015). According to this new paradigm, business models across a range of industries have shifted towards increased customization in production responding to the growing consumer demand while trying to maintain the core values of previously followed standardization for profitability. This new model, which emerged in this context, has been called mass customization, and since the last two decades of the 20th century, it has been adopted by companies across many industries and accepted as the production paradigm of the upcoming 21st century.

However, unlike other industries, mass customization has not been thoroughly explored and investigated within construction due to the industry's delayed nature and dynamics until the end of the first decade of the 21st century. Although the potential of this business strategy was eventually recognized by the industry, its

implementation in production has been found just as challenging. The practical applications of examples lacking a well-prepared theoretical foundation have lagged behind those in other industries (Nahmens & Bindroo, 2011).

In the following years, the popularity of mass customization strategies within the industry relatively declined, and the few remaining applications began to concentrate on modular houses, the typology where industrial production aspects are the most prominent. Modular housing, which is a good fit for mass customization applications considering its production process and product structure, has seen significant developments, particularly in manufacturing-focused aspects. Success factors such as solution space development and a robust design process, which are deemed necessary for a successful process, have been achieved during this period. However, despite all these advancements, in the end, as Eid Mohamed and Carbone have stated, mass customization practices in modular housing have also become stagnant (2022).

When a step was taken back to investigate the cause of this stagnation, it was seen that the issue lies in the insufficient research and integration of another crucial element of mass customization applications, one that is just as important as the production aspect: choice navigation, which stands for inviting customers into the process and guiding them through it. Herein, in the academic discussions, it has been frequently noted that the web-based modular house configurators offered by companies providing mass customization services today have long been an unresolved problem within the industry (Eid Mohamed & Carbone, 2022). While manufacturers from other industries are developing and optimizing their choice navigation models used in web-based configurators (main mass customization tools in the current market) constantly to provide the most enjoyable and satisfactory customization experience to their users, the configurators provided for modular houses have been found to be developed using conventional methodologies and offer an inadequate experience in till this day.

Within this context, the research problem of this study can be formulated as follows:

Despite many achievements in production over the years through academic studies and experiments, the mass customization services offered in modular houses today have not fully succeeded due to deficits in the integration of the customers in the process. To address this issue, which is also quite evident in configurators, the ubiquitous tool for mass customization applications, a new product-focused choice navigation methodology should be developed, and these tools should be equipped with the necessary features, as successful cases in other industries have done to overcome the stagnation and meet market expectations.

1.2 Objective of the Research

This research aims to establish a new choice navigation model tailored to the modular house industry. To achieve that, it first seeks to identify a set of adequacy criteria for web-based configurators which refers to the expectations of customers from both process and products as a tool. Then, it's intended to evaluate the currently available web-based modular house configurators following the adequacy criteria, for detecting shortcomings in the tools. After noticing these deficits, it's targeted to determine what kind of methodology and features have the potential to overcome these deficits by responding to the expectations of customers. Ultimately, the research aims to develop and propose a choice navigation methodology to build a web-based modular house configurator along with a framework illustrating the essential features of these configurators that offer a satisfactory experience to users, whose applicability is then examined by developing an example following it.

1.3 Research Questions

The research seeks to investigate a range of critical inquiries relevant to the successful development of a choice navigation model to be employed in the mass customization services offered in modular houses. Herein, these inquiries also encompass significant complementary subjects identifying the adequacy criteria that

can be used to evaluate the performances of web-based configurators, examining currently available examples and identifying their strengths and shortcomings and lastly establishing a theoretical framework of a choice navigation methodology and a set of features to set a groundwork for building a more successful web-based modular house configurator. Accordingly, the following research questions can be defined for the study:

- What are the preferences and expectations of users regarding web-based product configurators used as customization tools within mass customization services?
- Can a set of adequacy criteria that configurators are expected to meet to provide a satisfactory experience be determined based on the preferences and expectations of the users? If so, what would be these criteria?
- What are the navigation methodologies followed, and what features are integrated in current examples of web-based modular house configurators? How are these components evaluated by users?
- Are the currently available examples of modular house configurators able to provide a satisfactory design experience to their users? If not, what are the main reasons behind that?
- By applying what kind of methodology and employing which features can the most suitable configurator tool and process be designed for modular house configuration? Can this newly designed model truly respond to the users' demands and expectations?

1.4 Hypothesis

The broader aspect of the research aimed to examine the process, identify, and prove the hypothesis: “With the help of an advanced choice navigation methodology incorporating a set feature responding to the demands and expectations of the users from the configurators, more successful models can be offered compared to currently available modular house configurators.”

Since the hypothesis is based on the recognition of the importance of tailor-made navigation strategy developed for web-based modular house configurators, establishing the framework within the research requires elaborating on three major components, namely, adequacy criteria to be followed in configurator to offer a satisfactory experience, strengths, and shortcomings in currently available examples and lastly development of a new model consisting of a navigation methodology and a set of feature which can be a reference while building configurators targeting offering a better experience. Providing a broader overview of the research, the hypothesis for this study regarding the above-mentioned components can be formulated like this:

Adequacy Criteria for Configurators:

The hypothesis proposes that the users' expectations from the configurators can be formulated into a set of criteria. These criteria can be referred to while building the configurators in order to offer a satisfactory customization experience to the users. Also, the features that need to be integrated into the configuration tool can be developed following these criteria.

Currently Available Web-Based Modular House Configurators:

This hypothesis suggests that the web-based modular house configurators currently available on the market are insufficient to provide a truly satisfactory customization experience. The main reason for this is that these configurators are still being developed based on conventional methodologies and equipped with a standard set of features. Again, companies offering mass customization services for modular homes will continue to remain incapable in this regard unless they tailor their choice navigation methodologies to their products "modular house" and introduce new features suitable for this tailor-made methodology.

Development of a Choice Navigation Model for Web-Based Modular House Configurators:

Within the scope of the hypothesis, it is proposed that it is possible to develop a model following a methodology that is designed considering user demands and the characteristics of modular homes as a product, which also consists of all the features necessary for the functionality of this methodology. This developed model will promise a much better experience for users, as it will address the shortcomings of currently available web-based modular home configurators.

CHAPTER 2

LITERATURE REVIEW

In this chapter, the subjects associated with the theoretical background of the model developed within the scope of the study are researched and presented in a detailed overview. In this context, the history and evolution of the mass customization paradigm are explored, along with the features the concept is based on and the success factors necessary for its effective implementation. Subsequently, the history and examples of mass customization applications in the fields of construction and architecture are focused, with a particular interest in modular construction, where mass customization applications are concentrated within the construction industry. In this way, the theoretical groundwork necessary for the continuation of the study is laid out within this chapter.

2.1 Mass Customization

While the objective encompasses a number of very significant terms that need to be elaborated upon for a full understanding, mass customization should be the first focus of the analysis since it is the foundation of the study. Mass customization is discussed within the review starting from its definition to its use in architecture and construction to provide sufficient background.

2.1.1 Introduction and Background Information

The dynamics and changes are particularly evident within the realm of production, a shared domain for both disciplines, as observed across various facets of the economy and technology. Despite numerous claims and endeavors in the manufacturing

industry throughout history, only a select few have left a significant and enduring impact, resonating across a broad spectrum of influence.

The first conceptualized approach to manufacturing that can be systematically evaluated started with the distribution of labor seen in the settled communities to meet the demands and needs found within. While the offerings varied following the abilities of the performers, “craftmanship” stepped forward to be one of the driving forces shaping society and economy (Kaplan & Haenlein, 2006). Considering the economic conditions back in that time, the craftsmanship approach in manufacturing has focused on the service as much as the product which means the possibility of specifying the fit, style, and features of each product for customers, which eventually led the approach to serve smaller audiences and markets.

Undoubtedly, a pivotal and profound transformation in manufacturing techniques and technologies unfolded consequent to the Industrial Revolution which is consolidated by demographic expansion and shifts in consumer behaviors. The increase in demand within the markets found a basis for the substantial advancements in manufacturing techniques facilitating the meeting of supply requirements, fostering the emergence of significant paradigms that endured over centuries. Herein, the integration of machinery into the manufacturing processes attained a prominent status with the introduction of the first moving assembly line by Henry Ford in the year 1913 to be used in the automotive industry (Figure 2.1) (El Nabli, 2008). The mass production and standardization processes and practices, which would form the backbone of contemporary production comprehension, emerged as a result of the massification of production aimed at meeting high demand, alongside the evolving discourse surrounding coordination and control concepts within production (Taylor, 1911). This development marked a significant milestone in production techniques, particularly during the 20th century.

Figure 2.1. Ford Model T by Ford Motor Company produced from 1908 to 1927 (İlksoy, 2015)

In the process of manufacturing, the massification strategies increased production volumes, which, in turn, exerted the effect of reducing prices. This approach was deemed as the most appropriate as the global markets and consumer-centric societal structures would come under the influence of two major world wars and shifting consumption habits.

The adequacy of the expectations for faster, cheaper, and more reliable products to the consumers with standardization has become a subject of discussion as the customer profile encouraged to spend and have more all around the world by the governments with the end of the world wars in the 20th century. Herein, mass-produced products, that are widely available in the market and commonly possessed by numerous consumers, started to be found mundane by the owners (Kotler, 1989). Based on this, the absence of craftmanship in manufacturing, which began to be abandoned approximately a century ago due to its timing and cost shortcomings started to be looked after for its potential for personalized production. Thus, the statement "the company produces, the customer buys" which reflects the demeanor of the sectors particularly emphasizing mass production and standardization has started to be questioned and receive backlash from a growing customer base with heightened expectations from their purchases (Savaş & Bardakçı, 2006).

Efforts to address these drawbacks of mass production have initially employed the subsidiary branches of the production paradigm to provide considerably sudden and cost-effective responses. After all, even though the customers' demands from the

products start to vary in terms of quality within this period, there a strong criterion about the production numbers, durations, and costs to be met in terms of profitability and adequacy for the mass production lines that are initiated with high budgets and relatively longer-term business plans by the investors. Therefore, based on the marketing methodology followed, manufacturers decided to offer alternative iterations of products which can be achieved by using the present production lines to respond to the tangible demand of the market (Sarıyar, 2008). At this point, the introduction of alternative products forming a range for the catalog from the mid-1950s onwards formed groups of customers centered around specific needs and expectations among the options offered rather than feared uncontrollable demand possibilities (Smith, 1956). Thus, a rational and scalable market enabling cost management and manufacturing process validity is found for the newly developed approach. When this specific manufacturing approach is intended to be conceptualized, it will be referred to as mass customization, reflecting its nature of fusing two very prominent ideologies in the field, namely mass production, and personalization (Dedrick & Kraemer, 2011; Duray & Milligan, 1999; Pine, 1999).

Definition

The approach of offering alternatives in the product lines within the framework of mass production was neither experimental nor revolutionary in sight; its responsiveness to customers' expectations rendered the strategy highly effective for the market. Owing to its effectiveness, the methodology draws significant attention from the academic environment which renders it not only practically applicable but also theoretically investigable and developable. Herein, the first notable and highly referred mention of the approach is made by Stanley Davis in his book titled *"Future Perfect"* where he stated a mass customization is an approach that aims to reach tailor-made quality with industrialized speed and cost-effectiveness (1987). After Davis's first coin on the subject, the concept often takes place in academic discussions by scholars which understandably varied and developed its definition (Table 2.1).

Table 2.1 The Highlighted Definitions of the Term Mass Customization by the Prominent Scholar Within Their Studies and Publications

Scholar	Definition
Kotler (1989)	"Mass customization is a kind of scope economies application, through single manufacturing process modularization, providing tremendous variety and individual customization, at prices comparable to standard goods and services."
Pine (1999)	"Providing tremendous variety and individual customization, at prices comparable to standard goods and services with enough variety and customization that nearly everyone finds exactly what they want".
Joneja and Lee (1998)	"The practice of mass customization by using information technology, flexible manufacturing and organizational structures in offering diversified yet individualized products and services at prices similar to that of mass production."
Silveira et al. (2001)	"Mass customization is an ability providing customized product or service by high volume flexible process and reasonably low cost."

At this juncture, one that provides a broader view gathering the previous studies and allegations' highlights has been made recently as a "paradigm that enables customized and personalized design at a cost near mass production" (Larsen, Lindhard, Brunoe, Nielsen, and Larsen, 2019, p.1). As it can be comprehended from the definition, the term provides crucial aspects for the intention of maintaining mass production which brings benefits of lowered unit costs, standardized quality, and shortened project time as well as an opportunity to personalize the elements to bring desired functional additions and aesthetic touches (Larsen et al., 2019). Considering the definitions of the term, it varies on the same foundation of fusing concepts of mass production and customization which reveals much about the approach and gives valuable insights for the fast and better compression of the term.

2.1.2 Features of Mass Customization

Mass customization distinguishes itself as a paradigm that diverges from the set of rules and practices that standardize the flow of thoughts, thus consolidating the principles it advocates. In this framework, adapting the fundamental principles and features for a particular service or product to achieve optimal outcomes is one of the most significant aspects attributed to mass customization. As it's possible to remark all the inputs and the outputs of the process as the features, the most prominent ones here appear to be the approaches and the strategies as they outline both practices and discussions while determining the following steps and preferred components.

2.1.2.1 Approaches in Mass Customization

Within this discussion advanced on the approaches in mass customization, a categorization has been made based on the fundamental characteristics and affinities. The primary determinant of this categorization appears to be the extent and level of customization which led the academic discussions to diverge into the broadest categories of purists and pragmatists. Herein, while purists aim to respond to all the demands of customers, pragmatists defend employing the system of delivering products following customer options (Silveira, Borenstein, and Fogliatto, 2001). Considering the contention, the initial discussions about the approaches in the mass customization paradigm elaborated more on the conceptual ideologies rather than the practical methodologies.

The solution for this initial contention is proposed to be found in the act of determining the needed customization range for a specific product or service to get optimal results which directs the conversations toward the practice aspect (Hart, 1995). As a consequence of this, the classification spectrum broadens with the cases to be examined and the factors to be considered, which also meant a whole new categorization strategy for defining the approaches in mass customization reflecting the differentiation and depiction of different levels of customization needed for

distinct products and/or services. In this regard, among many studies on the approaches of mass customization focused on the needed new categorization, Gilmore and Pine's concept stated in their article *"The Four Faces of Mass Customization"* (1997) steps forward in the academic discussion as being prevalent and frequently referenced suggestion. As being identified namely, collaborative, adaptive, cosmetic, and transparent mass customization approaches, the study has a vast potential to offer valuable insights in terms of strategy and methodology formulation with the consideration of nuances of varied products and services for divergent industries.

Collaborative Mass Customization

Collaborative mass customization stands out as the approach providing the highest degree of customization among all identified by Gilmore and Pine (1997). Since the customer is invited to the process of customization from the very beginning of the design stage, a significant drawback in mass customization, namely the customer sacrifice–what the customers want and what they settle for is thus avoided (Broekhuizen & Alsem, 2002).

Herein the statement of a maximum level of customer involvement in the process presents an intriguing argument for the approach since it introduces numerous considerations about shifting the supply chain to the demand chain. As this shift potentially damages the scalability factor of the business and manufacturing with the possibility of the infinite number of unique combinations of choices made by the customers on the product, it needs to be carefully thought out, addressed, and –if it's required– avoided in the execution. Therefore, the manufacturers should strategically position themselves within the process while integrating the customers to ensure they uphold the performance metrics and protect the customers from burdensome responsibilities. When all these characteristics –both strengths and weaknesses– considered, collaborative mass customization, appears to be a suitable option mostly for the cases that consist of customers that are not be able to fully express their preferences and frustrated when presented with an overabundance of options. Since

this condition has often been observed by companies that offer niche products and services, collaborative mass customization is preferred by those companies, particularly in footwear, clothing, accessories, and luxury services, such as hospitality (Broekhuizen & Alsem, 2002).

Adaptive Mass Customization

The collaborative mass customization approach poses a great risk of damaging the fundamental targets of the concept particularly in profitability as it actively engages the customers in the manufacturing process from the very beginning of the design phase to achieve a higher level of customer satisfaction from the product. In this context, the methodology conceptualized by Gilmore and Pine as adaptive mass customization puts forward the fundamentals of mass customization, in a way that both standardization and customization's principles are distinctly manifested. The method is described as "an approach that offers a standard, but customizable, product that is designed so that users can alter it themselves" in the article *"The Four Faces of Mass Customization"* which remarks on the role of the customer in the production process more as a configurator than a designer as in collaborative mass customization approach (1997).

In adaptive mass customization, with the invitation of the customers having the role of configurators into the process, it's aimed to strike a balance between conflicting expectations of customers and manufacturers through a system that offers configurability of the products with a variety of options. In this context, these options are developed with the consideration of the manufacturer's pre-established parameters and resources which form a model for the solution space that represents product variations that can be configured within the system at an early stage. Furthermore, the development of the solution space becomes more of an issue in the later stages as it's the key element for the aspects of scalability of the business as well as positioning in the market by defining the range of services and products along with the alternatives. Herein, the significance of extensive market research focusing on the customer profiles becomes more tangible in the adaptive mass customization

approach as it steps forward as the primary and may be the only reliable source of information for the decision of the solution space.

Although the customer profile analysis in market research is regarded as primarily done for solution space development, it also gives valuable insight into the targeted audience for the manufacturers. Herein, Gilmore and Pine suggest that it is deemed appropriate to employ the adaptive mass customization method for the customers with defined expectations on the performance in different ways on different occasions in their articles (1997). Nevertheless, this is not a wholesome definition of the suitable profile considering the process of adaptive mass customization in practice; the customers are also responsible for having a basic knowledge of the ways of configuring the products following their intentions through the provided navigation tools. Fortunately, with the developing tools and interfaces in computation and online marketing, the customer doesn't need to be highly competent in that; the manufacturers trying to provide the most user-friendly experience for their customers in their configuration process facilitates the over-burdening and unsuccessful endeavors.

Herein, the widespread use of the internet since the beginning of the 21st century facilitated the provision and use of web-based configuration tools for the adaptive mass customization process which, therefore, catalyzed the emergence of examples and gain of recognition in the market. Like prominent cases, miAdidas by Adidas and Nike ID (later renamed as Nike by You) by Nike (Figure 2.2), the well-established firms began to establish a platform for their customers to customize their products by changing various components on preferred base models from their existing product ranges to reach a desired fit, function, and style (Berger & Piller, 2003). Undoubtedly, for the establishment and successful progression of such a system, a well-thought background of scheme and plan should be prepared including the definition of the solution space and customer profiles as well as a working navigation interface for the configuration process that facilitates the production and delivery stages. For this reason, it should be noted that all the successful cases of adaptive mass customization should be evaluated with the auxiliary terms that

constitute the whole process and the experience such as information technology, organization design, issues of mass customization, customer integration, and customer relationship management (Baena & Winkelhues, 2016).

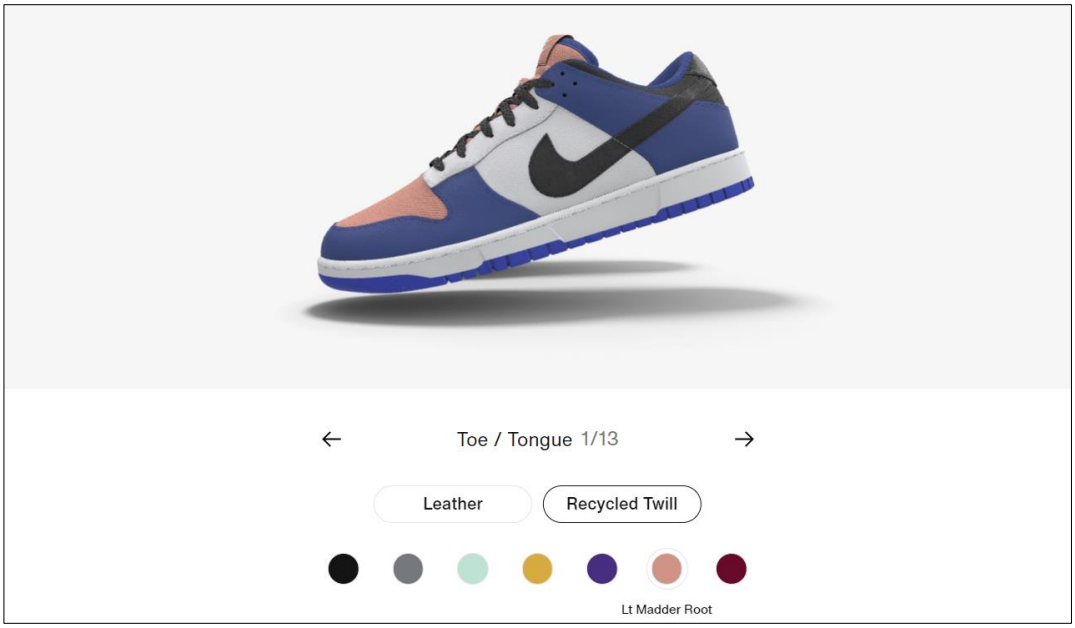

Figure 2.2. “Nike by You”: The configuration tool for the footwear products of Nike (URL-1)

Although it’s mostly associated with it, the success of adaptive mass customization is not limited to the cases of footwear and accessories in the market as it offers a significant potential for utilization within relatively complex customization processes in compelling products. Today numerous firms with products resembling a complex system prefer the adaptive mass customization approach such as automobile and prefabricated house manufacturers (Figure 2.3). The offering of these types of products, especially housing units, consisting of a multitude of components at varying scales in their production reflects the potential of adaptive mass customization in practice. Consequently, the adaptive mass customization approach steps forward as a prominent strategy for firms transitioning to the mass customization model in competitive markets as it offers a satisfactory medium between the customers’ modification and manufacturers’ performance expectations in any market with any type of product and service.

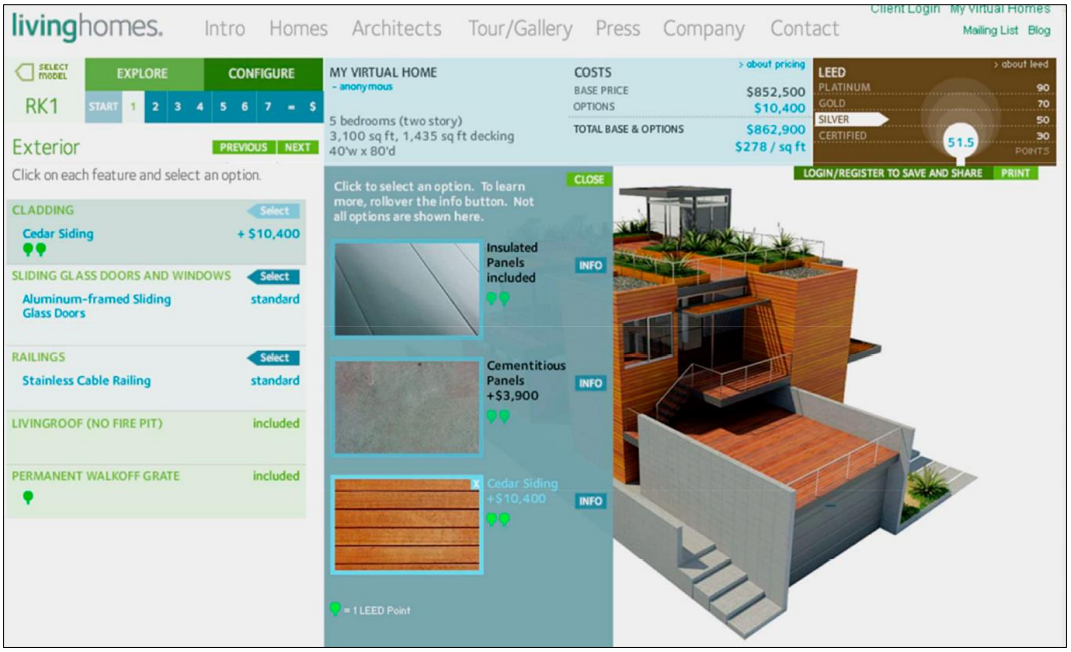

Figure 2.3. The configuration systems interface of the US prefabricated home manufacturer "livinghomes." (Eid Mohamed & Carbone, 2022)

Cosmetic Mass Customization

The third method identified by Gilmore and Pine is cosmetic mass customization which defines the condition of customers who are satisfied with the product itself, but demanding customization related to more visual-oriented aspects like packaging (Broekhuizen & Alsem, 2002). This implies that the scope of customization in cosmetic mass customization is exclusively concerned with the presentation of the product, which impacts the manufacturing feasibility at the end of the process (Aaltonen, 2011). Herein, the significance of the packaging for branding and positioning in the market has been emphasized in the academic discussions. In this context, as a prominent explanation, Gilmore and Pine (1997) state "…the product is displayed differently, its attributes and benefits are advertised in different ways, the customer's name is placed on each item, or promotional programs are designed and communicated differently". Hence, cosmetic alterations can create a realistic difference in the perception of the customers and affect satisfaction regarding the

product which validates the impact of the cosmetic mass customization's integration into production.

Transparent Mass Customization

The latest approach defined by Gilmore and Pine is transparent mass customization. As the name implies, the primary objective of this approach is to provide tailored products or services to the customers without their knowledge (Gilmore & Pine, 1997). In scenarios where the customer profiles can be extracted and the decision patterns in configuration processes can be detected, the approach is found to be logical to adopt for the paradigm. In these conditions, it is deemed that encountering options according to their demands and preferences without the identification of the profiles positively influences the experience of the customers about the process. As a common strategy in the application of transparent mass customization, a collaborative model is formed with the data taken from the tracking of the subsequent preferences of customers which facilitates the offering of suitable alternatives in the following stages based on the customers' initial selections. This experience can be seen in many popular e-commerce, music streaming, and video hosting platforms today.

2.1.2.2 Strategies of Mass Customization

In the realm of mass customization applications, the factors such as industrial structure, product qualification, and customer profile have an undeniable impact on the approach selected, just as, the approach affects customer satisfaction, the final product qualification, and production efficiency. However, the decision on the approach for the mass customization process is not sufficient to define a roadmap for the application of a paradigm having a compelling structure like mass customization. To address this insufficiency, mass customization strategies have been determined to classify the levels and details of the personalization capability offered to customers. From a theoretical perspective, mass customization strategies offer

practice insights and complement the previously evaluated approaches within the execution plans to facilitate in-depth decision-making by the manufacturers. In this context, numerous studies have been made about the identification of mass customization strategies, yet Lampel and Mintzberg's *"Customizing Customization"* (1996) appears as one of the most referenced works among the others. Within their study, Lampel and Mintzberg identify a spectrum from standardization to customization (Figure 2.4). Even though the range presented scrutinizes the strategies with a comparative evaluation of standardized and customized products, these two terms are not inimical to each other. Instead, they can be considered as the "poles of a continuum of real-world strategies" (Lampel & Mintzberg, 1996, p.21).

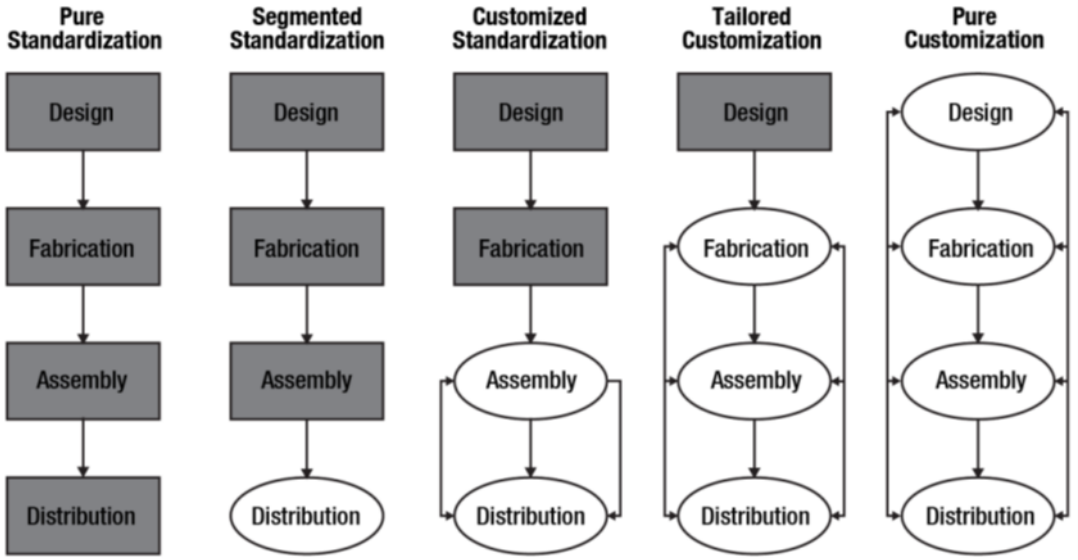

Figure 2.4. The strategies of mass customization identified by Lampel & Mintzberg (1996)

According to Lampel and Mintzberg, the strategies within the spectrum of standardization to customization are defined as five different groups namely pure standardization, segmented standardization, customized standardization, tailored customization, and pure customization (1996). The strategy chosen here is based on mass customization with the process ranging from standard to customized, the product from being common to unique, and the customer experience from being

generic to personalized (Lampel & Mintzberg, 1996). To clarify, with pure standardization there is no potential for differentiation between the products or services provided to customers, therefore, the customers are not accepted in the manufacturing process as a part. Opposing that, in pure customization, the customers are integrated into the process as the modification and interpretation of the product or service become the primary concern. Herein, the highly standardized mass-production products with a dominant design targeted to the broadest possible group of buyers such as early examples of household appliances and automobiles (Ford Model T) exemplify pure standardization, whereas the work of jewelers and residential architects appears to be the well-known cases of pure customization (Gözen, 2011).

Other strategies lie between the two poles of pure customization and pure standardization are identified as segmented standardization, customized standardization, and, lastly, tailored customization. These strategies diverge by the stages at which customers become involved in the manufacturing process. Segmented standardization allows customers to have a voice in the process only at the distribution stage, while in customized standardization, customers are involved in the assembly stage (Lampel & Mintzberg, 1996). In this regard, customized standardization shows parallelism to the adaptive mass customization approach that is elaborated on previously. Herein, by configuring modular components from the catalog that are already optimized following the standardization paradigm, customers personalize their products. This strategy can also be denoted as platform-based customization (Simpson, 2004). Lastly, with tailored customization, it is seen that the customers are actively involved in the manufacturing process starting from the production stage.

The identification of the mass customization strategies emphasizes the necessity to optimize the adoption of mass customization processes tailored to the firm, the customer, and the product. From this perspective, it is seen that an optimization process is imperative as mass customization cannot be integrated into the manufacturing execution with a stereotypic one-size-fits-all approach. Yet, it must

be noted that the successful implementation of mass customization is not solely based on the component's presence such as mass customization approaches and strategies which only define the execution aspects. Within this context, developing a qualified solution space, founding a robust development process that sustains production seamlessly and efficiently, and, most importantly, integrating a navigation system to provide an adequate experience to the customers appear to be the crucial elements needed for success.

2.1.3 Factors of Success in Mass Customization

All the appreciated examples of mass customization in practice are expected to have their features carefully developed and integrated, yet it is obviously not the only item in the recipe for success for the implementation. Herein, a prominent work authored by Salvador, de Holan, and Piller, titled *"Cracking the Code of Mass Customization"* (2009), presents a framework for identifying success factors that complement the features of mass customization for a successful implementation. These success factors, namely solution space development, robust process design, and choice navigation, are remarked on within the study as topics to be considered by the manufacturers at the very beginning of the process to make necessary adjustments required for the integration of the mass customization paradigm into their manufacturing schemas and execution plans (Figure 2.5) (Salvador et al., 2009).

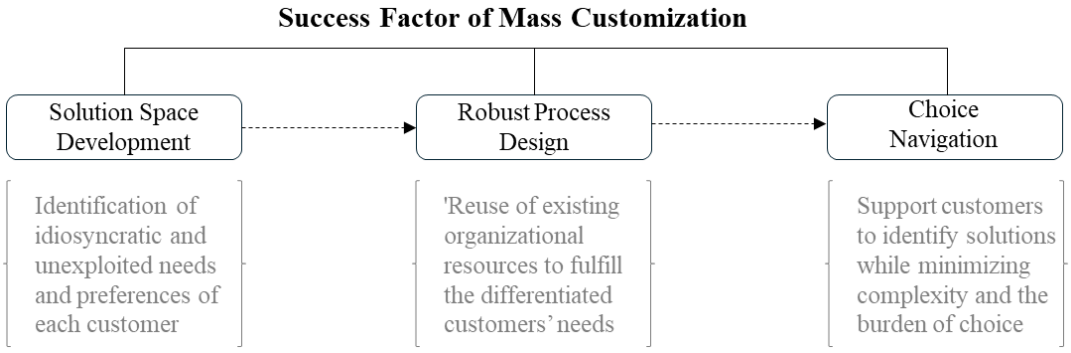

Figure 2.5. Mass customization success factors (Salvador et al., 2009)

2.1.3.1 Solution Space Development (SSD)

The firms engaged in mass production aim to establish a product range that can address the basic needs of their target customers by defining average preferences following the fundamentals of standardization (Smith, 1956). Despite this situation respond the need of the time that the approach came up in the discourse, later it was subjected to critique for imposing a constraining structure for manufacturing with the alteration in the needs and the expectations of the market. As the fundamentals like this of the mass production interpreted into the newly arising mass customization back in that time, the mentioned aspect constituted one of the success factors of mass customization namely the solution space which is explained by Hart (1995) as a "predetermined envelope of variety for the customization of similar products" (p.37). Hart's definition of the solution space herein appears to be an initial suggestion and can be regarded as a foundation that has been subjected to developments along with the mass customization itself. As a result of these developments, the currently preferred interpreted version of solution space development's definition is made by Salvador et al. (2009) as "the ability of an organization to identify idiosyncratic and unexploited needs and preferences of each customer, to optimize the functional, aesthetic, and hedonic fit between the product variants offered by a firm and the needs and preferences of every customer" (p.71).

Considering the alteration in the definition, the first thing that attracts attention is that the analysis and the identification of the market's expectations for any product is attributed a greater significance in the development of solution space. Herein, mass customization already stands out as an approach that integrates these expectations into production with a theoretical basis that will also clarify the rational perspective involved in the implementation. The perspective gained within this subject can be thought of as a compendium of the academic discussion and studies mostly focusing scope of customization and the solution space. Salvador et al.'s (2009) allegation that customization should only be offered where customers' needs diverge the most or where the options become prominent shapes the current structure of solution space

development in its simplest form of adding most valued customization options to the products that are found feasible to manufacture. However, although it appears to be straightforward and considerably elementary, in practice, the decisions here regarding solution space development including the features and options offered vary depending on each case.

The tailoring of the decision on the solution space for each case brings another term into discussion alongside rationality in the perspective, which is flexibility in the development. The introduction of a notion like flexibility may cause concerns at first glance about the feasibility in terms of production, and profitability as it's highly associated with a high level of customization and craftmanship in the manufacturing. Yet, the response to this concern is given with the optimization of the width of the solution space. At this point, as the theoretical acceptance of providing the solution space as wide as possible increases the satisfaction rate of the customers, it also threatens three fundamental intentions namely, scheme economic efficiency, technical restrictions, and standards and laws, of the firms that adopt mass customization (Figure 2.6). On the other hand, narrowing the solution space down may turn the system into mass production which is tried to be avoided in the first place (Dellaert & Stremersch, 2005). In this regard, it becomes obvious that the development of a solution space requires optimization to find a delicate balance between flexibility in the customization and feasibility of the production.

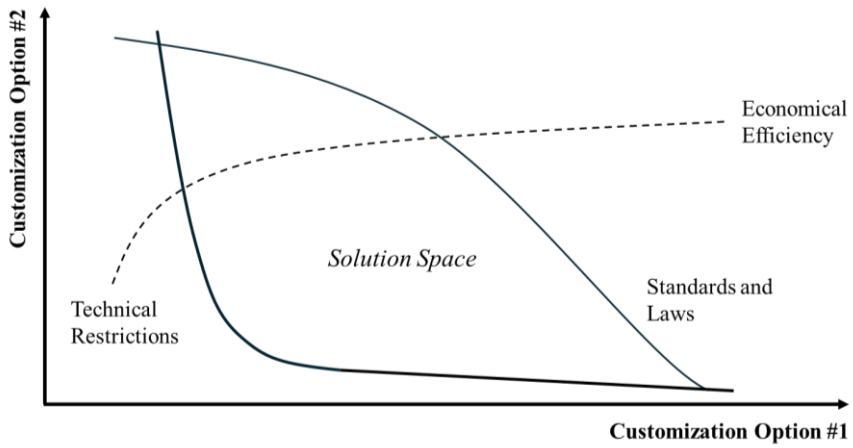

Figure 2.6. The limiting factors bounding the SSD (Dellaert & Stremersch, 2005)

In the current application, the extent of the solution space tried to be reached by determining the fundamental intentions of the manufacturing identified by Dellaert and Stremersch and reflect this extent as the options of three characteristics of a product are particularly significant in the customization phase: the fit (measurements), the functionality, and the form (style and aesthetic design) (Piller, 2004). In this regard, via informatics and data-driven execution plans, a satisfactory level for the base models is tried to get, and after that, the customer expectations across the spectrum of possibilities try to be responded to with the added options varying by these three characteristics.

2.1.3.2 Robust Process Design (RPD)

Even though solution space development establishes an initial point for the process as well as a foundation for the manufacturing within the mass customization implementation, it requires a complementary manufacturing-oriented aspect to demonstrate its impact in practice. The complementary aspect herein can be explained as the optimization of the solution space in a way that ensures increased variability in customers' requirements will not significantly impair the firm's operations and supply chain. Yet, it’s known that variety-introduced productions confront complexity, especially in operations and supply chain management of mass customization (Blecker & Friedrich, 2007). The greater uncertainty in demand realizations, increase in manufacturing cycle times, and increase in shipment lead times appear to be the direct consequence of the complexity in these stages which also affect the cost of the whole process undeniably (Piller & Kumar, 2006).

Illustratively, in an empirical study conducted by Wildemann in 2001, it is seen that in production cases where no optimization strategies were employed against variety increase, the cost per unit increased by 20-35%. When the proposed solutions to avoid the increase to exceed acceptable levels are investigated, it is seen that they converge upon two major points: reducing the varieties in the solution space or redesigning the production system. At this point, as the reduction in the varieties in

the product range implies a shift towards standardization which also damages the mass customization's main allegation of offering offer customers high-variety goods with near mass production efficiency; rethinking the manufacturing paradigm would come up with a better approach to focus on (Tseng & Piller, 2011). In this context, the second factor of success for the implementation of mass customization is identified as robust process design which is structured around this approach.

The robust process design, defined as the "reuse or recombine existing organizational and value-chain resources to fulfill a stream of differentiated customers' needs" highlights the flexibility in production in contrast to the conventional mass production scheme once more (Figure 2.7) (Jensen, Pero, Nielsen, and Brunoe, 2020, p.144). With the consideration of this highlight, the establishment strategies of robust process design can be expected to be tailored to each specific case as done in mass customization's other aspects; yet, on the contrary, the presence of various established methodologies frequently referenced and analyzed within scholarly discourse is seen in the practice. The first and foremost methodology is postponement which suggests the sequential production of standardized bases followed by customized features to complete the product (Tseng & Piller, 2011). As functionally more direct, the method aims to expedite the process and reduce the costs since a significant portion of the production process is handled like a standardized mass production. Since the postponement method does not possess a particularly comprehensive structure, it may be inadequate when employed in multi-component compelling systems. In response, the flexible automation method developed with the consideration of these conditions, which emphasizes the segmentation of the value-chain processes into units that address the diverse variety of expectations of the customers with often reference to the process modularity (Pine, Victor, and Boynton, 1993). Regarded as a more innovative and hard-to-implement approach back in time, today, flexible automation is feasible for implementation owing to technological advancement.

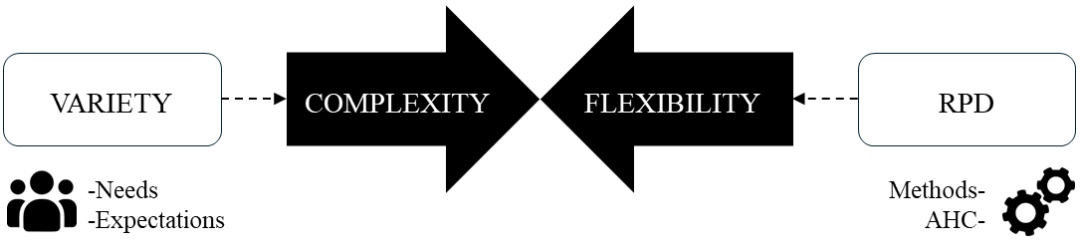

Figure 2.7. Inputs of the success factors that outline the intentions of Robust Process Design (RPD) (Harzer, 2013)

Regardless of the methodology preferred, the investment in adaptive human capital (AHC) is mandatory in the robust process design to achieve the desired production success (Bhattacharya, Gibson, and Doty, 2005). Adaptive human capital is defined as the successful execution of the task by employees and managers while being trained for upcoming challenging tasks that may arise related to production; and aims to successfully integrate the human factor into any methodology chosen to execute mass customization (Tseng & Piller, 2011). Conclusively, robust process design targets the rendering of the practice more conducive to the fundamentals of mass customization by incorporating complexity aspects in production with the solution space development's complementary concept of product variety. Thus, various concerns on the manufacturability of the products that may arise in the solution space development are responded to with robust process design; thereby, facilitating the coherent structuring of a mass customization formwork that will be ready to interact with the customers.

2.1.3.3 Choice Navigation

Elaborating on the success factors of mass customization, it's found out that the discussions and studies on the subject are dominantly centered around the robust process design considerably leaving the factors of solution space development and choice navigation out of the scope; and these interconnected factors have thus remained relatively underexplored (Harzer, 2013). Presumptively, consideration of choice navigation as a more impalpable stage in the process like the showcase of the

catalog prepared to the customer considering the severity of manufacturing may be the justification of this negligence; yet, without any presumption, choice navigation requires an examination preluding from its definition.

As the definition of the term “support customers in identifying their solutions while minimizing complexity and the burden of choice” is reviewed to get an initial impression of the concept, its close relationship with solution space development is noticed in the first place (Jensen et al., 2020, p.144). Upon examining scholarly resources, however, it is apparent that the concept of choice navigation, contrary to expectations, doesn't directly support and validate the ideas put forth within the scope of solution space development, but rather critiques, and differentiates to adapt them within its framework. As a result of this differentiation, which occurs primarily within the context of variety in production, the aspect shifts from “the greater the product variety offered to the customer, the better” to “finding an optimum that provides enough options without causing potential ramifications caused by indecisive customers” (Iyengar & Lepper, 2000). Furthermore, when the fact that each option presented for a feature of the product exponentially expands the solution space while reducing the differences between products offered to minor details, is considered; the concept of burden of choice and the reason for customer attrition becomes more comprehensible and the above-mentioned shift in the approach is justified (Piller, 2010). Herein, the concept of choice navigation, emerging precisely at the origin of this complexity, aims to guide the customers through this intimidating environment and make sure that they have what they had wished for at the end of the product customization process. In pursuit of this objective, choice navigation strategies, developed to facilitate the necessary interaction with the customer, have been introduced to the customers as diverse toolkits. Therefore, analyzing these tool kits has great significance for elaborating on the discourses of choice navigation.

Tool Kits

Within the examination of the choice navigation toolkits, an analysis should be conducted centered on the notion of the customer as it is one of the most prominent

factors in the context of mass customization. After all, the integration of the customers into the process is a constant and immutable element of mass customization despite the fact that their roles and authorities may vary across preferred customization strategies, levels, and approaches. At this point, the perspective of the customers and their direct involvement in the process is tangible particularly in the choice navigation, although they are considered as a parameter and considered in all success factors. Notably, customers, upon integration into the process of mass customization, especially in the design stage, start to be recognized as co-designers (Franke & Piller, 2003). Co-design, defined by Anderson-Connell, Ulrich, and Brannon as the collaborative relationship between consumers and manufacturers in which, via a process of interaction between a design manager and a consumer, constitutes a theoretical framework significant to both choice navigation and fundamentally mass customization, and thereby takes a crucial role in facilitating the choice navigation's translation into practice (2002). Herein, the platforms where customers can reflect their desires and preferences on the product are termed "co-design toolkits" referencing the concept (Franke & Piller, 2003). Co-design toolkits can be presented to the customers in various forms such as configurators, choice boards, and design systems, and essentially serve to turn a process requiring highly creative problem-solving skills, like design collaboration, into a pleasing experience for the customers; thereby resembling a great potential to be a significant motivator for purchasing a mass customization product (Piller, 2010). Among these options, web-based configurators appear to have established themselves in the market as being the most frequently preferred toolkits in today's conditions.

Configurators

The configurators, which began to appear in the late 20th century with initial examples as the internet became widespread, are today commonly known as web-based or sales configurators and are defined as the knowledge-based software applications that support a potential customer, or a salesperson interacting with the customer, in completely and correctly specifying a product solution within a company's product offering (Sandrin, Trentin, and Forza, 2014). As understood from

this definition, configurators have a broad range of applications in both Business-to-Business (B2B) and Business-to-Consumer (B2C) markets. Particularly in the Business-to-Consumer market, where they function as a design tool, configurators have made a significant impact and have thus gained high recognition over time with examples from varying industries such as automotive, cosmetics, and shoes/clothing.

The B2C configurators mentioned here are built to facilitate customization by enabling customers to modify various features of the products through provided options on interfaces, thereby tailoring the products and services to meet the desired criteria of the customers (Figure 2.8).

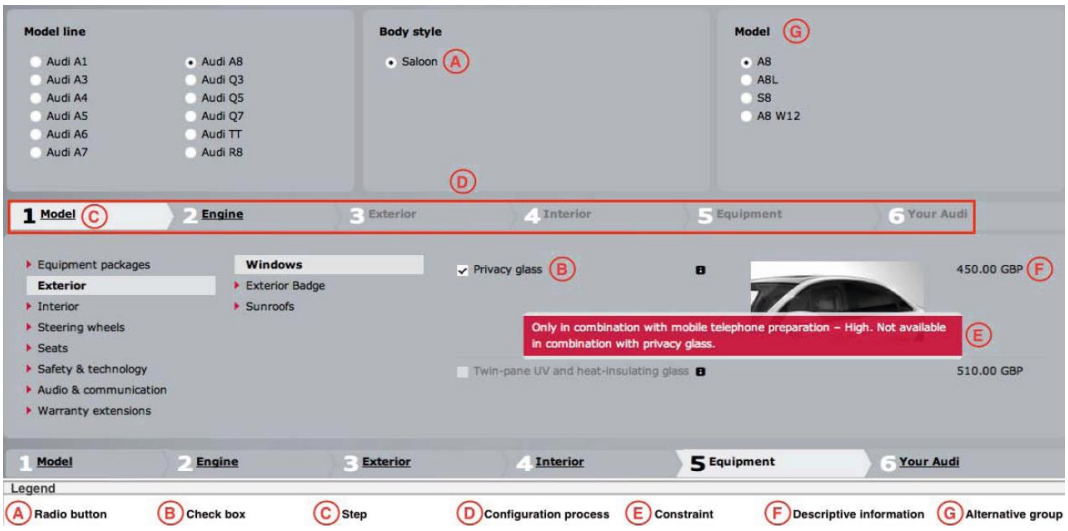

Figure 2.8. Audi's car configurator application allowing customers to personalize their vehicles (Abbasi, Hubaux, Archer, Boucher, and Heymans, 2013)

The choice navigation tools to be examined within the context of web-based configurators have a broad spectrum varying based on customer profiles and product characteristics, yet they are universally expected to perform one consistently straightforward task which is enabling customers to be actively involved in the process while retaining the flow of the process (Piller, 2010). However, putting theory into practice for this objective is considerably more challenging due to the threat of mass confusion. In response to this threat, the web-based configurators

employed today are designed to offer much more than a catalog presented through an interface (Figure 2.9).

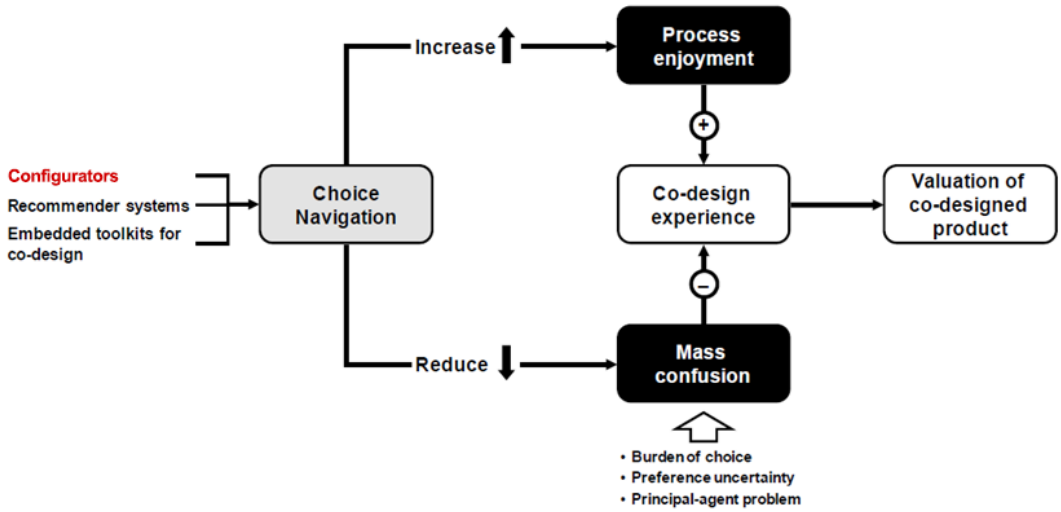

Figure 2.9. Augmentation of process enjoyment while targeting the reduction in mass confusion in the process of choice navigation (Harzer, 2013)

The technological and, specifically, computational advancements have consolidated the functionality of modern product configurators with the integration of product data management (PDM) and customer relationship management (CRM) through the development of applications for efficient and effective customization (Forza & Salvador, 2008). Herein, additional methods and technologies have been introduced to configurators used in relatively complex cases containing systems consisting of multiple components with an increased risk of mass confusion to enhance the user experience under this kind of specific conditions. These methods and technologies aim to achieve this enhancement by rethinking and reconstructing the configuration process starting from the very beginning to the end. In this regard, the integration of default models that allow to initiate the dialogue with the customers through pre-configured visual elements and to progress from a pre-configured structure; as well as incorporating filtering and suggestion engines into the configuration models are crucial. Owing to these advancements, the feasibility of integrating mass customization in challenging sectors noticeably increased.

Default Levels

One of the most prominent advancements that remains as a blind spot in the discussion even commonly employed within the current choice navigation tools is the default levels which define a prelude for the product and a virtual canvas for the depiction of the configuration and customization processes of the customers. The virtual canvases presented herein aim to enable the customers to synchronically see the differences that the changes they want to make in their products will create on the product; so that, the customers can be better integrated into the process and thus related threats of burden of choice and indecisiveness can be avoided. Therefore, the use of navigation tools and models with defined default levels is encouraged, especially in cases where the customer cannot explicitly define or describe the product they want in their minds (Levin, Schreiber, Lauriola, and Gaeth, 2002). In terms of the implementation approaches and strategies, diverse interpretations can be seen sharing the aspect of guiding customers to reach the product they desire through an interface by making additions and subtractions to the offered base (default) model, as common. When this common approach is investigated by Crow, it's found that employment of default levels enables customers to achieve the desired conditions with less alteration and indeed prevents them from experiencing the burden of choice and noted that default value decreases customers' perceptions of difficulty (2005).

Besides the significance of the default levels in establishing a canvas and defining a prelude model in the process of choice navigation, it can also function as a feedback mechanism since the base models can keep any alterations made by the customers on the product as the data. The data collected here can be used to update the base models and provide options considering the mainstream desires; furthermore, facilitating the employment of more innovative methods in choice navigation just like recommendation engines that highlight the previously preferred options in cases where customer profiles or decision patterns overlap. Therefore, default levels can also collaborate within a cooperative framework with advanced methods which represents a huge benefit for the adoption of mass customization.

Advanced Methodologies

In the realm of configurator applications, the intricate cases caused a search for further innovations that eventually led to the development of numerous advanced methodologies. Just as the justification behind the establishment of default levels in the choice navigation, the advanced methods aim to eliminate any inadequacies in completing the tasks by customers and maintain the seamless flow in the process. Considering this, while default base levels serve to define an origin and establish a canvas for the process, the advanced methodologies aim to enhance the customer experience in the following steps as well as motivate their purchasing impulse throughout the process.

Among these methods, integration of the recommendation systems steps forward as the commonly encountered examples. These systems are developed for situations to yield favorable outcomes in terms of product purchases where the customers are indecisive and need to be motivated and guided through the configuration process by recommending specific options and scenarios via various means following data provided by the customer at the beginning (Piller, 2010). Herein, these systems have been specialized and differentiated among themselves based on their approach to the utilization and processing of data for performance enhancement, in other words, how and what they recommend to the customers. The arguably most prevalent example among all the approaches is customer profile recognition which is remarked on beforehand within the discussion of success factors in mass customization. This system, which relies mainly on the personalization paradigm, derives its operational foundation from the profile data of customers as its name suggests (Piller, 2007). For the other examples in filtering and selection systems (engines), collaborative and content-based filtering cuts in the first place as being established almost two decades ago within the scholarly discussion with the high expectations of taking the whole experience one step forward when they are employed correctly. In the example of collaborative filtering, preferences from a vast array of customers are gathered as data and used to recalibrate the engines that provide the services regularly following this data flow, while for content-based filtering, the previous purchases of a customer

are tracked to refer when new alternatives are offered to customers (Burke, 2002; Huang, Krawczyk, and Huang, 2006).

As is often mentioned within the subject, mass customization processes are constructed in a tailor-made manner according to products, customers, and markets. Therefore, the decisions about the advanced methods and strategies selected to integrate vary from one context to another. However, it's advised that these elements are taken into consideration to integrate as they facilitate the implementation of mass customization, a strategy renowned for its inherent complexity in execution, and enable significant improvements in practice. Herein, the establishment of choice navigation tools developed with advanced methods has the potential to be a significant motivator and facilitator, especially for compelling sectors such as automotive and housing as their products have multiple systems and components.

2.1.4 Mass Customization in Architecture and Construction

In the fields of architecture and construction, the "market of one" ideology is embraced opposing the practices seen in the counterparts in the global arena (İlksoy, 2015). This contrariety in the dynamics can be justified by the contention between the habituated traditional production approaches and methodologies preferred in the construction industry and contemporary technologies and techniques that have evolved and developed constantly since the Industrial Revolution along with standardization. Despite the fact that this underdevelopment has been a long-standing issue, it has become more obtrusive with the advancements in informatics and information technologies. Owing to these developments introduced, more in-depth analyses have been made, the results have been compared with other industries, and consequently, a better understanding of the issue has been provided. Thus, responsiveness to industrial standards and market expectations has stepped forward as critical subjects within the construction industry, especially over the past two decades. In this context, mass customization, which is defined as the production paradigm of the 21st century by Huang and colleagues, stands out as one of the

prominent concepts in academic studies and field-oriented research focusing on these subjects (2006).

The preliminary studies regarding the suitability and applicability of mass customization in the fields of construction and architecture were carried out at the beginning of the 21st century, with a standout focus on the theoretical framework of manufacturing in general. Within the scope of these early studies, significant issues were examined that reveal the applicability of mass customization for construction production, such as the parallelism between the stages of construction with the scheme proposed within the mass customization remarked by Winch (2003); the suitability of construction for platform-based production that is demonstrated in Veenstra, Halman and Voordijk's work (2006) and lastly the market already having a demand and expectation for such products and services observed by Frutos and Borenstein (2003), and thus, the transition from theory to practice accelerated in the search for the possibility of the mass customization adaptation in the construction industry. Herein, in 2001, Duarte published his work *"Customizing Mass Housing: A Discursive Grammar for Siza's Malagueira Houses"* where he translated the design elements and language into the computational environmental codes to create a generative design engine, which established itself as one of the milestones and also laid the groundwork for the future developments in the practice-oriented studies. After Duarte, subsequent studies remained concentrated on developing generative engines providing product suggestions and modeling opportunities following customer demands within the solution space defined by the manufacturer. However, especially in the 2010s, a shift in the focus of the studies from developing these engines to opening them to customers with better human-machine communication tools and approaches occurred as a reflection of the development of information technologies, changing customer expectations, and market dynamics. An important project in this regard, *"House_n"* was conducted by the Department of Architecture at Massachusetts Institute of Technology (MIT), where the term customer profile was introduced and explained in the academic environment, which led to the discussion about the search for mediums and toolkits that highlight the current

interest of the organization (Wacks, 2002). Nowadays, studies within this context are increasingly focused on internet-based configuration apps, which are not only designed to define customers to the system but also to engage them.

Concludingly, when studies evaluating the adaptability of mass customization in the construction industry are examined two significant points stand out. Firstly, current practices mainly focus on enhancing communication with customers and improving their engagement with the system as it was previously explored on success factors in mass customization applications. Secondly, it's remarked that most studies have been conducted specifically within the housing branch of the construction industry. Therefore, evaluating and grasping the significance of housing in the context of mass customization and adaptation in the construction industry is considered essential for the study.

The term "house" is a unique example of a product and idea within the need-driven construction industry, where desires play a more significant role in preferences and choices (Rapoport, 2004). These desires prompted the behavior of reflecting the inner self and establishing a comfort zone through personalization, resulting in customizing houses regardless of wealth, climate, location, and construction technique (Salvador et al., 2009). This urge for individualization was fulfilled in early times successfully with the widespread "single houses" typology until the search for industrialization within the industry prompted the concept of mass housing which became an integral part of that time's highlighted urban design. Yet, these residences ended up being one of the most controversial topics in the dialogue as the people who settled in them could fit the role of static customers, and ultimately led to a discussion about the qualities of a good home, which Friedman further explained as meeting not only physical needs but also emotional and social (2017). In this context, as individualization remains one of the most important criteria for users seeking a good home, housing has emerged as a highly potential product for mass customization applications that need a customer base with this demand.

Individualization practices have been observed all along within the context of housing, yet assessing the practices from an industrial perspective, and addressing them on a mass scale could not be achieved until recently. Likewise, the concept of housing units' mass customization has been approached with prejudice since a house differs from typical industrial products where mass customization strategies are applied by being larger, heavier, more durable, more expensive, and permanent; consequently, the concept required a broader-vision and special roadmap to explore the opportunities (Sarıyar, 2008). Furthermore, the manufacturing process of the housing units is coordinated and carried out by architects who adhere to the ideology of craftsmanship in production which does not fully conform to the feasible and adequate customization approach required in mass customization. The primary objective is therefore to understand customer demands and the capabilities of manufacturers, followed by further studies of the early solution space development for varying scenarios to evaluate the customization's feasibility and adequacy. The levels of customization in housing determined through these studies have provided housing manufacturers with customization ranges that can be offered in different conditions and typologies, thus defining a scale and scope for mass customization applications (Figure 2.10).

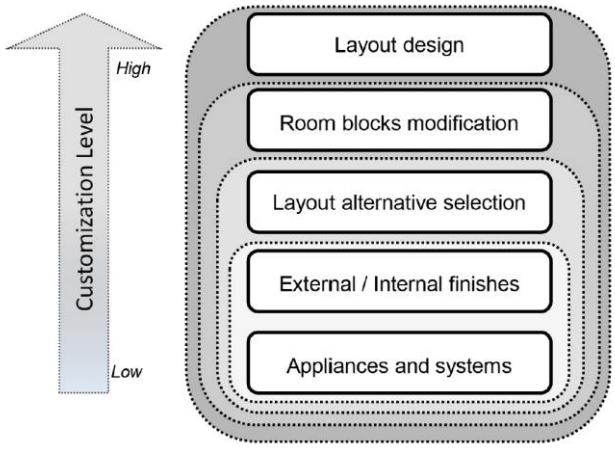

Figure 2.10. The levels of customization in housing identified by Eid Mohamed and Carbone (2022)

Today, the customization dialogue for the housing industry starts with the levels determining the extent of solution space and scope of practice, which depend mostly on typology. Herein, in terms of typology, while the previously prevalent single-family houses are adaptable to making changes at all levels, in today's ubiquitous high-rise buildings, customization is limited to elements such as fixtures, finishes, fixed and movable furniture, technical services, etc. Since these systems and products from the sub-industries of construction form the basis of the personalization in high-rise buildings, the process gets more compelling and often fails to meet the primary demands of the customers. Among the initial solutions to this issue, profiling studies targeting customers' personalization demands and assessing their feasibility have emerged as the first steps in the study. Additionally, these studies illustrate that even though customers often desire higher-level personalization practices, their choices are typically limited to lower-level interferences (Table 2.2). The inability to meet customer demands underscores that the housing sector has yet to achieve ideal levels of personalization within conventional scenarios (Nahmens & Bindroo, 2011).

Table 2.2 The Levels That the Changes Made by the Homeowners Belong to (Sarıyar, 2008)

	Intended	*In Practice*
Levels and Systems	Percentage (%)	Percentage (%)
Spatial Organization	**37**	**19**
Finishings	21	44
Fixtures	20	85
Services (Technical)	13	28
Services (Environmental)	9	-

Modular housing lost its popularity over the years following the world wars since it failed to meet the expectations in the market for “variability and an individually identified design” (Kieran & Timberlake, 2004). However, with the realization of

the fact that traditional on-site construction techniques have reached their technical limits, modular construction has got back to the discussions as an innovative approach particularly in the 21st century to end this trend of stagnation (Bock, 2015). When the fact that it is a branch where industrial concerns and strategies are already applied, as well as its close connection to the concepts of modularization and platform-based production significantly complementary components of the mass customization implementations is considered, the compatibility modular construction for mass customization can be better comprehended. To convey this affinity from the theoretical level to practice, the production schemes, whose importance was previously discussed under this topic, were modified to establish an application-oriented framework that would have a feedback mechanism between stages and a customer integration strategy added to the conventional examples seen in use. By making these changes, the production process of the modular houses has been enabled for mass customization, specifically in terms of design and production. However, as Eid Mohamed and Carbone have stated, following these initial changes, mass customization practices in modular housing have also become stagnant (2022). Herein, the focus for the development of modular housing should be on consolidating the communication with the customer, which refers to an interface or configurator in today's conditions enabling them to better participate in the process and have decision-making authority as being "co-designers" of the product that they're purchasing.

2.2 Modular Construction

As observed in the study, modular construction, particularly modular housing, steps forward as the prominent area where mass customization practices have gained prominence in the construction industry. In this regard, having knowledge about the subject of modular construction will provide an important theoretical background for understanding the model to be developed within the scope of research.

2.2.1 Definition and Background

Undoubtedly, modular construction stands out today as one of the most frequently mentioned building techniques in the industry which also brings a high recognition for the paradigm within society. This recognition has further increased as modular construction has been presented as a potential solution to the stagnation resulting from construction techniques reaching their technical limits in recent years (Bareiss, 2022). As a result, although a similar image comes to mind for most people all over the world when modular construction is mentioned today, there is no such commonality regarding its definition. Due to its frequent presence in academic discussions leading to numerous interpretations, and its applications varying based on geographical conditions, economic aspects, and regulations, the definition of modular construction differs from country to country and person to person. However, it has been noticed that recent academic studies have attempted to universalize the definition of modular construction. At this point, Musa, Yusof, Mohammad, and Mahbub examined how modular construction is defined in studies from different countries and synthesized these definitions to reach a comprehensive conclusion (2014). The resulting definition from this study, "modular construction is a construction method that produces a building consisting of modular units or modules, mass-produced off-site in a manufacturing facility," stands out as a final and satisfactory example in this context (Musa et al., 2014, p.84). Although this definition provides solid preliminary information about modular construction, understanding the history of the concept is necessary to establish a necessary background for this paradigm.

The first examples of construction fabrication and modularization in construction are seen in the 17th century with the exporting of prefab building components in various scales from England to their colonies such as Australia and the United States of America. Prefabrication and modularization methods were, starting from these early examples, predominantly used in structures aimed at emergency sheltering for a long time, leading to its being labeled as a cheap production method in the public eye.

However, the fortunes of these paradigms began to reverse from the mid-19th century onward when they were employed in the building of fascinating and innovative structures of their time, such as Joseph Paxton's famous Crystal Palace and George Fred Keck's House of Tomorrow and Crystal House (Boafo, Kim, and Kim, 2016). Following this, the reputation of prefabrication and modularization methods continued to grow, especially as they were preferred to meet urgent housing needs after the world wars in the 20th century (Taylor, 2010). During this period, examples like the Sears Modern House emerged, with modular construction becoming particularly preferred for single-house construction and even regarded as a prestigious approach due to its ability to offer better quality and more flexibility in design (Wolfman, 1988). At that time, modular production techniques provided a cost savings of around 20 dollars per square meter in construction (Abdelmageed & Zayed, 2020). However, despite this, the popularity of modular construction began to decrease mainly due to shifts in market expectations and declining production quality. From the late decades of the 20th century onward, modular construction found rare applications area in commercial buildings and started to be associated again with single-story houses and emergency shelters. Although it still finds a place in many innovative projects today, modular construction is far removed from the glamorous days it experienced in the mid-20th century. Despite all these ups and downs in its history, it’s still believed that modular construction has huge potential for becoming the future of the industry as its impacts and offerings related to its characteristics are considered.

2.2.2 Impacts of Modular Construction

The discussion about the impacts of modular construction is running on its comparison with conventional construction methods and products. When conventional construction is compared with modular construction, it is evident that the advantages and disadvantages of modular construction are already established. It also identifies and describes solutions for addressing the shortcomings of modular

construction. Shortening the construction time and reducing labor costs are two of the top advantages of modular construction, which are also inherent characteristics. Nevertheless, the cost of materials has increased in common with the cost of transporting components. However, it can be seen that despite the higher material consumption and costs, waste generation, energy demand, greenhouse gas emissions, and embodied carbon have decreased, leading to the conclusion that the method is faster, more environmentally friendly, yet more expensive. Accordingly, the solutions for recruiting the shortcomings focus primarily on cost. Finally, it has been claimed that modular construction has the potential to be even cheaper than conventional construction, depending on the project, because the parameters of labor time and cost can be compensated (Loizou, Barati, Shen, and Li, 2021). Thus, the implications and advantages of modular construction as a method are consolidated.

The benefits of modular structures in various fields in the construction industry cannot be ignored. However, the most important advantage of these structures is their potential to adapt to the future. Thanks to their ability to rapidly adapt to changing needs and technological developments, modular structures can offer solutions that are in line with both the developments in the sector and the expectations of users. These features support the development of modular structures, increase their preference, and allow them to stand out more than other building methods. Hammad and colleagues argue that incorporating the Internet of Things (IoT), Radio-Frequency Identification (RFID), and Global Positioning System (GPS into modular construction will bring the method in line with Industry 4.0. The ability of the method to integrate these technologies will make modular construction a more sustainable method in the industry in many ways (2019).

When examining the characteristic features of modular construction, it becomes evident that many of them emerge due to their production approach being closely aligned with standardization and mass production. Indeed, one of the most prominent and perhaps most important characteristics of modular construction is its tendency to divide the structures into identical and standardized modules. As a result of this tendency, specific component types are introduced in construction facilitating

shifting production towards off-site locations and moving into factory production which also becomes another characteristic of modular construction. Lastly, since fabrication brings control mechanisms in production, terms like scalability and plannability are also introduced into discussion further defining the characteristics of modular construction under this subject.

2.2.3 Characteristics of Modular Construction

One of the best ways to determine the characteristics of modular construction is to examine the definitions provided by the various parties involved in the production process such as the client, owner, manufacturer, consultant, designer, engineer, and contractor (Musa et al., 2014). In view of the divergent definitions, the shared traits of being faster, greener, efficient, productive, and finally, controllable step forward as the qualifications that outline the characteristics of the modular construction. When these qualifications are elaborated on, ultimately, it's seen that they gather around main characteristics on the subject of production, life cycle, and time and cost efficiency.

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In terms of the subject of the life cycle, the produced modular units' flexibility, and reuse appear to be significant characteristics of modular construction. As these units also have the chance of dismantling, refurbishing, and reconfiguring, the concept of lifecycle in construction is almost revolutionized. Herein, the altered life cycle in favor of the products and their reuse also has a positive reflection on the economy and environment by reducing the need for raw materials and energy spent on construction.

Lastly, the abovementioned production characteristics and their associated qualities directly affect the concept which resulted in the attribution of different characteristics to modular construction namely time and cost efficiency. Although this topic is not very suitable for generalization due to variations from case to case, when looking at current applications, it's seen that the use of prefabricated components on the construction site reduces construction time by almost half (Figure 2.11).

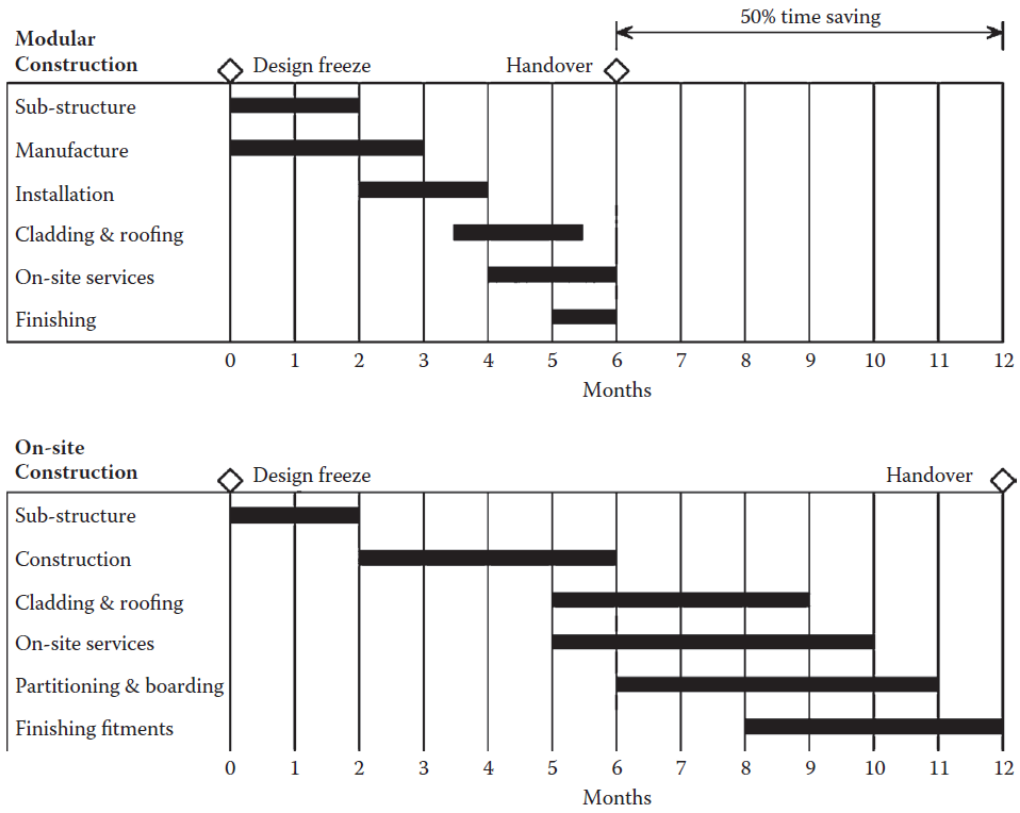

Figure 2.11. The construction timelines (Lawson, Ogden, and Goodier, 2014)

2.2.4 Production in Modular Construction

In the subject of modular construction, production undoubtedly stands out as one of the most significant topics. While this concept encompasses many details and aspects that can be elaborated upon, from the perspective of mass customization, providing an overview of the components and process involved will suffice as a solid foundation.

Components in modular construction are considered as manufactured items used in site-intensive processes and larger and more complex organizations. Herein, in a narrower framework focusing on the aspect of mass customization, components are defined as the items that form modular units with specific compositions and assemblies. Components are often categorized into five main areas in modular structures: Foundations, Structural Frames, Finishes, Mechanical, Electrical and Plumbing (MEP), and Joints. Although these components vary in scale, each one is crucial, especially for modular structures which have a high degree of completion as standard. From the modular construction perspective, these components are essential for completing the process and achieving the final product, but they are not assigned a more significant role. However, in mass customization applications, these components stand out as areas where customers can reflect their preferences. At this point, to understand where these customization processes can be integrated into modular construction production and what they can change, it is necessary to have a clear understanding of the production processes of modular structures.

Modular construction production processes, which are focused on standardization, initially differ from the examples where mass customization applications are observed. However, this difference stems from the modification of some parts of the modular construction production processes in mass customization applications. From this perspective, both production approaches share similar values and processes which highlight the significance of understanding the production in mass construction.

The manufacturing phase in modular construction before the transportation of the units has three stages namely sub-assemblies manufacturing, module assembly, and module completion (Jonsson & Rudberg, 2014). The final product is prototyped before the phase begins, and all information regarding the products that will be manufactured is prepared in advance. That's why the manufacturing process is based more on management rather than research and design. In this instance, there is a decision to be made about the product line based on expectations over performance values, either prioritizing the number of units produced or the level of customization to be provided to the customers. The preferred production line offers different processes and stages, which results in fundamental changes between products.

The production lines for volumetric modular units are often categorized into two systems namely, static, and linear (Lawson et al., 2014). While the static production system needs "… operators move between the designated workstations where the modules to be fitted-out are placed," the linear production system enables the modules to move along the assembly line as it's ubiquitous in other manufacturing industries and plants (Yang, Pan, and Pan, 2017, p.57). Static production systems are characterized by more customization capacity on the line, while linear production is associated with high-volume, standardized products. As a matter of fact, in today's modular structures, particularly in modular housing, most companies offering mass customization services use static production systems, mainly because with these systems higher customization levels can be achieved and it does not require to have high production volumes to operate.

2.2.5 Modular Housing

Modular housing is a type of prefabricated home formed by the repetition of units with the same or different functions, based on a specific size. Although modular homes are often presented today as a new product or a concept of the future, they actually have quite an extensive background. The history of modular homes, which are among the most significant figures in the industrialization of the construction and

architecture sectors, should be considered within the context of “industrial solutions to housing needs” alongside prefabricated and panelized structures.

The first examples of the industrialized solution to housing needs emerged from an urgency seen in the Gold Rush event in today’s United States. The migration of the masses of workers couldn’t be responded related to the considerably slow offerings of construction opportunities at that time, various entrepreneurs stepped up with early examples of prefab dwellings like Manning Portable Colonial Cottage (Cobbers, Oliver, and Gössel, 2010).”

Since the concept of portability became the prominent characteristic within these newly introduced housing solutions, the inclination towards prefabrication as a broader aspect mainly focused on portability leading towards the panelized construction. Although this sudden response played a huge role in the introduction of prefabrication, the faith of the industry has shifted and superficialized in a sense as the world faced many other booming eras of housing needs along with the migration waves because of the terms of industrialization and globalization as well as world wars. Immense interest in urgent housing seeking has shined the relatively newly introduced prefab dwellings. Herein, the example of companies catalogs houses by the time in the U.S. offered by several companies–with Sears Roebuck and Co. in the United States as the foremost manufacturer, accounting for the non-negligible sales figure of 250.000 until 1943 (Kelly, 1951). Portable houses were established as already a healthy business at the turn of the century being highlighted as single-family houses at a competitive price that could instantly fit in with current aesthetic trends (Bergdoll & Christensen, 2008).

While prefabrication of construction was mainly founded on the developing panelized dwellings made from timber at that time as the approach was raised with the colonial style architecture, the further potentials of the prefabrication were also tested. An interesting portfolio of experiments and prototypes from Edison´s poured concrete houses in 1908, Prouve´s panelized houses and bathroom module, Buckminster Fuller’s Wichita House and Deployment Unit, to Gropius and

Wachsmann Packaged House, techniques, and materials equally more and more elaborated. Herein, as a non-architectural attempt at industrialized housing solutions, the American mobile home stepped forward. While they can be regarded as the closest approach to modular volumetric construction of living units, their faith, and impact would become detrimental to the concept. Since they are closely associated with lower-class people, the labeling is easily put on to modular dwellings of any kind in people's minds. Even, they are later named mobile homes to be distinguished from manufactured homes by the H.U.D. (U.S. Department of Housing and Urban Development) code in 1979, the perception is maintained for a long period of time (Ovando-Vacarezza, Lauret-Aguirregabiria, Lirola-Pérez, & Castañeda-Vergara, 2014).

Despite their poor reputation in the U.S. and the U.K., modular homes have become increasingly popular in countries like Japan and Sweden in subsequent years. Looking at current figures, 20% of new homes in Japan are modular, compared to only 6% in the U.S. (McKeever, 2024). Yet, due to the incorporation of mass customization applications in modular housing today, along with their strategy of offering high-quality housing at lower prices, it is predicted that this number will also rise globally.

CHAPTER 3

METHODOLOGY

Within this chapter, the materials and the methodology of the study are elaborated on to outline the design of the research. Under the subject of the materials, the literature review conducted to identify and decide on the adequacy criteria of web-based configurators is mentioned. Then the configurator database is used to search for the detection of currently available web-based modular configurators. Lastly, the participants of the research are interviewed to get feedback on the accuracy of the adequacy criteria identified and the functionality of the choice navigation model proposed. Within the methodology section, the steps and phases followed are discussed in a way that provides a detailed overview of the process carried out in the study.

3.1 Research Material

The materials of this research are the research and studies on the subject of web-based configurators, the Configurator Database and Google Advanced Search used to find available modular house configurators, of which four different examples were identified, interface design application Figma and lastly the participant group of the experiment.

3.1.1 Configurator Database

Within the scope of the research, an open-source search engine called the Configurator Database was used to identify modular house manufacturing companies that currently offer personalization services through web-based configurators. The database was created by the media specialist cyLEDGE Media in

2007 under the name Configurator Database Project to provide practitioners and researchers with an overview of the wide range of existing configurable products which later took its current name. Since then, it has been constantly extended and updated and thus grew to the largest collection of web-based customization tools. Starting with 600 listed companies and configurators, today, the database lists more than 1,400 configurators from varying industries worldwide. As the database aims to provide detailed and qualitative data about these configurators, each of them is listed with a full profile, including a screenshot and a tag showing fundamental criteria like industry, product type, and country which thus provides quick access to the desired examples through search options based on these criteria.

However, even though the annually published database provides an extensive source of information in general, it has some shortcomings that can't be overlooked depending on its update frequency. First, many companies that have ceased their mass customization practices or stopped offering this service through web-based configurators are still listed in the database. Secondly, many companies and configurators have not been detected and listed by the database due to their publishing dates. Herein, to clear up these problems as well as expand the scope, Google Advanced Search is also employed as an auxiliary search engine alongside the Configurator Database.

3.1.2 Interface Design Application

The success of the developed methodology and the framework of features was validated by implementing the choice navigation model in practice and testing it within the scope of the study. For this validation, a web-based configurator was built following this model and presented to participants to gather their feedback. Figma, a cloud-based design and prototyping tool for digital projects, was chosen to build this example. With Figma, which allows for design, prototyping, and developer handoff all within a single tool, there was no need for external coding software.

The configurator developed in this study was built by modifying one of the sample configurators that was highly favored by the participants. To import the sample configurator into the Figma interface to work on, the HTML to Figma plug-in was used. Additionally, Figma's feature of allowing digital projects to be presented without being published enabled the developed model to be shared with participants without encountering any copyright issues within the study.

3.1.3 Participants

The selection of the participants for the in-depth interviews within the research is carried out in line with the suggestions of Tullis and Albert who set the standards for the user experience studies according to many authorities in their book *"Measuring the User Experience"* (2008). Referencing from the publishing, the three main concerns steps forward to address are participants' profiles, numbers, and assortment which also outline the selection criteria and the process. In this regard, initially, a population that would represent the study is selected to fit the use of web-based configurators into a real-life scenario (Sauro & Lewis, 2012). Herein, since mass customization practices aim to reach the widest possible customer base, the configurators are designed and built in line with that purpose. Therefore, it is found more appropriate for the objectives of the research to select participants without being tied to a specific discipline, profession, or academic background. Yet, as participants will be presented with exemplary configurators during the interviews and expected to configure their desired house through these tools, it is looked that the participants have basic knowledge about the "house" as a product; therefore, participants were selected from individuals who have recently moved as tenants/homeowners or renovated their houses.

The number of participants needed for the in-depth interviews emerges as the following important issue, which has already been one of the frequently discussed topics in user experience studies for decades. Over the years, two different camps have emerged on this topic: one believes that 5 users are enough to identify most of

the usability problems, and another believes that this number is nowhere near enough (AlRoobaea & Mayhew, 2014). Although Tullis and Albert also believe that 80% of usability problems can be identified with a sample of 5 users, a more cautious approach has shown that 10 to 12 participants offer a good baseline range for user experience studies (Macefield, 2009). Based on this information and similar studies, the number of participants was decided to be 10 people for the first phase of the interviews aiming to verify the effectiveness of the identified criteria. For the second phase of the interviews, which are done to validate the functionality of the proposed model in practice, this number is reduced to 5 participants randomly selected from the first group. In this case, the reason for the change in the number of interviewees in the second phase is due to two main factors. First, the discussions conducted in the second phase are built on the outcomes of the first phase, which makes it likely that similar and repetitive responses will be encountered during these interviews. As the research methodology does not employ a quantitative approach, these repetitive responses are not necessary to examine. Second, the structure and content of the second phase interviews for functionality validation resemble that of a typical usability interview profile. It is therefore possible to refer to Tullis and Albert's work when performing such a fundamental evaluation of usability. For these reasons, the reduction in the number of interviewees in the second phase is justified.

The last critical issue among these concerns is the assortment of participants, in other words, whether to separate the data by different groups of participants. At this point, it was decided that there is no need to divide participants into subgroups based on any criteria whatsoever since the web-based configurators are specifically designed and introduced as not being professional tools that require prior experience and/or a skillset. Additionally, considering that these tools aim to serve the widest possible range of customers and reach as many people as possible, it was deemed more appropriate to evaluate users with different profiles together.

3.2 Research Methods

The objective of this research is to propose a choice navigation model tailored to the modular house industry consisting of navigation methodology along with a framework illustrating the essential features for configurators. To achieve that, it first identifies a set of adequacy criteria for web-based configurators to offer a satisfactory experience. Then following these criteria, currently available modular house configurators are compared and evaluated by the participants to discuss their shortcomings and strengths which laid the groundwork for the proposal.

The process of the research can be examined under two stages as follows:

- Preliminary Preparation: Finding the Cases,
- Design of the Conduction.

3.2.1 Preliminary Preparation: Finding the Cases

Within the preliminary preparation phase of the research, companies offering mass customization services through web-based configurators were searched to detect the case studies for the subsequent stages. At this stage, through a search conducted on the Configurator Database, which hosts over 1470 configurators provided by cyLEDGE, 40 examples that provide the service for modular homes and their web-based configurators were reached. As a sidenote herein, since the last comprehensive update of the database was in 2022 an extensive search is made through the Google Advanced Search tool to compensate for the shortcoming which eventually adds 6 more firms to the sample set. After 46 total firms were found another filtering process was made to detect the ones that fit into the criteria that outline the intent of the study best, those criteria about the manufacturers are as follows:

a) Provision of Standard Dwellings Rather Than Any Alternative Living Units

Since the scope of the study is focusing on modular homes, firms that provide the mass customization service on any other alternative units, tiny houses being the first

place, were eliminated from the sample set. As the intention behind the design of these is differentiated from the traditional housing units being “a new form of housing intervention”, to not make the research superficial and lose focus; it’s expected from cases to offer modular homes larger than under 400 square feet (37 square meters) and has at least 1 bedroom (Jackson, Callea, Stampar, Sanders, Rios, and Pierce, 2020).

b) Possession of a Solution Space Responding to the Expectations of Customers

As customers' expectations from mass customization will lead to a critique of the service received, configurators are also affected in this regard. Therefore, it’s seen that the potential of the offered customization services and options to meet customers' expectations becomes more of an issue in the determination of the configurators’ adequacy. For the identification of the extent of the customer expectations from both the process and the firms, the works of Pakdil, and Eid Mohamed and Carbone that are mentioned within the literature review are referenced which showed that specific services dealing with different levels of customization are found essential by the customers. Those services are listed in order of priority (from higher level of customization to lower level) as follows:

- Layout,
- External and Internal Finishes,
- Appliances and Systems,
- Fixtures and Furniture.

The firms that are not capable of providing these examples are eliminated from the sample set as they are insufficient to deliver a final product that meets all the expectations and needs.

c) Provision of Software-Wise Sufficiency

As mentioned under the Configurator Database heading, many of the configurators listed in the databases have discontinued software support which caused them to be

found outdated. These configurators were eliminated from the sample set since they have numerous accessibility and usability issues.

As a result of this elimination process, it was found that only 4 firms from the sample set possessed the necessary qualifications to be examined as being the cases within the scope of the study. These firms are listed and their homepages are provided below (Figure 3.1):

- Firm A,
- Firm B,
- Firm C,
- Firm D.

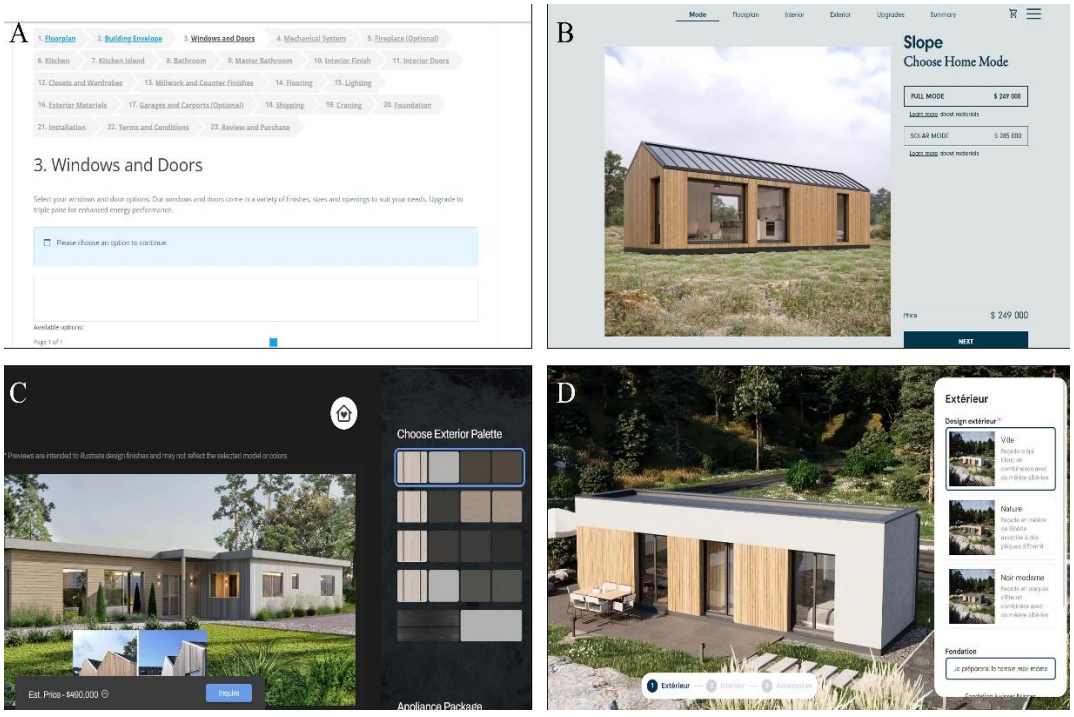

Figure 3.1. The home pages of the web-based configurators found at the end of the elimination process: Firm A (upper left), Firm B (upper right), Firm C (lower left), and lastly, Firm D (lower right) are seen together (URLs 2, 3, 4, & 5)

3.2.2 Design of the Conduction

Within the scope of the research, a three-phase model development methodology which is commonly preferred in exemplary studies is followed (Figure 3.2). These phases are named as the identification of the adequacy criteria of the model to be developed (Identification), verification of the effectiveness of these criteria on the model to be developed (Verification), and validation of the functionality of the model developed based on the verified criteria (Validation).

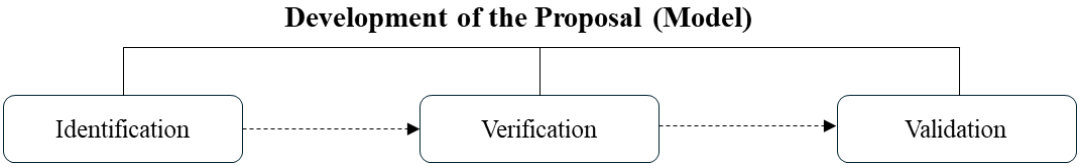

Figure 3.2. The phases in the development of the proposal followed in the Design of the Conduction

First Phase: Identification of the Adequacy Criteria

First of all, to identify the adequacy criteria, the data and conclusions reached by the research and studies analyzed within the literature review section were utilized. Herein, the first study referenced stepped forward as being the one conducted by Zhao, McLoughlin, Adzhiev, and Pasko from Bournemouth University in 2018 named *"3D Mass Customization Toolkits Design, Part I: Survey and an Evaluation Model"*.

For the Online 3D Mass Customization Toolkit Evaluation Model they presented within their study, prominent research on web-based configurators was done to specify the criteria that they need to have to offer a satisfactory experience to users. Herein, although the criteria presented within this study have already undergone a detailed filtration and elimination process to be finalized, these criteria are then reevaluated and filtered within this study for web-based modular home configurators considering this research's objective (Table 3.1).

Table 3.1 The Interaction Design Criteria for Configurators Identified by Zhao et al. (2018)

Interaction Design	Procedure Design	Provide step by step tasks with increasing challenge [28]
		Provide multiple pathways [84]
		Creativity tasks follow flexible design procedure [48]
		Functionality tasks follow top-down hierarchical design approach [47]
	Design Guide	Provide support resources for consumer interaction [28]
		Provide libraries of standard modules [34]
		Provide a preset design at the starting point [34], [65], [32]
		Prioritize the customizable options [31]
	Direct Manipulation	Provide rapid feedback [6]
		Provide direct manipulation on 3D toolkits [28]
	Collaboration Design	Build up collaboration between consumers [65]
		Provide a historical record of work and progress of consumer collaboration [28]
		Provide space for consumers to leave comments [65]

In the identification phase of the research, another prominent study that provided important insights into the criteria of adequacy for web-based configurators was "*Value Creation Through Mass Customization: An Empirical Analysis of the Requisite Strategic Capabilities*" conducted by Thorsten Simon Harzer in 2013. Unlike Zhou et al.'s research mainly founded on an extensive literature review, Harzer's study identifies the features that a configurator needs to possess to provide a good user experience through a field study which eventually reaches a conclusion quite parallel to Zhou et al.'s (Table 3.2).

Table 3.2 The Must Configurator Features Identified by Harzer (2013)

Configurator Features	
Need-based elicitation (NEEDS)	Explanation of product (EXPLAIN)
Default configuration (DEFAULT)	Shortcut to shopping cart (SHORT)
3D view and navigation (3D)	Recommendation following others (PEER)
Visual comparison (COMPARE)	Module pricing (MODPRICE)
Possibility to save (SAVE)	Help function (HELP)

The adequacy criteria for web-based configurators that will offer customization services in modular houses were obtained by combining the results of these two studies and evaluating and revising them according to the focused industry and product, along with the consideration of current technologies (Table 3.3).

Table 3.3 Identified Customer Navigation Adequacy Criteria and Guidelines

Customer Navigation Adequacy Criteria	Procedure Design (a)	1. Step by Step Increase of Challenge in Task 2. Providing Multiple Pathways 3. Following a Flexible Design Procedure 4. Task Following a Top-Down Hierarchy in Significance 5. Showing the Path of Process 6. Any-time Save Possibility 7. Providing an Opportunity for Visual Comparison of Decisions
	Design Guidance (b)	1. Providing a Standard Library Consisting of Modules with Prices 2. Providing a Base / Default Model at the Beginning of the Process 3. Providing Information About the Choices Made 4. Including a Need-Based Elicitation System in the Configurator
	Direct Manipulation (c)	1. Allowing Customers to Manipulate the Model/ Visuals 2. Having a Direct Reflection / Feedback on the Choices
	Collaboration Design (d)	1. Building the Collab System Between the Customers 2. Providing a Record of Work 3. Offering a Recommendation System 4. Providing a Segment to Leave and Review Comments

Second Stage: Verification of the Adequacy Criteria

In the verification phase of the research, firstly, the web-based configurators selected in the preliminary preparation stage were evaluated based on which of the criteria identified in the first stage “Preliminary Preparation” of the study they met to have an initial idea of the success of each example that will be examined. The results are shown below (Table 3.4).

Table 3.4 Evaluation of Currently Available Configurator Following the Criteria

	Firms			
Criteria	*Firm A*	*Firm B*	*Firm C*	*Firm D*
Procedure Design				
a.1	-	+	+	±
a.2	-	±	±	-
a.3	-	±	±	-
a.4	±	+	±	+
a.5	+	±	-	-
a.6	-	-	-	-
a.7	±	±	-	±
Design Guidance				
b.1	+	+	±	-
b.2	+	-	-	-
b.3	+	-	±	+
b.4	-	-	-	-
Direct Manipulation				
c.1	-	±	-	+
c.2	-	-	-	+
Collaboration Design				
d.1	-	-	-	-
d.2	-	-	-	-
d.3	-	-	±	-
d.4	-	-	-	-
Total				
	5	5.5	4	5

In the next step, to verify whether the results and the scores given reflect the experience they provide to the customer, in-depth interviews are designed and conducted face-to-face with 10 individuals. At this point, the primary reason for choosing in-depth interviews as the data collection technique within the scope of this study is the great potential of this method to reveal the experiences, thoughts, and perceptions of the interviewee, to uncover the unknown, and to discover new things (Uslu & Demir, 2023). On this basis, in-depth interviews were selected as the data collection technique for this experience-focused study. In relation to the selection of this technique, the material for verification has been the information derived from the insights provided by the interviewees. During this interview process, participants were first briefed on configurators and customization procedures in general. In this briefing, it was emphasized to the participants that they should focus on the customization experiences offered rather than the product range and variety of options available in the configurators.

Afterward, the configurators were tested by customers in random order, independent of the scores determined at the beginning of the verification phase. After completing the customization process with each configurator, the first four questions listed in the questionnaire were asked, and their answers were noted. At this point, if the answers to the first set of questions did not cover the adequacy criteria, auxiliary questions were asked to deepen the conversation and extend the discussion. Once this process was completed for each configurator, the final two questions, which required participants to provide a collective assessment, were asked (Table 3.5).

Following the interview process, the participant replies are gathered, compiled, and summarized to be presented in tabular format within the research which eases the tracking of the data. The preparation of scoreboards for each configurator based on this data completes the verification phase of the research. The analysis of these tables and scores verifying the developed adequacy criteria of the web-based modular house configurators which also set the ground for the model built upon the investigated criteria is done in the following chapter.

Third Stage: Validation of the Model Developed Following the Adequacy Criteria

In the last phase of the research, a choice navigation model consisting of a methodology and a feature framework has been developed and demonstrated for the adaptation of adequacy criteria identified through literature review and verified with the interviews which aims to increase customer satisfaction with both the process and the final products obtained.

Within this context, in the Discussion and Proposition chapter, insights from the initial interviews were organized to form the above-mentioned theoretical model. To validate this model and conclude the designed research, the proposed choice navigation methodology and feature framework were applied in practice with a developed web-based configurator. Herein for the development, a configurator that had been well-received by participants was used as the foundation and the configurator was developed on that on Figma (Figure 3.3). With the modification made following the findings, the configuration was then presented to the 5 randomly

selected participants from the original group, who were asked to compare it with the original version (Table 3.6). By gathering their feedback, the proposed methodology and feature framework were validated sheerly at the end of the research.

Table 3.5 Interview Questions Asked to the Interviewees in the First Phase

	Interview Questions (1st Phase)
(To be Asked After the Use of Each Configurator)	
Q1	What are the features of the tool that enhanced your customization experience the most about the configurator? Please explain based on your experience.
Q2	What came across as obstacles to having a satisfactory customization experience with the configurator? What solutions can be attempted to resolve these problems?
Q3	Is there a feature in the tool that you like the idea of but find it impractical?
Q4	For a more satisfactory experience and result, what should be added /integrated to the configurator?
Aux.	How would you rate the overall configuration procedure and navigation experience?
	Were you confident in making your choices during the customization process?
	During the customization process, were you assisted by the tool regarding options and steps? If not, did you feel the need for such assistance?
	When the customization process was completed, did you obtain the final product you requested? If not, what were the reasons?
	Do you have any doubts about the aesthetics or usability of the final product? If so, what solutions could address these issues?
(To Be Asked After the Use of All Configurators)	
Q5	Based on your usage experience, can you rank the configurators you tested?
Q6	When the customization process was completed, did you obtain the final product you requested? If not, what were the reasons?

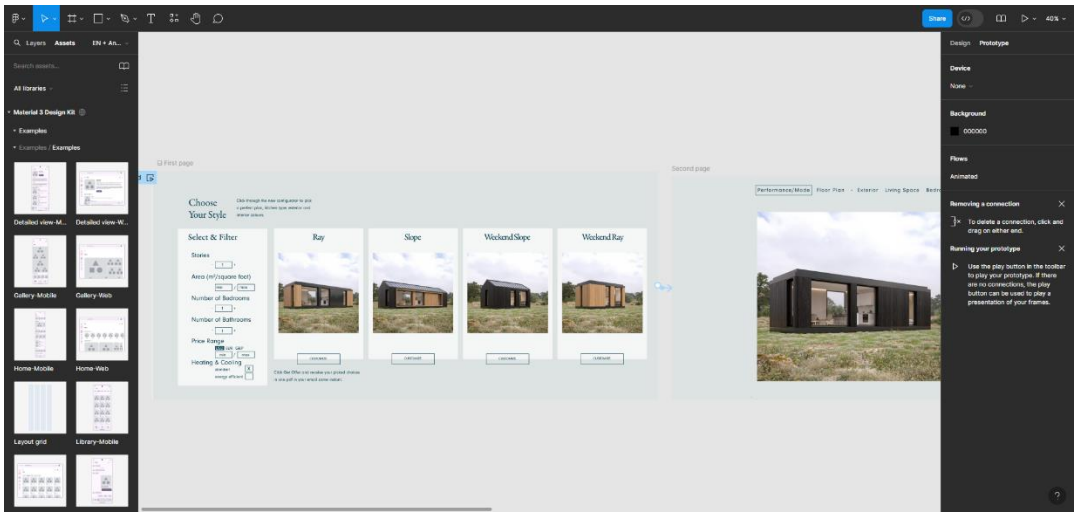

Figure 3.3. The configurator interface developed on Figma (URL-6)

Table 3.6 Interview Questions Asked to the Interviewees in the Second Phase

	Interview Questions (2nd Phase)
(To be Asked After the Use of Both Configurators)	
Q1	Do you think that the experience offered by the configurator this time is different from your first experience? If so, what are the differences?
Q2	What are the features of the newly offered configurator that stand out compared to the original version and which features do you think fall behind?
Q3	Can you compare the experience provided by the new configurator with that of the original version?
Q4	How would you rate your satisfaction with the product obtained at the end of the newly offered configurator, can you compare it with the original version?

CHAPTER 4

FINDINGS

Within the research, a series of interviews were conducted in two phases. In the first phase, interviewees were presented with four web-based modular house configurators that were identified during the "Preliminary Preparation: Finding the Cases" stage. Then they were asked to design a modular house using these configurators as they wished. As participants completed the customization process with each configurator, they were asked to comment on how well these configurators met the identified criteria for adequacy. During these interviews, participants were also encouraged to discuss the aspects of the configurators they found lacking. At the end of the interviews, participants ranked the configurators they experienced from their most to least favorite, and these rankings were noted. Highlights from the participants' reviews were compiled into a table at the end of these interviews. Additionally, scoreboards filled out based on the participants' comments were included in the findings of the first-phase interviews.

For the second phase of interviews, participants' feedback on the configurator built according to the model developed in the study is also presented in this chapter in table form. These tables, like those from the first-phase interviews, include highlights from the participants' reviews.

4.1 First Phase of Interviews

Herein, four tables are provided for each interviewee. The first two tables contain the participant's comments on the configurators, while the third table includes their answers to the wrap-up questions. The final table presents the scoreboards filled out based on their comments.

Table 4.1 Participant #1's Highlights from the Interview (Firms A-B)

p#1	Web-Based Configurator: *Firm A*
Q1	• Although a more detailed customization service was offered, the process was easy to follow. • Pricing was provided for each option, and an overall estimation was calculated during the process.
Q2	• The offered customization path was restrictive and confusing in terms of customization levels and sequence. The orientation between scales was lost in the process. • The modeling and visualization capabilities were limited and almost nonexistent.
Q3	• Visuals for each option and additional content were provided, but they were out of context and not presented holistically. • Information notes were provided, but they were presented after choices were made. • An overview of the final product was provided at the end of the process, but it was complex.
Q4	• The base model and selected options should have been presented in 3D. • Assistance with the procedure and recommendations for the technical components were needed.
p#1	Web-Based Configurator: *Firm B*
Q1	• The procedure design presented in the configurator was very smooth and easy to follow. • The visualizations provided were high-quality and allowed for comparisons between options. • Pricing was provided for each option, and an overall estimation was calculated during the process. • The information provided was sufficient and easy to understand. • The final product overview presented after completion was satisfactory.
Q2	• A strict pathway was chosen in the navigation.
Q3	• Panoramic visuals could have been provided instead of static renderings. • Some of the options were not shown, and there were deficiencies in direct manipulation.
Q4	• 3D navigation capability was not provided.

Table 4.2 Participant #1's Highlights from the Interview (Firms C-D)

p#1	Web-Based Configurator: *Firm C*
Q1	• The navigation design of the configurator is found appropriate for a top-down hierarchy while offering flexibility and a chance to keep track of the process. Owing to the compact design of the procedure, it is necessary to have an assistance or recommendation system. • The synchronization between customization levels and provided visualizations was a strength of the configurator. • The provision of an estimated price depending on the choices was an appreciated feature.
Q2	• Although visualization in a variety is provided, a lack of 3D navigation and direct manipulation was feasible. • The information about the options and their aesthetic and performance-wise impact was not provided. • At the end of the process, the summary of the choices made and the visualization for the final product was expected to be seen.
Q3	• The decision to offer the options as palettes for finishings and fixtures was appreciated.
Q4	• Starting with a base model assigned with the decision on the layout eased the process, yet the manipulations made with the options selected were missing.
p#1	Web-Based Configurator: *Firm D*
Q1	• The visual navigation through the model enhanced the experience most. • The presentation of the configuration options as modules eased the design procedure which also helped to recognize the alterations. • The navigation of the configurator is also designed following the top-down hierarchy, and the options are listed in order of priority.
Q2	• The customization ability was found insufficient due to the extent of the modules provided. Additionally, no information is provided about the content of these modules. • The price estimate was not provided, which meant losing track of the budget. • The configurator does not provide information on which stages the user has completed and at which stage of the process they are. • After the completion of the customization process, an overview was not provided.
Q3	• 3D navigation was satisfactory, yet there was a need for assistance. Herein, information notes were not sufficient to unconfuse the user.
Q4	• There was room for a recommendation system that would at least explain the extent of the option modules.

Table 4.3 Participant #1's Highlights from the Interview (Wrap-Up Questions)

p#1	Wrap-Up Questions
Q5	Firm B > Firm D > Firm C > Firm A
Q6	• When considered independently of the solution space it contains, only Firm B's configurator offered a satisfactory service. However, the following common shortcomings were noticeable in all configurators. • There was not enough visualization, especially 3D navigation should have been provided. • A more detailed customization process was needed; many levels in the customization hierarchy were found superficial. • An easily trackable procedure design –like an improved version of the one in Firm C– was needed. • The options offered should have been placed within the customization level they belonged to, not in the main interface. • There should have been an any-time save option within the tools.

Table 4.4 Scoreboard Prepared Following Participant #1's Feedback

	Firms			
Criteria	*Firm A*	*Firm B*	*Firm C*	*Firm D*
Procedure Design				
a.1	-	+	-	±
a.2	-	-	±	-
a.3	-	-	-	-
a.4	-	+	-	+
a.5	+	+	-	-
a.6	-	-	-	-
a.7	-	+	±	±
Design Guidance				
b.1	+	+	+	±
b.2	±	-	+	-
b.3	±	-	±	+
b.4	-	-	-	-
Direct Manipulation				
c.1	-	+	±	+
c.2	-	-	-	+
Collaboration Design				
d.1	-	-	-	-
d.2	+	+	+	-
d.3	-	-	-	-
d.4	-	-	-	-
Total				
	4	7	5	5.5

Table 4.5 Participant #2's Highlights from the Interview (Firms A-B)

p#2	Web-Based Configurator: *Firm A*
Q1	• Offering the customization service in detail from higher levels to lower differentiated the configurator from the others. • The additional catalogs and videos provided enhanced the experience. • Comprehensive information was shared about the presented options throughout the process.
Q2	• The customization process was found to be quite dull, and hard to focus on and integrate. • Even optional stages seen in the menu could not be skipped due to the strict path provided. • The provided information and the summary of the product were hard to understand. • The process felt more like construction rather than configuration since there was no sensible starting point for the design.
Q3	• There was a chance to compare the alternatives through visuals, yet the experience was not satisfactory with the visualizations provided.
Q4	• A further guidance system could be integrated as it would make a difference in making decisions, especially about performance and technical issues.
p#2	Web-Based Configurator: *Firm B*
Q1	• The navigation scheme offered by the tool, as well as the created interface, were quite satisfactory in the mean of procedure design. • The information provided was presented at the right place and right amount. • The summary provided at the end of the process was comprehensive and sufficient. • The inclusion of the prices and the price estimation were also among the appreciated features.
Q2	• (-)
Q3	• The renderings were high-quality, giving the opportunity to see the changes, yet the provision of an extensive set of them showing the interior and exterior of the home in more detail would be better.
Q4	• 3D model navigation with a similar quality in rendering would enhance the experience for sure. • Integrating a menu showing all decisions made throughout the configuration process would be beneficial.

Table 4.6 Participant #2's Highlights from the Interview (Firms C-D)

p#2	Web-Based Configurator: *Firm C*
Q1	• The first thing that stepped forward was the success of overall navigation and the synchronization between the menu and the interface which facilitated the easy following of the processes. • The display of the estimated price in a pop-up panel during the configuration process was an appreciated feature. • The ability to create profiles on the site and save designs were among the strong points of the case.
Q2	• The visualization capabilities of the configurator were limited. The impact of decisions on the visuals was insufficient. • The layouts were not well explained, which confused the very early stage of the process. • The final look of the product was not provided, which the participant wanted to have before the decision. • The completed steps in the process were not displayed even though it didn't complicate things much.
Q3	• The provided information boxes were well thought out, yet the information presented was insufficient.
Q4	• Different numbers of options were offered among the layouts; expanding the alternative range would be good. • Adding panoramic views or a 3D model would be beneficial for the visualization of the product.
p#2	Web-Based Configurator: *Firm D*
Q1	• Providing a gallery of applications' photos consolidated the realism of the product configured. • The 3D model synchronized free navigation and the ability for instant visualization manipulation were found satisfactory. • Explaining the presented options through info texts which also provides recommendations to support the interactive experience.
Q2	• There were some problems in the flow while transitioning from layout to lower-level customization services in the process. • The contents of the packages/palettes were too extensive which interfered with the desired detailed design approach.
Q3	• Texts were provided to explain the alternative packages and palettes, yet the way of presentation was not satisfactory.
Q4	• Price estimation was not provided in any way or form throughout the whole process, and it needed to be added. • Presenting a summary at the end of the process is a must as it could wrap up the design process.

Table 4.7 Participant #2's Highlights from the Interview (Wrap-Up Questions)

p#2	Wrap-Up Questions
Q5	Firm B > Firm D > Firm C > Firm A
Q6	• Considering the processes provided by the configurators, the only one that truly met expectations was the one offered by Firm B. • Most of the configurators, including Firm B at times, suffered from insufficient visualization. There should be more visualizations provided in each configurator. • Most configurators lacked any kind of recommendation tool, which could have made the process easier. • Although Firm D's example offered successful visualization and direct manipulation, it did not provide a genuine customization service due to its extensive palette and packages. • The ability to create profiles and save models, as seen in Firm C's example, should have been offered by all configurators.

Table 4.8 Scoreboard Prepared Following Participant #2's Feedback

	Firms			
Criteria	*Firm A*	*Firm B*	*Firm C*	*Firm D*
Procedure Design				
a.1	-	+	+	±
a.2	-	±	+	+
a.3	-	±	+	+
a.4	+	+	-	±
a.5	+	+	-	-
a.6	-	-	-	-
a.7	±	+	±	±
Design Guidance				
b.1	+	+	+	±
b.2	±	-	+	-
b.3	+	+	±	+
b.4	-	-	-	-
Direct Manipulation				
c.1	-	±	±	+
c.2	-	+	-	+
Collaboration Design				
d.1	-	-	-	-
d.2	+	+	+	-
d.3	-	-	-	-
d.4	-	-	-	-
Total				
	6	9.5	7.5	7

Table 4.9 Participant #3's Highlights from the Interview (Firms A-B)

p#3	Web-Based Configurator: *Firm A*
Q1	• Sharing the catalog at the first stage of the process stood out as both a professional and more inclusive element. • The offered customization process was quite detailed and extensive, yet it was surprisingly easy to follow.
Q2	• There were too many stages almost randomly placed to complete and decisions to make, most of which were a waste of time; and due to that, the experience was found to be challenging and hard to complete. • Navigating between options and stages was difficult, and the provided path was very strict. • The visuals provided were not sufficient.
Q3	• Recommendations were offered through info boxes, but they were far from being comprehensive. • Visuals were provided to facilitate comparison between alternatives, but as they were regular catalog pictures, they did not give enough information about the selection.
Q4	• A panel showing the price estimation and selected options throughout the process would be better. • Being aware of what standard options entail and how they look at the beginning could have made this detailed customization process easier.
p#3	Web-Based Configurator: *Firm B*
Q1	• The navigation scheme offered by the tool was considered flexible, enjoyable, and inviting in general by creating and maintaining a flow. • The configurator's responsiveness was much higher than the previous. • The display of price estimation throughout the process was a notable feature. • The information provided with each option was one of the components elevating the experience considering the other examples.
Q2	• It would be better to categorize and thus organize the upgrade section of the configurator in some way.
Q3	• The overview presented at the beginning and the end was satisfactory with the given information, but it could be further improved with the visualizations. • Although the visualization was generally quite successful in terms of, there were some deficiencies in some stages and options.
Q4	• 3D model navigation with a similar quality in rendering would enhance the experience.

Table 4.10 Participant #3's Highlights from the Interview (Firms C-D)

p#3	Web-Based Configurator: *Firm C*
Q1	• The overview screen presented at the beginning, the sliding menu promoting enjoyable navigation, and the price estimation pop-up were among the successful features. • Progressing through the process was quite easy; there was coherence and logic between the stages, yet the "you're here" info was not given.
Q2	• The visualizations provided in the exterior and interior palettes did not reflect the preferences. • The process did not offer a comprehensive customization experience, and the number of options given was found to be particularly limited.
Q3	• The additional information provided regarding appliances and finishings was quite useful, and it would be good to offer the same service for the fixture options as well. • Offering customization services with palettes and packages made the process easier, but giving the customer more decision power within these options would be better.
Q4	• A summary should either be presented as a separate page, or the overview interface should be updated with the selections and presented at the end of the process.
p#3	Web-Based Configurator: *Firm D*
Q1	• It was quite an enjoyable configurator in terms of interface, which enabled users to freely navigate the stages as well as the model. • Seeing the reflections of the selections on the product was easy and enjoyable.
Q2	• The configurator had both a sliding interface and different stages combined in this navigation scheme which reduced the traceability of the process. • It was not entirely clear what the standard model was and what it looked like, so the differences made by the choices were not fully reflected and comprehended.
Q3	• Information notes were provided to explain the packages, but they were insufficient. The provision of further information could be useful herein.
Q4	• Price estimation and the summary of the product were not provided in any way.

Table 4.11 Participant #3's Highlights from the Interview (Wrap-Up Questions)

p#3	Wrap-Up Questions
Q5	Firm B > Firm C > Firm D > Firm A
Q6	• There was no issue with Firm B delivering the requested product; the configurator provided was both enjoyable and successful. • Firm D's configurator was advanced in terms of capabilities, but it had problems related to the base model and the alternatives offered. By adopting a more conventional scheme and interface, like those in other configurators, these issues could have been overcome. • The other tools used were weak in many aspects and had significant deficiencies in both the final product and process presentation. Generally, to be satisfied with the process and the final product designed, more visualization and information needed to be provided. • Even though it had a poor presentation, using a scheme like the one offered by Firm A could have increased the satisfaction with the final product.

Table 4.12 Scoreboard Prepared Following Participant #3's Feedback

	Firms			
Criteria	*Firm A*	*Firm B*	*Firm C*	*Firm D*
Procedure Design				
a.1	+	+	+	±
a.2	-	+	±	+
a.3	-	+	±	+
a.4	-	+	+	+
a.5	+	-	-	-
a.6	-	-	-	-
a.7	-	+	-	±
Design Guidance				
b.1	±	+	±	-
b.2	±	±	-	±
b.3	±	+	±	±
b.4	-	-	-	-
Direct Manipulation				
c.1	-	±	-	+
c.2	-	±	-	+
Collaboration Design				
d.1	-	-	-	-
d.2	+	+	-	-
d.3	±	-	-	-
d.4	-	-	-	-
Total				
	5	9.5	4	7

Table 4.13 Participant #4's Highlights from the Interview (Firms A-B)

p#4	Web-Based Configurator: *Firm A*
Q1	• The prices and features of each option were clearly explained.
Q2	• Showing all the processes to be completed at the very beginning on the main screen was found to be intimidating. • The path provided was quite strict, even though you could go back and forth, the optional stages couldn't be skipped. • There were significant shortcomings in visualization, sample images were provided, yet comprehensive visuals showing both the exterior and interior were needed. • Completing the process was exhausting, and many choices had to be made at various stages unconsciously just to finish the process. • Due to the length of the process, the choices made were forgotten in the later stages.
Q3	• The overview provided at the final step was detailed and satisfactory, but it would have been much better if it had been presented more compactly, including the visuals of the final product. • The process gave me the feeling of designing from scratch, which was also intimidating in this respect.
Q4	• It would have been better if the system could have made suggestions.
p#4	Web-Based Configurator: *Firm B*
Q1	• Tracking and completing the configuration process was considerably easy and enjoyable. • There were no steps in the sequence of stages that caused confusion or disrupted the flow of the process. • Owing to the menu design within the configurator, the progress could be easily tracked. • The overall quality of the images provided was high and the changes made can be noticed easily in the images.
Q2	• (-)
Q3	• The necessary information for users was sufficiently provided in the configuration process, but it was tedious to look for and check the information boxes each time. • It was good that the upgrades were presented all together, but these options could have been further classified and supported with more visuals.
Q4	• The visuals were fine, but the experience could be further improved with a 3D model.

Table 4.14 Participant #4's Highlights from the Interview (Firms C-D)

p#4	Web-Based Configurator: *Firm C*
Q1	• The sequencing and presentation of the stages offered in the process were successful. It was also easy to track which stage you were in within the configuration process. • The defaults presented in the first stage allowed for a general insight into the process and the product.
Q2	• Although the navigation in the configurator was easy and the process straightforward, it did not give the feeling of ending up with a completed product in the end. • While the sliding navigation theme design was fun, but not functional. • Many options presented in the configurator weren't visually supported. • There were significant differences and inconsistencies between the options seen in the configurator interface and their visualizations. • No clear information or graphics were informing about where the process started and where it ended.
Q3	• The inquiry pop-up contained important information like a summary and estimated price, but lack of visualization. • The information provided in the tool for the options was not sufficient.
Q4	• It would have been much more appropriate for the visualizations to synchronize with alternatives rather than stages.
p#4	Web-Based Configurator: *Firm D*
Q1	• The navigation construct presented in the configurator was simple and easy to follow. • The interface presented was enjoyable and easy to complete from start to finish.
Q2	• There was no information about prices provided in the interface. Even in the final stage, there was not a summary showing the final price. • There was a sense of incompleteness because no summary was presented at the end, and the model could not be differentiated much from its default settings. • The information texts presented on the interface were not informative but more descriptive.
Q3	• The model presented in the configurator was of high quality and a top-level component, but there were some shortcomings in showing the choices made.
Q4	• Showing the effects of the options on the design in the model was particularly good but searching for these in the model made things difficult; a highlighting mechanism would make things easier.

Table 4.15 Participant #4's Highlights from the Interview (Wrap-Up Questions)

p#4	Wrap-Up Questions
Q5	Firm B > Firm D > Firm C > Firm A
Q6	• The products designed using the configurators offered by Firm D and Firm B resulted in satisfying outcomes. However, the performance data of the products offered by both companies was not accessible; more information could have covered this deficiency. • Additionally, Firm D should have provided information about the final product; without a summary, it felt no different from a game. There was no sense that it was a purchasable product. • In this regard, Firm A provided information on everything, but insufficient visualization was a significant problem herein. • Using Firm C's configurator was relatively enjoyable, but there was no insight into the final product, leading to issues with reality. • Overall, there was a need for a sales simulation; in their current state, most of the configurators could only be used as informational tools.

Table 4.16 Scoreboard Prepared Following Participant #4's Feedback

	Firms			
Criteria	*Firm A*	*Firm B*	*Firm C*	*Firm D*
Procedure Design				
a.1	-	+	+	+
a.2	-	+	+	+
a.3	-	+	±	+
a.4	-	+	+	+
a.5	+	-	-	-
a.6	-	-	-	-
a.7	±	+	-	±
Design Guidance				
b.1	±	+	+	-
b.2	-	±	+	±
b.3	±	±	±	-
b.4	-	-	-	-
Direct Manipulation				
c.1	±	±	-	+
c.2	-	+	-	+
Collaboration Design				
d.1	-	-	-	-
d.2	+	+	-	-
d.3	-	-	-	±
d.4	-	-	-	-
Total				
	4	9.5	6	7.5

Table 4.17 Participant #5's Highlights from the Interview (Firms A-B)

p#5	Web-Based Configurator: *Firm A*
Q1	• The ability to design the offered product (house) in detail was the correct way of doing it. • The overview presented at the end of the process showed every choice and service in detail with their costs. • The configurator gave the feeling of designing the house from scratch.
Q2	• Such a detailed customization service process should have had a more understandable and easily navigable scheme. • The number of options offered was quite few compared to the stages. • Visuals felt randomly placed, with no sense of belonging to the project.
Q3	• Presenting the visuals of the options separately allowed for visual comparison but did not provide sufficient information. • The information texts were given in detail but lacked an inviting presentation. • The process tracking bar at the top was well thought out, but showing what decisions were made under that heading would have been better. • The total price was visible in the final stage, but a pop-up that allowed tracking it throughout the process would have been better.
Q4	• More interactive components that assist in decision-making could have been used for this configurator.
p#5	Web-Based Configurator: *Firm B*
Q1	• The menu and interface offered by the configurator were enjoyable and could be completed without any confusion. • The sequencing of the stages was logical and as it should be. • The design experience presented on images and visuals was quite straightforward. • Tracking and completing the configuration process was enjoyable and easy.
Q2	• It was not logical to present completely different products under the upgrades, and there was also a lack of information about many of these options.
Q3	• Although the visualizations were carefully prepared and presented, they were lacking in important elements such as the floor. • Although the summary at the end was quite explanatory and satisfactory, presenting the final product's visual would be good, even necessary.
Q4	• Presenting a 3D model with this rendering quality could elevate the experience to a higher level.

Table 4.18 Participant #5's Highlights from the Interview (Firms C-D)

p#5	Web-Based Configurator: *Firm C*
Q1	• The personalization process could be easily tracked through the menu. • The stages and options could be navigated freely, and the process could be completed and saved at any time. • The costs of each option were presented on the interface, and the total price could be tracked at every stage.
Q2	• No visual of the final product was presented at the end of the process. • The visuals presented on the interface were taken from any sample, independent of the selected layout or other options, providing an insufficient visual experience. • There was no information explaining the purpose of the selected extras or the differences they would create. • Some important stages and components were incorrectly presented, and confusing, for example, the inquiry pop-up.
Q3	• Although the inquiry pop-up contained important information such as the summary and estimated price, it lacked visualization.
Q4	• The presence of a 3D model in this type of example would make a big difference in enhancing the experience of the process.
	Web-Based Configurator: *Firm D*
Q1	• Focusing the configuration process on the model rather than the navigation scheme made the process more enjoyable and easier to follow. • It was easy to navigate through the process in the configurator. • The fact that the interventions made could be seen very clearly kept the interest in the process always high.
Q2	• The information provided about the preferences was not satisfactory. • The option packages presented seemed comprehensive, but there was no information about their content. • No price estimation information was provided in any way. • Navigation within the model was more complicated compared to the process.
Q3	• The way information and recommendations were presented in the configurator was quite good, but they were not sufficient.
Q4	• An overview or summary should have been presented at the end of the process.

Table 4.19 Participant #5's Highlights from the Interview (Wrap-Up Questions)

p#5	Wrap-Up Questions
Q5	Firm B > Firm D > Firm C > Firm A
Q6	• Among the configurators, Firm A's example, despite being the least successful, provided the most realistic experience. Although the design phase wasn't enjoyable, the ability to make decisions on all aspects and get to know the product from every angle was the biggest advantage. • Firm B's configurator was more successful than the other examples, but presenting the product only visually was insufficient for a home-buying process. This product might have been considered for purchase as a hobby house. • The configurators offered by Firm C and Firm D could be used as supporting features in the purchasing process, but making a purchase through these tools alone was not very realistic. • Firm D's failure to provide any price or information about the home through the configurator and the absence of a summary at the final stage harmed the sense of completeness of the final product.

Table 4.20 Scoreboard Prepared Following Participant #5's Feedback

	Firms			
Criteria	*Firm A*	*Firm B*	*Firm C*	*Firm D*
Procedure Design				
a.1	-	+	+	+
a.2	-	+	+	+
a.3	-	+	±	+
a.4	-	+	+	+
a.5	+	-	+	-
a.6	-	-	+	-
a.7	±	+	-	+
Design Guidance				
b.1	±	±	+	-
b.2	-	-	+	-
b.3	+	+	-	-
b.4	-	-	-	-
Direct Manipulation				
c.1	±	±	-	+
c.2	-	±	-	+
Collaboration Design				
d.1	-	-	-	-
d.2	+	+	±	-
d.3	-	-	-	±
d.4	-	-	-	-
Total				
	4.5	8.5	8	7.5

Table 4.21 Participant #6's Highlights from the Interview (Firms A-B)

p#6	Web-Based Configurator: *Firm A*
Q1	• The process provided a very detailed design opportunity, positively affecting the realism of the product to be obtained. • It was good that the completed stages were clearly shown in the menu during the process. • The summary provided was comprehensive and successful in general.
Q2	• There was a problem with the navigation scheme, especially felt during transitions between different stages. • Overall, the visualization choice provided by the configurator was not right, and the quality of the visuals was also low. • Due to the inadequate visualization, it was not possible to see how the selected options made a difference.
Q3	• There were many layout options presented in the configurator, but it was hard to understand the differences between the options. • Very detailed explanatory texts about the products and services were provided, but they were not catchy or engaging.
Q4	• A set of visualizations of the standard model could have been presented as the origin of the process.
p#6	Web-Based Configurator: *Firm B*
Q1	• Navigation of the configurator was easy and engaging. • The transitions between stages created a flow, and there was no sense of getting lost in the process. • During the personalization process, stages could be easily navigated without any loss of information. • The options presented in the interface were well-explained and presented. • The summary provided at the last stage was explanatory and sufficient.
Q2	• (-)
Q3	• Although the visualizations were of high quality, they did not reflect a comprehensive change according to the choices, giving the impression that they were sample images. • The initial lay-out choice also provided the defaults, but it was not feasible after that stage.
Q4	• Presenting a 3D model with this render quality could elevate the experience to a higher level.

Table 4.22 Participant #6's Highlights from the Interview (Firms C-D)

p#6	Web-Based Configurator: *Firm C*
Q1	• Showing a completed project was a big plus. • The search panel presented in the layout section was a liked feature, even though it could not fully fulfill its function due to the few options provided. • Being able to create profiles and save favorite models on the site were other good features. • Navigation within the menu was quite simple and enjoyable.
Q2	• There were significant deficiencies in visualizations, and they were quite noticeable. • Alternatives were presented as packages and palettes, but they were neither visualized nor often explained.
Q3	• The synchronization of the menu and visuals was a cleverly thought-out feature, but due to the deficiencies in visualization, it did not provide a satisfactory experience. • The configurator gave the feeling of designing from scratch, but this reduced the realism of the product due to the limited visualization offered.
Q4	• A summary screen should have been positioned at the end of the process, clearly showing the visuals of the final product.
p#6	Web-Based Configurator: *Firm D*
Q1	• Presenting the product as a detailed model and visualizing it with a setting was a very nice feature. • Every choice made during the process could be reflected in the model. • Having a starting model encouraged trying out the options.
Q2	• Navigating within the model presented was difficult. • Although the process tracking was easy, it was not clear what decisions were made at the stages and what exactly these decisions changed overall. • No price estimation information was provided in any way.
Q3	• The visualizations of the design option packages presented were done very well, but information should have been provided on what changed, or the changing components in the model should have been highlighted.
Q4	• An overview or summary should have been presented at the end of the process.

Table 4.23 Participant #6's Highlights from the Interview (Wrap-Up Questions)

p#6	Wrap-Up Questions
Q5	Firm D > Firm B > Firm C > Firm A
Q6	• Among the configurators, only the product offered by Firm B allowed the differences created by personalization to be seen and felt. For this reason, the final product was satisfying. • The detailed design process provided by Firm A was cleverly thought out and might even have been the path to follow, but it couldn't reach its potential due to a poorly designed process. • The experience offered by Firm D was quite enjoyable, but it felt more like a game. Since personalization could be done through very few choices, the final product, although it looked beautiful, did not feel personal. • The interface of Firm C's configurator was innovative, making the product design process enjoyable, but since neither what the product would look like was shown nor could it be personalized through many options, the final product didn't feel truly designed.

Table 4.24 Scoreboard Prepared Following Participant #6's Feedback

	Firms			
Criteria	*Firm A*	*Firm B*	*Firm C*	*Firm D*
Procedure Design				
a.1	-	+	+	+
a.2	-	+	+	+
a.3	-	+	±	+
a.4	-	+	+	+
a.5	+	-	-	-
a.6	-	-	+	-
a.7	-	±	-	+
Design Guidance				
b.1	+	±	+	-
b.2	-	±	+	+
b.3	+	+	-	-
b.4	-	-	-	-
Direct Manipulation				
c.1	-	±	-	+
c.2	-	±	-	+
Collaboration Design				
d.1	-	-	-	-
d.2	+	+	±	-
d.3	-	-	-	-
d.4	-	-	-	-
Total				
	4	8.5	7	8

Table 4.25 Participant #7's Highlights from the Interview (Firms A-B)

p#7	Web-Based Configurator: *Firm A*
Q1	• Having a chat box in the configurator was one of its good features. • Showing the options with sample pictures allowed for comparisons. • Indicating the prices and providing information about all options were other good features. • Providing the dimensions of the options was an important detail. • The navigation construct was quite straightforward and easy. • Seeing which stages were completed through a bar was a cleverly thought-out feature for this tool that offered long personalization.
Q2	• The personalization process was difficult to complete. • Although the sample visuals allowed for comparisons, they did not provide any information about what the final product would look like.
Q3	• It would have been much better if the stages without options were skipped and presented later in the summary. • The detailed summary provided did not include a visual of the final product.
Q4	• There was no noticeable base model, having one would facilitate the visualization of the process and the navigation on the menu.
p#7	Web-Based Configurator: *Firm B*
Q1	• The stages presented within the process were not irrelevant; there was no feeling of disconnection or getting away from the process. • The options were well-explained, providing both technical and informative details. • Although sufficient visuals for visual comparison were provided for most stages, there were some overlooked parts that were noticeable. • Making various changes over a pre-designed template made the process easier to follow and complete. • Thanks to the provided information and visuals, it was quite easy to create the most liked scenario among all options.
Q2	• (-)
Q3	• The solar and full models presented as the first option could have been included among the upgrades instead of being a separate stage. • It was not possible to see other rooms in the navigation. • The summary at the end wrapped up the information provided in the interface well, but the lack of visuals was a noticeable shortcoming.
Q4	• Having a chat box available during the configurator's use would have brought more confidence to the process.

Table 4.26 Participant #7's Highlights from the Interview (Firms C-D)

p#7	Web-Based Configurator: *Firm C*
Q1	• The sliding menu made the design process simpler and easier to complete.
Q2	• Options like faucets, where the changes were not very noticeable, were presented, but less personalization was allowed for more important areas such as the exterior and interior. • Not enough visuals were provided, requiring some imagination for the final state of the house. • The inability to simulate the options on the visual was a major shortcoming. • No information or visuals were provided about what the final product would look like from the outside. • Presenting the summary of the configurator as a pop-up was not a good choice. • Providing this tool with a chat box would improve the experience.
Q3	• It was annoying that the menu could be scrolled down while the rendering part was fixed. • There was a sense of having a standard model, but if the provided visuals did belong to that model, it would be much better.
Q4	• Showing a floor plan during the process would have been better. • Providing a 3D model would solve many of the mentioned problems.
p#7	Web-Based Configurator: *Firm D*
Q1	• The configurator made technical recommendations, which were important for someone without knowledge. • The navigation scheme and setup presented on the configurator were very good. There was a flow that was enjoyable to complete, easy to follow, and direct. • Starting the process with a model having default settings was a feature that encouraged trying all the options in the later stages and positively impacted the experience.
Q2	• (-)
Q3	• Although many options and upgrades were provided and added visually, there was no information about these elements, and their prices were not shared.
Q4	• The experience gained was better thanks to the detailed model with good visualization instead of just visuals.

Table 4.27 Participant #7's Highlights from the Interview (Wrap-Up Questions)

p#7	Wrap-Up Questions
Q5	Firm A > Firm B > Firm D > Firm C
Q6	• The configurator offered by Firm A provided a realistic configuration process tailored to needs. This tool, which was quite detailed and offered assistance within the system, was the most functional example in these aspects. • The examples from Firm B and Firm D also allowed for the design of the desired product and even provided more visual information about the final product, but more information about the final product was needed. In particular, Firm D's configurator had many shortcomings in this regard. • Firm C's configurator was not well-received; the tool had many deficiencies, most of which were major, so the final product designed through this configurator did not meet expectations.

Table 4.28 Scoreboard Prepared Following Participant #7's Feedback

	Firms			
Criteria	*Firm A*	*Firm B*	*Firm C*	*Firm D*
Procedure Design				
a.1	+	+	-	+
a.2	-	+	+	+
a.3	-	+	+	+
a.4	-	±	+	+
a.5	+	-	-	-
a.6	-	-	+	-
a.7	+	+	-	+
Design Guidance				
b.1	+	±	+	-
b.2	-	±	±	+
b.3	+	+	-	-
b.4	-	-	-	-
Direct Manipulation				
c.1	+	+	-	+
c.2	-	+	-	+
Collaboration Design				
d.1	-	-	-	-
d.2	+	±	±	-
d.3	-	-	-	+
d.4	-	-	-	-
Total				
	7	9	6	9

Table 4.29 Participant #8's Highlights from the Interview (Firms A-B)

p#8	Web-Based Configurator: *Firm A*
Q1	• The summary presented at the end listed all the preferences with their prices in detail.
Q2	• The visuals provided in the configurator looked more like a photo archive of mood images rather than belonging to the product. • The number of stages was almost more than the number of options, which was an odd choice for the configurator feature. Despite so many steps, not being able to make very different changes from the initial model was a drawback. • Although the process was not difficult, it was boring mainly due to the scarcity and poor quality of the visuals. • Although example photos and texture maps of the visuals were provided, there was no real visualization.
Q3	• The process could be easily tracked on the menu, but unrelated topics were presented as more important in terms of the sequence of stages. • Although comparisons could be made on the example photos, there was no information on the overall impression of the house. • The information about the options was shown after the selection was made; it would have made much more sense to show it beforehand.
Q4	• Including a system that suggested options better suited to the needs of a customer without any information could have been a good idea.
p#8	Web-Based Configurator: *Firm B*
Q1	• The order of configuration stages presented in the configurator and the ability to navigate between these stages was good. • Proceeding with the design over a default setting encouraged budget tracking and testing among alternatives. • Mentioning the construction process in the summary was a nice detail.
Q2	• Generally, fewer options were presented, offering more options could have led to a more qualified design process. • The visuals of the upgrades were not provided. • Info boxes were hard to notice, especially at the beginning of the process; a pop-up that opened when approaching could have been better.
Q3	• Although almost all options were presented with visuals, seeing the visuals of two different options side by side in some stages could have provided a better visual comparison.
Q4	• Having a chat box available during the configurator's use would have brought more confidence to the process.

Table 4.30 Participant #8's Highlights from the Interview (Firms C-D)

p#8	Web-Based Configurator: *Firm C*
Q1	• As it had a simple interface, the process could be easily followed, and navigation within the menu was effortless. • The ability to filter standard models through the search box at the beginning of the process was a very good feature.
Q2	• Overall, the configuration interface was very generic both in terms of visuals and design. • The visualizations were not of the selected layout; random visuals were used for reference, which neither allowed for comparison nor provided a good experience of the process. • There was no satisfactory summary of the designed product at the end of the process. • There was clear confusion about where the process started and ended.
Q3	• Information about pricing was well provided, but there were deficiencies in the information about the packages and pallets offered. • The pop-up showing the price, and the summary was confused with the "accept cookies" pop-up.
Q4	• Adding high-quality renderings or a 3D model would be beneficial.
p#8	Web-Based Configurator: *Firm D*
Q1	• Some options provided in the configurator were especially recommended on the system for technical topics, which was a feature that cleared up confusion in those areas.
Q2	• Comparison between option packages was limited as navigation within the model was restricted. • The packages offered made too many changes rigidly. It felt like selecting among standard models. • Although the navigation of the design process was enjoyable and easy, navigating within the model was confusing.
Q3	• The reflections of the choices on the model were almost entirely made, but it was difficult to track where and how the changes were made. • A few descriptive sentences were provided under each option on the interface, but they did not include important information like prices. • The final product was shown, but no page or menu was providing important information like measurements and budget.
Q4	• Presentation of a summary along with the estimated overall price would have responded to many of the concerns.

Table 4.31 Participant #8's Highlights from the Interview (Wrap-Up Questions)

p#8	Wrap-Up Questions
Q5	Firm B > Firm D > Firm A > Firm C
Q6	• There was a clear difference in quality among the configurators offered. Designing through the configurators provided by Firm B and Firm D was much easier. Although the final products could be designed to fully reflect the requirements, Firm D's configurator limited you to choose from just three options due to the restricted alternatives offered. In this sense, Firm B's configurator was much better. • Although Firm A's configurator offered many alternatives, they couldn't be fully visualized, leading to doubts about the final product. Additionally, in certain areas, the advice of an expert was needed. • Firm C's configurator had many problems; although the interface was enjoyable, there were significant issues with all the other features. As a result, it was not possible to personalize the desired home using this configurator.

Table 4.32 Scoreboard Prepared Following Participant #8's Feedback

	Firms			
Criteria	*Firm A*	*Firm B*	*Firm C*	*Firm D*
Procedure Design				
a.1	+	+	+	+
a.2	-	+	+	+
a.3	-	+	+	+
a.4	-	±	-	+
a.5	+	-	-	-
a.6	-	-	+	-
a.7	-	+	-	±
Design Guidance				
b.1	+	+	+	-
b.2	-	±	-	+
b.3	+	+	±	±
b.4	-	-	-	-
Direct Manipulation				
c.1	-	+	-	+
c.2	-	±	-	+
Collaboration Design				
d.1	-	-	-	-
d.2	+	+	±	-
d.3	-	-	-	±
d.4	-	-	-	-
Total				
	5	9.5	6	8.5

Table 4.33 Participant #9's Highlights from the Interview (Firms A-B)

p#9	Web-Based Configurator: *Firm A*
Q1	• Although the menu was very crowded and the process was boring, tracking the design process was easy. • Each option's prices and features were clearly explained.
Q2	• Various steps were presented as options but could not be skipped; in some stages, selections had to be made even when there was no option. • There was confusion about what difference would occur when the initial settings presented were changed.
Q3	• There was an opportunity to make comparisons on the visuals, but it did not provide sufficient experience overall.
Q4	• The presence of a 3D model could have been a significant advantage at this point because many photos presented in the visuals were samples and did not fully reflect the choices made. • Topics like technical issues could be guided by the computer, and the accessories sections could be presented instead of separate headings, leading to a much smoother process. • The summary screen could have been presented in a more organized manner and perhaps briefly explained with highlighted information.
p#9	Web-Based Configurator: *Firm B*
Q1	• The provided summary screen had sufficient information and was genuinely presented as a summary; it could have been perfect with an additional visual showing the exterior. • Seeing the results of the changes and decisions made through visuals was a significant plus. • Although there were minor visualization inadequacies in some headings, these deficiencies compensated for the provided information. • Tracking the process was generally easy; the determined scheme and the stages followed were logically structured.
Q2	• The scheme and standards of the presented model sometimes hindered the full expression of needs. • One of the other negative aspects was the limited number of options, especially under certain stages.
Q3	• Although working with the model was enjoyable, some stages had illogically lined up.
Q4	• Always showing the plan during the process would have allowed for tracking the focused rooms and sections while following the process. • The absence of a 3D model on the configurator was one of the negative aspects affecting the experience.

Table 4.34 Participant #9's Highlights from the Interview (Firms C-D)

p#9	Web-Based Configurator: *Firm C*
Q1	• Navigating through the menu was easy and fast, and transitions between stages could be easily made. • The search box presented at the beginning of the process was a nice detail, but it did not fully serve its purpose due to the limited number of examples. • It was possible to see how the price was updated with each decision made, and the selected extras could also be tracked here.
Q2	• Access to the summary was indirect, and the information provided on this screen was insufficient. • The visualizations presented on the configurator were inadequate; many of the photos used did not reflect the selected options and did not match the layout of the chosen house. • The default settings that were progressed on were not even shown in the initial visuals. • It did not give the impression that the process ended with a finalized product.
Q3	• Information on prices and measurements was missing in the info boxes for some of the options presented. • The process could be qualified by presenting visuals in the pop-up.
Q4	• Adding a 3D model would be beneficial.
p#9	Web-Based Configurator: *Firm D*
Q1	• Overall, the interface's visuals, along with the model presented, were good, and it was enjoyable to see the changes resulting from the choices made.
Q2	• There was no information about prices in the configurator. Since the summary section was also not accessible, there was no information about the total cost of the product. • The provided information for the options was not sufficient, furthermore, the reasons behind the recommendation for specific options were not given. • Similar to the lack of price information, there was no information provided on measurements other than square meters.
Q3	• (-)
Q4	• To better explain the changes resulting from the choices made, a visual could have been enclosed in a cloud bubble. • Navigation within the model was relatively difficult, and it could have been solved by providing a small key plan.

Table 4.35 Participant #9's Highlights from the Interview (Wrap-Up Questions)

p#9	Wrap-Up Questions
Q5	Firm A > Firm B > Firm D > Firm C
Q6	• Although Firm D's configurator didn't offer much opportunity for design, the visualization of decisions eliminated any questions about what the final product would look like. Similarly, Firm B addressed this issue with renderings. • For Firm D's example to be fully successful at this point, it needed to provide more information and have a summary screen. • While Firm A's clear presentation of all information was a feature that reduced concerns about the final product, the insufficient visualizations made it difficult to get an idea of what the final product would look like. • The search box offered by Firm C was quite useful, but since other aspects were problematic, the experience provided, and the final product achieved were very poor. It might have been sufficient for configuring an ordinary product, but it was inadequate for a house.

Table 4.36 Scoreboard Prepared Following Participant #9's Feedback

	Firms			
Criteria	*Firm A*	*Firm B*	*Firm C*	*Firm D*
Procedure Design				
a.1	-	+	+	+
a.2	-	+	+	+
a.3	-	+	±	+
a.4	-	±	+	+
a.5	+	-	-	-
a.6	-	-	-	-
a.7	±	±	-	+
Design Guidance				
b.1	+	±	+	-
b.2	-	-	-	+
b.3	+	+	±	±
b.4	-	-	-	-
Direct Manipulation				
c.1	-	±	-	+
c.2	-	±	-	±
Collaboration Design				
d.1	-	-	-	-
d.2	+	+	±	-
d.3	-	-	-	-
d.4	-	-	-	-
Total				
	4.5	7.5	5.5	8

Table 4.37 Participant #10's Highlights from the Interview (Firms A-B)

p#10	Web-Based Configurator: *Firm A*
Q1	• The extra material that was shared before the process was a nice addition as it gave a detailed overview of the product provided. • Although the process was hard to complete and overwhelming, the tracking of the process was one of the features easing the completion. • It did not provide any guidance throughout the process, which felt like the process was started from nothing.
Q2	• The process of configuration took too much time, yet most of it was spent on things that didn't really matter to the user. • The visualization was an obvious weakness of the configurator, there was way too much text and a few visuals. • Even though the menu bar provided at the top was a well-thought feature of the interface, it did not help that much.
Q3	• The catalog-like configurator was encouraging users to compare the alternatives, yet the images provided for that were insufficient.
Q4	• Any kind of guidance tool, maybe even a real salesperson, would be very helpful in deciding on the technical components. • A 3D model or a set of renderings could elevate the adequacy of the process.
p#10	Web-Based Configurator: *Firm B*
Q1	• There was a feasible flow in the process of configuration, the process was presented neat and tidy. • The scheme of the interface was very informative, it provided an easy-to-follow process overall. • The pictures provided were beautifully prepared and presented, and the decision on the alternatives was recognizable.
Q2	• The scheme and standards of the presented model sometimes hindered the full expression of needs. • One of the other negative aspects was the limited number of options, especially under certain stages.
Q3	• The configurator was responsive and informative, yet the information box had room for improvement. More visuals could be added to them. • Although the visualization was successful, the upgrades provided within the process were not included in those.
Q4	• A 3D and/or panoramic view could be provided in the process. At least, they could be included in the summary. • A filtering/search box could be integrated into the configurator to easily find the right options and alternatives.

Table 4.38 Participant #10's Highlights from the Interview (Firms C-D)

p#10	Web-Based Configurator: *Firm C*
Q1	• The sliding menu decision was a genuine feature, as it's commonly encountered with more popular configurators. • Navigation through the menu was easy and more fun considering the other examples. • The price of each option could be easily tracked as they are both shown in the menu and calculated in the pop-up.
Q2	• Although the interface showing the process was jazzed up and rich in visuals, they were insufficient as they were not able to reflect the decision on the images. • Base models were provided as layouts, but that approach was complicating the process. • Offering customization services with palettes and packages made the process easier, but giving the customer more decision power within these options would be better.
Q3	• The filtering menu provided at the beginning was a crucial feature, but the labeling of the components was not complete, so the search and filtering option was not working well. • The price and inquiry pop-up was another well-thought feature, yet it does not work well as the summary screen of the process.
Q4	• Adding a 3D model could be the first step to improve the experience.
p#10	Web-Based Configurator: *Firm D*
Q1	• The 3D model provided within the configurator was the most advanced visualization feature of all. • The navigation through the menu was considerably easy. • The responsiveness of the model was appreciated.
Q2	• The pricing and the summary screens were not provided in any way. • The provided information for the options was not sufficient, they were descriptive and did not provide the needed explanation about them. • Navigation within the model was more complicated, a guidance should be provided for navigating through different rooms.
Q3	• The tracking of the decision could be made only on the model, it should be presented as a list as well. • It was good that recommendations were given on the configurator, but they were few and given on the most insignificant components.
Q4	• The changes made with the decision given should be highlighted on the model, or users could be notified via a tracking pop-up.

Table 4.39 Participant #10's Highlights from the Interview (Wrap-Up Questions)

p#10	Wrap-Up Questions
Q5	Firm B > Firm A > Firm D > Firm C
Q6	• Overall, the personalization service conducted through Firm B's configurator was able to deliver a product that met expectations at the end of the process. There were areas open to improvement, but other than that, the process was quite successful. • All other configurators had deficiencies or errors in terms of providing information. For example, important information was not provided in the configurators offered by Firm C and Firm D, so the final product could only be assessed visually. • In Firm A and C's configurators, even a visual assessment was not possible. • Overall, if more alternatives were available and a more detailed design scheme was provided, satisfaction with the final product would definitely increase.

Table 4.40 Scoreboard Prepared Following Participant #10's Feedback

	Firms			
Criteria	*Firm A*	*Firm B*	*Firm C*	*Firm D*
Procedure Design				
a.1	+	+	+	+
a.2	-	+	+	+
a.3	-	+	±	+
a.4	-	+	+	+
a.5	+	-	-	-
a.6	-	-	+	-
a.7	-	+	-	+
Design Guidance				
b.1	±	+	+	-
b.2	±	±	+	+
b.3	±	±	-	-
b.4	-	-	-	-
Direct Manipulation				
c.1	-	±	-	+
c.2	-	+	-	+
Collaboration Design				
d.1	-	-	-	-
d.2	+	+	-	-
d.3	±	-	-	-
d.4	-	-	-	-
Total				
	5	9.5	6.5	8

4.2 Second Phase of Interviews

In the second phase of the interviews conducted within the scope of the study, participants were asked to compare and evaluate the experience provided by the newly developed configurator with the one provided by Firm B which is also used as the foundation for the development. Highlights from their comments were compiled into a table and presented accordingly.

Table 4.41 Participant #1's Highlights from the Interview

	The Feedback of the Participant #1
Q1	• Although the initial experience offered by the configurator was found to be superior compared to other configurators, by the end of this use, it felt rather standard. There was no difference in terms of ease of use and the end product quality between the two experiences.
Q2	• Introducing the default model was found to be a good idea. The provision of information about the base price at the beginning of the process was especially appreciated. • Another creditable feature of the newly presented configurator was the ability to configure more components. In this context, the experience became more satisfactory with the addition of visuals and info boxes for each new component offered within the process. • The search and filter tool that is provided at the beginning of the process was found interesting and thoughtfully considered, yet, since it was not fully functioning due to the limited number of options offered in layouts, it could be completely tested. • The addition of the exterior renderings on the summary screen was another noticeable improvement.
Q3	• Although the experience provided by the developed configurator was found to be very close to the original, it also gave the impression of completing a more advanced process to the user. In this respect, it was evident that the developed configurator offered a more satisfactory experience.
Q4	• Comments made about the process could also be applied to the product obtained at the end. Even though the final products were very similar, or even the same, the fact that more information was available about the one obtained through the new configurator increased satisfaction with the product.

Table 4.42 Participant #2's Highlights from the Interview

	The Feedback of the Participant #2
Q1	• After using it a second time, nothing different from the first experience was encountered which confirms that the configurator offers an easy and enjoyable customization process.
Q2	• Many of the new features included in the process were found to be familiar from the configurators used in the first interview. However, their usability was improved by presenting them on a simpler interface, a search filtering tool was given as the most prominent example. • Some of the newly added visuals felt like they didn't belong to the house customized, but overall, the addition of more visuals and animations was referred to as a good improvement. • The introduction of the default model was found to be a nice feature, yet there were some problems regarding its interface and position in the process. • Overall, it was a more detailed configurator, yet it was still enjoyable and easy to follow.
Q3	• The new configurator was appreciated as it offered a more satisfactory process, despite some minor issues with the interface and functionality. It didn't have many shortcomings, but there was room for improvement—using a 3D model instead of renderings would be the most significant upgrade in this regard.
Q4	• Satisfaction with the final product was found to be higher than with the first configurator. However, having a section that shares images of a built example would provide greater assurance regarding the product's reality.

Table 4.43 Participant #3's Highlights from the Interview

	The Feedback of the Participant #3
Q1	• The first and second experiences didn't differ significantly, confirming the accuracy of the earlier comments made by the participant.
Q2	• It was found nice to see features from other configurators employed in the developed configurator. For example, the search and filter tool and the appliances section were seen in another example previously. • Introducing the default model was remarked as an expedient decision, as it allowed the participant to see where the design started. • Aside from this, the addition of more information, visuals, and animations addressed the main shortcomings of the configurator's original version. It was good to see these issues resolved.

Table 4.43 (continued)

Q3	• The experience offered by the second configurator stood out for being more detailed, but since the configuration process was followed through a similar interface, the experience was also similar. However, this was stated as a positive thing because the experience provided by the company's original configurator was already well-received.
Q4	• Even though the final product was the same in both processes, the fact that it was obtained through a more detailed process in the new configurator made the user more satisfied with the result. In this regard, the increased number of info boxes and visualizations made a significant contribution.

Table 4.44 Participant #4's Highlights from the Interview

	The Feedback of the Participant #4
Q1	• There were no significant differences between the first and second time using the configurator. The process still felt straightforward and enjoyable in general.
Q2	• Every new feature offered in the new configurator was easily noticeable. More importantly, it was stated that these new features did not make the process more difficult. • The newly designed process bar maintained the same simplicity as before, yet representing the default model with a dot on the bar was found to be a questionable decision—presenting it differently would have been better. • The addition of more visuals and information, as well as the ability to make more choices regarding components, were other well-received features.
Q3	• Although the overall feeling wasn't drastically different, it can be said that the experience offered by the new configurator was better since a more detailed process was completed at the end.
Q4	• The real difference created by the new configurator was related to the final product. Since more information was available about the product obtained at the end of this detailed process, doubts about the product were overcome.

Table 4.45 Participant #5's Highlights from the Interview

	The Feedback of the Participant #5
Q1	• The ease of use felt during the first experience was still pretty feasible the second time as well. However, during this use, being more attentive led to noticing details that weren't apparent in the first use, such as different upgrade options being offered based on layout preferences.
Q2	• Although many criteria could be pre-selected thanks to the added search and filter box, this feature was found to be not fully functional due to a limited number of options provided. • The addition of more steps and configurable components in the process was immediately noticeable by the participant, and since some of them could be reflected in the visuals, the customization process provided was found more qualified. For options lacking in visualization, the inclusion of info boxes compensated for this deficiency, as it's stated. • The overview provided in the middle of the process for the default model was found to be a useful addition, but it caused some confusion as its interface was identical to the summary's.
Q3	• It stated that the second configurator presented was a much more advanced example. Herein, the most significant feature of the newly developed configurators was highlighted as offering a more detailed personalization process while being understandable and easy to follow.
Q4	• Even though the products obtained at the end of both processes were found to be similar, it's stated that more choices could be made through the new configurator increased confidence in the product which enhanced the experience.

CHAPTER 5

DISCUSSION AND PROPOSITION

5.1 Discussion

The responses gathered from participants regarding a set of open-ended questions underwent interpretation, where they were organized into distinct groups in a discussion based on subheadings in customer navigation adequacy criteria. Following this, a comprehensive examination of each subheading was conducted, which was then followed by discussion.

In the process of evaluating the outputs of the interviews conducted within the scope of the study, it is important to examine two subjects, as they are of great importance in terms of creating a general framework and idea about the result. The first subject is to examine whether the evaluations of the configurators according to the success criteria carried out in the verification phase of the methodology align with the evaluations made by the participants based on their experiences. For this examination, evaluation tabulations were created according to the adequacy criteria based on the answers given by the participants to the questions, and an adequacy score was given to the configurators based on the criteria they met. The primary data examined herein are these qualification/adequacy scores. When looking at the results obtained from the participants, it is observed that the scores match the evaluations conducted in the verification stage of the study in a general manner.

When the differences among the results are examined, the first noticeable aspect is that, while the success scores of the web-based modular home configurators from companies meeting more criteria in the verification stage have increased based on participants' evaluations, the scores of others have undergone minimal changes overall, with a few exceptions of certain cases. The amplification observed in the scores of these more successful examples could be attributed to participants'

evaluations being relatively biased, as opposed to the comparative analysis method used during the methodology step, where the features of the configurators were assessed against each other while scoring. In the end, the positive features of the examples with a higher score (Firm B and Firm D's examples) were more prominently highlighted by participants, leading to having a superior experience than their expectations. In contrast, in Firm A and Firm C's examples, which were a step behind in adequacy scores compared to the others, the scores did not show significant variation in terms of increase or decrease but received much more criticism from the participants. Despite efforts to mitigate potential participant bias in comparison-focused studies, such as taking precautions in the design of the interviews, conducting informative and introductory discussions, and presenting the examples in a sequence independent of score rankings, it was not entirely preventable. However, since this amplification in the scores does not lead to misleading outcomes, it can be ignored in this part of the study.

Another key insight obtained from the results is the impact of adequacy criteria on participants' configurator preferences. Under this subject, the study examined whether the examples that received higher scores based on these criteria truly provided a better experience for users. The results of this examination showed that, for most users, their configurator preferences were directly proportional to the number of adequacy criteria met by the examples they experienced. In scenarios where this was not the case (Participants #3, #7, and #9), an analysis of the participants' responses revealed that these issues had resulted from well-known drawbacks of under/overdeveloped schemes of mass customization practices such as choice burden and lacking factor of enjoyment. This outcome aligns with frequently discussed concepts in the literature and serves as a modest example of these issues within the study. Aside from these exceptions, it is evident from the results that the success criteria were influential in shaping customers' experiences and, consequently, their preferences.

Although the evaluations and preferences of participants regarding the configurators they used during the interviews align with the analyses conducted in the verification

part of the study, achieving the study's goal of validating the impact of adequacy criteria on the experience and proposing a new custom navigation methodology along with the configurator qualification framework tailored to the modular housing industry following these criteria requires a more detailed examination of the feedback provided by the participants. This involves isolating and evaluating each criterion that shaped their experiences to create a comprehensive framework. To achieve this, in this chapter of the study, the information gathered from participants has been examined under each adequacy criterion.

5.1.1 Procedure Design

The procedure design section within the identified adequacy criteria stands out as the direct reflection of the customer navigation methodology offered by the tools and thereby represents the behavioral framework of the experience to be provided to the user. Herein, the behavioral frameworks of the configurators refer to what the customers need to do to be able to design/configure and how these configurable components of the product –herein, modular house– will be presented to them. In this aspect, the procedure design emerges as the most abstract and theoretically grounded section in performance evaluations of configurators, separate from technical and technological factors.

As the most frequently referenced subject when participants described their experiences with the web-based modular house configurator examples presented to them within the study, the importance of the procedure design in the development of strategies related to the experience is thus proven. The topic of procedure design, which participants most frequently referenced when describing their experiences with the web-based modular house configurator examples presented to them within the study, proves its significant importance in developing strategies related to the user experience. Within the scope of the study, since the objective is first to validate identified criteria and then to present a custom navigation methodology along with a satisfactory framework of configurator's qualifications based on adequacy criteria,

it is also crucial to examine the criteria under this section concerning participants' feedback.

Step by Step Increase of Challenge in Task (a.1), and

Task Following a Top-Down Hierarchy in Significance (a.4)

The immediate responses of the participants when asked to review their experiences with the configurators often focused on how challenging or enjoyable the process was. The adjectives they selected to describe their experiences, such as “fun, easy to follow and understand”, provide insight into how the task they were expected to complete on the configurator was designed and presented to them. It was observed that customers who did not encounter difficulties in navigating the configuration process were much more positive about their experiences. Herein, the navigation through the process offered by the configurators is found to be linked to the *Step by Step Increase of Challenge in Task* adequacy criterion in the identification phase of the methodology. As proof of this identification, in the conducted study Participant #3 highlighted the concept of coherence by stating, “progressing through the process was quite easy; there was coherence and logic between the stages” emphasizing the importance of sequencing in the division of tasks into stages. Also, from the interviews conducted, it became clear that, in the context of housing, the tasks and stages that customers found challenging or that required more thought were primarily related to topics mentioned in the second chapter of the study, which pertained to a higher level of customization. With this information, it can be said that the presence of a guide (the customization level hierarchy in housing) that can be followed when deciding on the ideal sequence was also recognized. This guide could help structure the configuration process in a way that progressively increases the complexity of tasks, making it easier for customers to engage with more complex options without feeling overwhelmed early.

It can be inferred that the guide mentioned here aligns with another adequacy criterion, namely the *Task Following a Top-Down Hierarchy in Significance*. The participants' comments, such as “the stages presented within the process were not

irrelevant" (Participant #7), indicate that the relevance of the phases is linked to their presentation according to the customization level hierarchy defined by Eid Mohammed and Carbone (2022). This is illustrated by the fact that Firm B's configurator, which structured its navigation and configuration scheme based on this hierarchy, was highly appreciated by almost all participants (Figure 5.1).

Figure 5.1. The configuration scheme in Firm B's configurator aligning with the customization hierarchy defined by Eid Mohammed and Carbone (2022) (URL-3)

In scenarios where these two competency criteria were planned and successfully executed together, participants also noted that there was a sense of flow in the process. The realization that this flow was not optional, but critical, came from participants' complaints about disruptions in the flow in cases where these criteria were not met. For example, Participant #2 stated, "There were some problems in the flow while transitioning from layout to lower-level customization services in the process" while evaluating the Firm D configurator, which lists lower-level customization items, such as upgrades, between the higher-level customization stages, disrupting this hierarchy. This immediate insight highlights the importance of integrating a top-down hierarchy and incremental task growth to ensure an effective and seamless user experience in configurators.

The complementary relationship between the criteria of *Increase of Challenge in Task* and *Top-Down Hierarchy in Significance* became clear in the evaluations of the configurators based on the participants' feedback. Apart from a few exceptional cases, these two criteria were generally fulfilled together in the configurators evaluated. In other words, participants noted that configurators that lacked one of these criteria often failed to meet the other. This suggests that both criteria together influence the user experience and are crucial in assessing the competence of a configurator.

The impact of these criteria on the configurator experience and the development of a navigation methodology is particularly important when determining the sequence of stages that customers must progress through to complete the configuration task. The success of Firm B's schema, which was frequently and clearly praised by participants, contrasted with Firm A's intimidating multi-step interface, leading the discussion to the conclusion that a successful navigation methodology and qualification framework should present fewer, more basic stages, with branching occurring under these main stage headings to provide a better user experience (Figure 5.2). This insight emphasizes the need for simplicity and clarity in the configuration process to ensure that users are guided through a logical and manageable sequence of tasks while maintaining a coherent and intuitive structure.

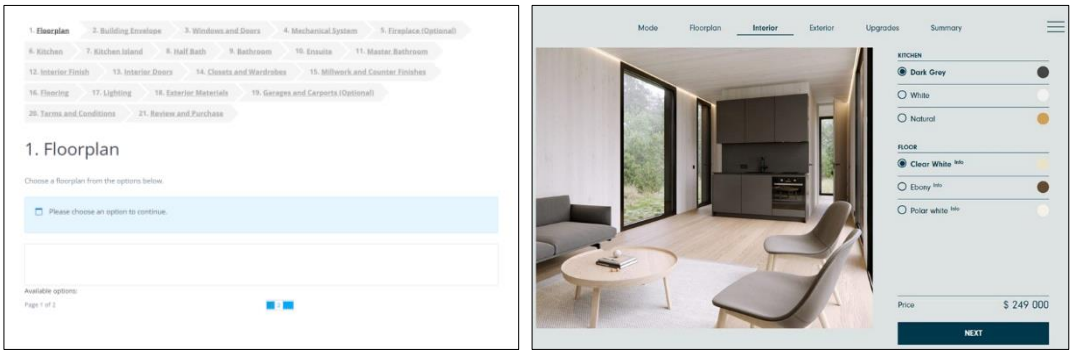

Figure 5.2. The interfaces of Firm A (left) and Firm B’s (right) configurators, showing the differentiation in the approach of process design (URLs 2 & 3)

Providing Multiple Pathways (a.2),

Following a Flexible Design Procedure (a.3), and

Showing the Path of Process (a.5)

According to the feedback received from the participants, the ability of the configurators to *Providing Multiple Pathways*, which is another qualification criterion under the Procedure Design section, was considered together with the *Following a Flexible Design Procedure* criterion and was expressed with the repetitive phrase “being the ability of freely navigating within the menu”. Within the study conducted, it was realized that although all four web-based modular house

configurators offered have this feature, the experiences they provided differed based on having two basic features which appeared as a must to be appreciated by the participants.

The first of these features is that the navigation scheme should not require mandatory steps and stages to be completed to move forward, which is the case in Firm A's configurator. Herein, the participants criticized the need to make a choice even in the optional headings in the previous step to move forward and complained that such a navigation scheme was too strict (Participants #1, #2, 3, #4, and #9). In contrast, in the examples provided by Firm B and Firm D, the ability to move freely in between stages was appreciated and this flexibility was highlighted as a qualification that supported the enjoyment of the experience.

Another feature that is considered as a necessity for the configurators to provide a satisfactory performance in terms of these criteria is the ability to remember the preferences made while freely navigating between the stages and showing them throughout the process. Although this subject is more appropriate to be evaluated in the Direct Manipulation section, it is included in this discussion as one of the necessary features since the participants mentioned it while appreciating the flexible configuration procedure presented in the example of Firm D.

Based on participants' experiences, the importance of the criteria *Providing Multiple Pathways* and *Following a Flexible Design Procedure*, which allows users to move freely between stages and tasks during the configuration process, has been proven in their evaluations. While these criteria significantly impact users' configuration experiences, through the interviews, it was also found out that a successful navigation experience must meet a specific set of expectations.

Although these expectations may not directly contribute to the navigation methodology itself, they provide valuable insight into a crucial component of a successful configurator. For an effective and satisfying configurator experience, there are broader user expectations that need to be addressed beyond the structural aspects of navigation, such as flexibility and multiple pathways. Taking these

expectations into consideration can lead to a better user experience, increasing the usability and appeal of the configurator.

The most significant of these components is a simple menu bar that contains headings that indicate how the stages and tasks are divided. In the case of a modular house configuration, where there are numerous components offered to be customized, this menu bar does not just organize and compile the process, but also, provides information about which sections the users have completed, their current stage, and the upcoming stages and tasks. Thanks to this modest component, the housing configuration process, which has a multi-layered and multi-element structure and in which customers are likely to get lost while navigating freely, can be carried out more successfully. Additionally, it addresses the adequacy criterion of *Showing the Path of Process* by integrating the simple feature of "you're here" visually as can be seen in Firm A's example (Figure 5.3). In this respect, separating this criterion from the other two criteria related to process flexibility for successful implementation would not be appropriate.

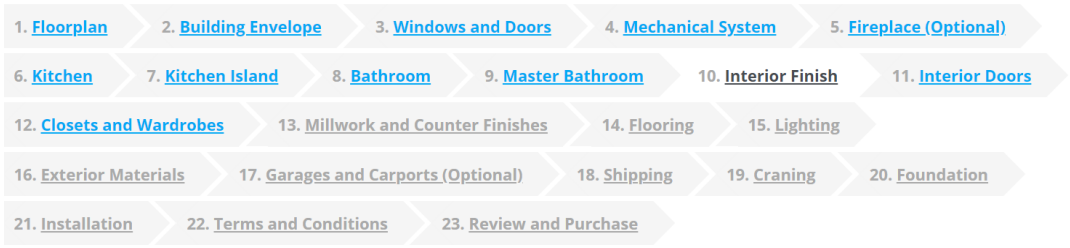

Figure 5.3. The menu bar in Firm A's configurator informing the users about the process while showing the completed and upcoming steps (URL-2)

Thus, it can be said that by implementing a menu bar, not only does the configurator gain a crucial organizational tool, but it also enhances the user experience by providing clarity and reducing confusion, which is vital to the overall satisfaction and effectiveness of the configuration process.

Any-time Save Possibility (a.6)

Under the Procedure Design section, the *Any-time Save Possibility* adequacy criterion stands out as the least experienced and commented-on feature during the

interviews as the participants completed all the configuration processes in one sitting which resulted in minimal information gathered on this subject. Despite this, in the case of Firm C's configurator, participants who noticed the "save model" button expressed their interest in this feature and mentioned it positively while sharing their feedback (Figure 5.4). On top of that, Firm C's strategy to allow users to create a membership and thus save models in a gallery, increased user engagement with a tool as the participants indeed signed up within the study just to see. However, since a similar feature was not presented with such a highlight in other examples, it could not be tried by the participants and therefore a subject-specific comparison could not be made. Although it can be said that this feature is better to have for a successful configurator setup based on the appreciation of Participants #2 and #5, it is unfortunately far from being a strong conclusion. However, the potential of this feature for a successful customer navigation methodology is discussed later in the chapter and it is emphasized that it should be included in the configurators.

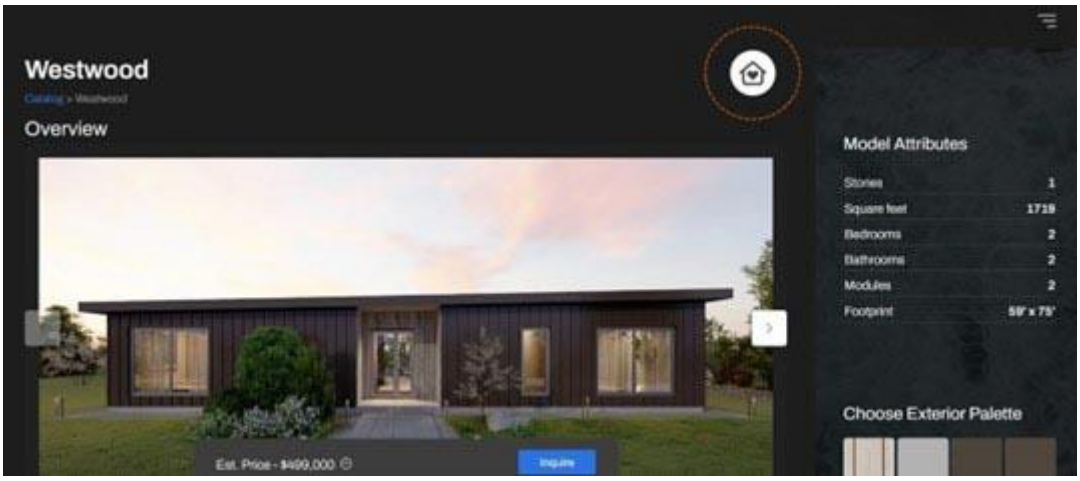

Figure 5.4. Firm C's configurator, the "Save Model" is button highlighted (URL-4)

Providing an Opportunity for Visual Comparison of Decisions (a.7)

The criterion *Providing an Opportunity for Visual Comparison of Decisions*, which is the last one under the Procedure Design heading, is frequently mentioned in participants' experiences. However, based on the responses of the participants, it is found better to be evaluated under the Direct Manipulation section. Participants

tended to make decisions based on models or images updated throughout the process rather than comparing preferences on a final model. Thus, it was decided to examine this criterion in relation to *Having a Direct Reflection / Feedback of the Choices* qualification criterion to draw more accurate conclusions.

5.1.2 Design Guidance

Although the core of the experience provided by configurators is built within the criteria addressed under Procedure Design, it is necessary to have additional features and services providing insights into both the product and process to customers as well as guiding them throughout the process to ensure that the personalization experience reaches a truly satisfactory level for them. Herein, the qualifications for these features and services are examined under the Design Guidance section within the study. Information gathered from the interviews has been discussed about the criteria listed under this section highlighting the impact on the user experience as well as the significance of the development of the custom navigation methodology along with the configurator qualification framework.

Providing a Standard Library Consisting of Modules with Prices (b.1)

Although it was clearly stated in the interviews that the interfaces and libraries of the configurators offered to the participants would not be evaluated within the scope of the study, still received feedback revealed the significance of the libraries containing components and alternatives for configuration. Considering that almost every configurator was criticized for the lack of alternatives by the participants, it would not be wrong to say that customers have a great expectation for the library to be offered through the configurator at this point. Although the library concept discussed here is related to solution space development, which is another success factor of the mass customization process, it has been realized that some of the features that are decisive in the users' experiences on this subject can be discussed under the subject of choice navigation.

The first of these features in the configurators examined and tested by participants is the strategy of presenting components and their alternatives in pallets and/or packages. The justification behind following this specific strategy is to make the process more understandable for the customers and to protect them from the burden of choice risk, which is indeed proven with the example of Firm A's configurator where this strategy was least utilized, and most of the participants stated that they had difficulty in completing the configuration process at the end of the study. However, it also has to be mentioned that the grouping and strategy to reduce task difficulty are poorly implemented, and the co-designer roles are taken away from the customers which turns out to be a significant drawback. For example, despite being appreciated by many participants, Firm D's configurator faced criticism for its extensive palette and package options which covered almost all levels of customization but only offered broad changes through a limited number of alternatives (Figure 5.5). At this point, examples of both situations that have been avoided have had the opportunity to be exemplified and evaluated within the scope of this study.

Figure 5.5. The extent of the changes made with alternatives selected is seen from Firm D's configurator (URL-5)

In the examples of Firm C and Firm B, on the other hand, it's seen that pallets and packages were prepared for different stages allowing customers to make decisions at different levels of customization and become more integrated into the process. This integration appears to be one of the main factors that increased customer satisfaction with both the product and the process when participants' responses were reviewed,

and the example of Firm B was regarded. Herein, Firm B's configurator has successfully divided the configuration process into stages which enable customers to focus on varying components and details in different settings; thus, achieved to not receive any feedback regarding the inadequacy of the library, even though the number of options offered was similar to other examples. Considering this, it has been observed that a navigation scheme developed following the criteria explained under the procedure design section also unexpectedly influences the perceived adequacy of the presented library.

At this point, another feature that affects the customer experience in the navigation and configuration process is the clear display of the pricing for the offered options, extras, and upgrades, as frequently mentioned in user reviews, and, if possible, the ability to see the total price throughout the process. The need for such a feature became obvious when the fact that participants criticized Firm D's configurator for not providing this information was considered. While all configurator examples except Firm D's responded to these demands in some way, they differed in terms of how they did it and allowed the participants to make a comparison in this sense. The pop-up panel of Firm C's configurator, which offers the most striking example among the configurators examined, was appreciated by some users (Participants #2, #3, and #4), but found "confusing" by others (Participants #5, #7, #8, and #9). The relatively traditional price estimation feature offered by Firm B and Firm A in their tool was found functional and did not receive much criticism overall (Figure 5.6).

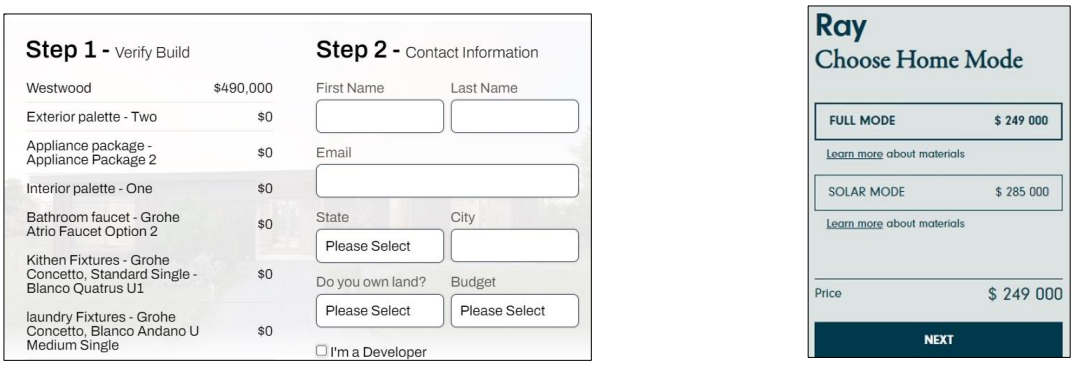

Figure 5.6. The different approaches in price estimation feature provided by the configurators of Firm C (left) and Firm B (right) (URLs 4 & 3)

Considering the qualifications that a successful configurator should have, it is concluded that features based on giving information such as pricing should be designed and presented to the users as simple and functional as possible and straightforwardly presented to users. This conclusion also appears to be valid for another adequacy criterion *Providing Information About the Choices Made*.

In this regard, the participants first stated that they expected the texts presented in the info boxes to be brief and easy to understand while emphasizing that the information texts should be informative. Likewise, the descriptive nature of the information about the alternatives offered by Firm D's configurator was criticized by the participants. In addition, the participants stated in their feedback that it is crucial to provide images and visualization in the information pages/boxes as much as possible (Participant #7). Considering that the technical drawings in the information boxes provided by Firm B were also appreciated by the participants, it can be said that such elements are more effective than extensive informative texts. Herein, the criticism of "the information texts was detailed but lacked an inviting presentation" towards Firm A's configurator exemplifies this situation while highlighting the importance of balancing the informative texts with descriptive visualizations for user engagement (Participant #5).

Finally, it also has to be mentioned that where these information pages/boxes are presented is just as important as how they are presented. Participants who viewed the information about their choices after making a selection in Firm A's configurator frequently complained about this. Since users shape their preferences based on the information they receive, the flaw in the practice seen in Firm A's example becomes clear.

Providing a Base / Default Model at the Beginning of the Process (b.2)

In this research, default models, discussed in the literature review chapter, are among the primary features that many companies aim to integrate into their configurators as they define a prelude and provide a canvas for visualization applications. On this basis, it was first thought that participants were already familiar with this feature and

that it would not facilitate a meaningful discussion, yet, the received feedback from the participants revealed that the default models significantly impact user experiences.

Firstly, as mentioned, the default models stand out as a mechanism that encourages visual comparison of options for many participants by creating a visual canvas (Participant #6). Participants who encountered a complete product at the beginning of the process did not have to wait until they completed the process to compare alternatives for a particular component in the intended settings. This made the process more understandable and smoother for users. As a result, participants' integration into the process and their satisfaction with the final product increased (Participants #10 and #12).

On the other hand, it was observed that the default models also had an impact on participants' sense of authority in their co-designer roles. Some participants expressed dissatisfaction with not being able to design their products from scratch, feeling that the configuration process, which proceeded from a complete product, was insufficient for them (Participant #8 on Firm D's configurator). Conversely, some participants complained that the absence of a noticeable guide or default model, as seen in Firm A's configurator, made the process much more complicated for them to complete (Participant #2).

At this point, drawing a definitive conclusion is relatively difficult, as many configurators presented had notable shortcomings in terms of visualization of decisions and preferences, as also noted by the participants. At this point, it is quite normal for the participants to find their involvement in the process insufficient when they cannot see the results of their changes through the images or model provided. Likewise, no such criticism was directed at the configurator provided by Firm B, which met the visual comparison and direct manipulation criteria relatively successfully.

Considering these outputs, it may not be appropriate to draw a definitive conclusion regarding the *Providing a Base / Default Model at the Beginning of the Process*

adequacy criterion, yet it can be mentioned that if a base model is provided on the configurator to define a prelude for the process, it is necessary to have an interface that allows visual comparison and direct manipulation.

Including a Need-Based Elicitation System in the Configurator (b.3)

Under the Design Guidance section, *Including a Need-Based Elicitation System in the Configurator* adequacy criterion was one of a few subjects that participants did not understand during interviews and therefore could not comment on clearly. Most participants mentioned the need for a mechanism like this elicitation system, especially in stages requiring technical knowledge, which they encountered in the example offered by Firm A. Yet it is also seen that the participants had definite difficulty in specifying and articulating this demand in this direction.

One reason for this inarticulation can relate to the adequacy criterion being an innovative feature evaluated under the title of advanced methods in choice navigation, and thus, unknown to the customers. Herein, while it is not possible to draw a clear conclusion about the qualifications of a need-based elicitation system to be integrated into configurators, feedback received indicates that this type of technology holds great potential, especially for customer guidance in detailed customization scheme preferred for personal individualization applications in modular housing (like Firm A). Projections on how to implement this potential effectively are discussed later in the discussion, particularly in the context of developing a custom navigation method.

5.1.3 Direct Manipulation

In mass customization practices, customers are intended to take part in the design process as co-designers to customize products according to their demands. To fulfill this role and reach the product they had in mind at the end of the process, customers need visualizations that allow them to see the decisions they make throughout the process.

Since this need was one of the most often mentioned issues in the mass customization title, it was also included in the adequacy criteria. Within the scope of the study, these criteria, defined as *Allowing Customers to Manipulate the Model / Visuals* and *Having a Direct Reflection / Feedback of the Choices*, are evaluated under the section of Direct Manipulation by referring to the expectation of responsive visualizations in the current context.

Allowing Customers to Manipulate the Model/Visuals (c.1),

Having a Direct Reflection / Feedback of the Choices (c.2), and

Providing an Opportunity for Visual Comparison of Decisions (a.7)

In the study, it is evident from participants' feedback that the majority of the adequacy criteria have a significant impact on user experiences with some of them relatively more effective. However, it is also important to highlight that some specific criteria are relatively more effective. Notably, visualizations, which can be described as reflections of the preferences are among the most emphasized aspects by customers, alongside design of the configuration process and navigation.

The first conclusion that can be drawn from the discussions on visualization is that the criteria presented under the Direct Manipulation section, namely *Allowing Customers to Manipulate the Model / Visuals* and *Having a Direct Reflection / Feedback of the Choices*, are perceived by customers as conveying the same meaning which can be expanded in a way that even include the criterion *Providing an Opportunity for Visual Comparison of Decisions* proposed under Procedure Design.

Given that many participants considered the visualization feature as a core element of the process, it seems more proper to consider *Allowing Customers to Manipulate the Model / Visuals* as a central criterion and examine it under the Procedure Design heading at this point. This conclusion is supported by some participants who suggested that it would be more accurate to deal with the entire configuration process through the model. Additionally, many participants could not separate their experiences from the visualization feature when discussing the configurator provided by Firm D, which placed the 3D model at the center of its interface. In fact, if

criticism of the limited alternative library presented in this example has been ignored, it can be said that this strategy increases the satisfaction of participants (Figure 5.7).

Figure 5.7. The interface of Firm D's configurator remarking the 3D model that the users can navigate through (URL-5)

The significant impact of visualization on user experience can be attributed to participants' concerns during the comparison and decision-making stages as they found the provision of only data and information insufficient. As proof of that, although the configurator offered by Firm A provided detailed information about products and alternatives, it was indeed found inadequate by most participants since it lacks strong visualizations and mostly relies on catalog-like sample pictures for comparisons within the process. At this point, the sample visualizations expressed by participants refer to static visuals that cannot respond to customer preferences. Similar visualizations were seen in Firm C's configurator as well, which, despite offering higher-quality visuals than Firm A's, was again considered insufficient by participants. Firm B's configurator, however, was praised for providing images that could be manipulated according to user preferences, aligning with the criteria discussed in this section. Despite this positive feedback, participants expressed a desire for further development, specifically for a 3D model they could navigate. Some participants even suggested that instead of models offering real-time rendering, like the one used in Firm D's configurator, models with simulation

abilities that allow users to explore and take measurements within the model freely would be more desirable (Participant #8) (Figure 5.8).

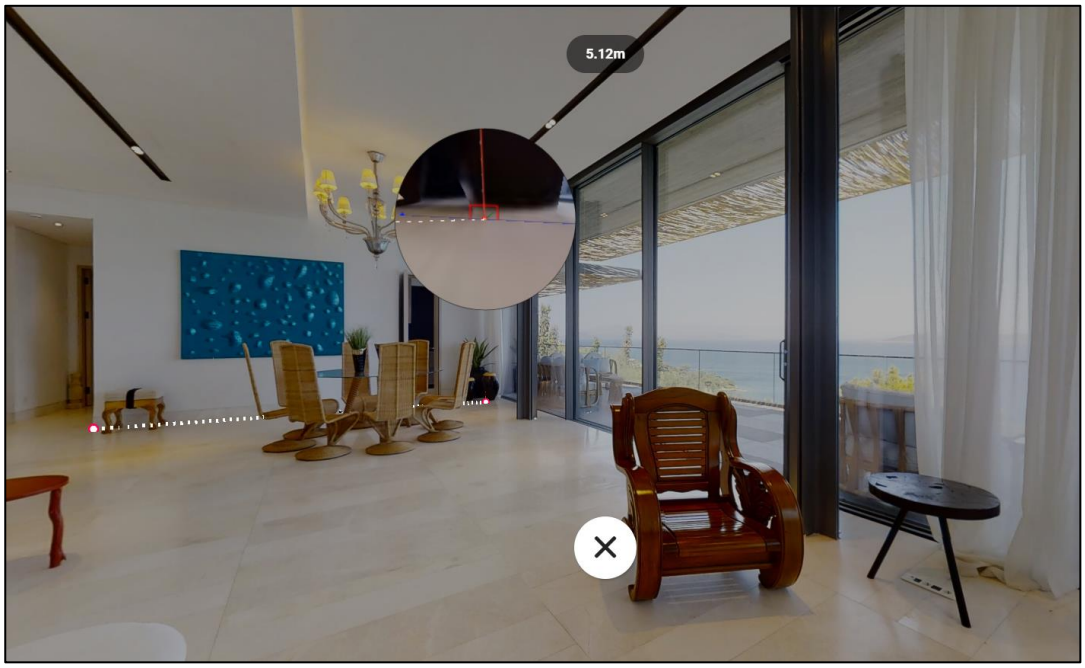

Figure 5.8. The example 3D simulation model of Nef Reserve Gölköy, which is referenced by Participant #8 as an advanced feature that can be integrated into the configurators (URL-7)

Simulation models have emerged as the most advanced and compatible solution with current expectations among various suggestions made by participants during the study, such as the inclusion of panoramic visuals and the creation of a render gallery. When evaluating participants' feedback as a whole regarding the model to be offered, it becomes clear that a model providing instant manipulation functionality, easy navigation, scalability, measurement capabilities, and the ability to highlight manipulated parts in a way that the user can understand would meet almost all the expectations discussed under this section. When the currently most successful configurators are visited, it’s seen that most of them including the Nike by You configurator, which has been mentioned multiple times within the research, have provided modes developed precisely according to this formula (Figure 5.9).

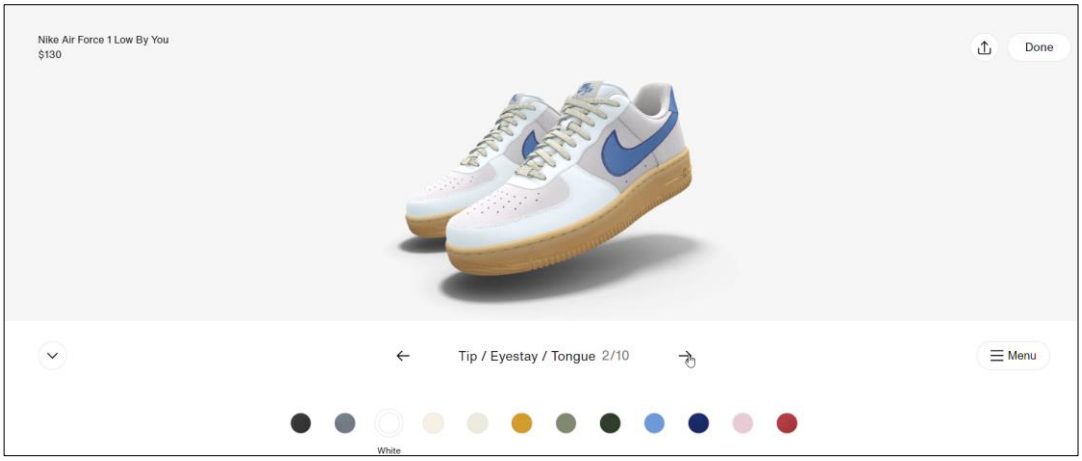

Figure 5.9. The configurator Nike by You highlighting the component that will be manipulated in that stage (URL-8)

However, it should also be noted that in scenarios where functionality is the sole parameter set for the tool and process, customers' visualization demands can be met with high-quality and comprehensive sets of renderings, as provided by Firm B. Indeed when critiques of the configurator made by the participants were reviewed, it was seen that none of the participants expressed any complaints regarding visualization, which came across as one of the remarks that need to be mentioned herein. It can be inferred that the decision at this point will focus on the performance of the configurator being offered. An ideal scenario would require a model that meets the criteria discussed here, while a high-quality set of renderings would be sufficient in a scenario for which a satisfactory experience is intended, providing both visual comparison and a clear indication of what the product will look like in reality. Since the outcome of this study aims for the ideal scenario, a 3D model will be preferred for the proposed qualification framework, as this type of model will form the core of the configuration process and will be a crucial component for the development of the custom choice navigation methodology.

5.1.4 Collaboration Design

Since mass customization applications are a strategy developed to serve a wide audience, businesses must ensure that their customers can actively participate in the process without having a specific technical background, and the tools for the process should be developed accordingly. Although conventional industrial products, which are mass-marketed and widely known, may not require extra efforts in development to ease the process for customers as they are already familiar with these products, the modular housing examined in this study steps forward as a different case. Therefore, these developments hold much greater importance. Based on this, they are included in the adequacy criteria for configurators in this study refer to customers' interaction with the system, sales representatives, or other customers, and have been examined under the section of Collaboration Design.

Providing a Record of Work (d.2)

Based on the interviews conducted, it was found that only two out of the four criteria presented under the Collaboration Design section had been discussed by the participants and actual an impact on participants' experiences. As one of these two, *Providing a Record of Work* criteria emerged as a subject that is highlighted by every participant in their feedback without exception. Herein, it's observed that just as participants wanted to track their choices visually and financially throughout the process, they also expected to review a detailed summary of their final product at the end to be sure. Given this, it became clear that this criterion was viewed by participants as an integral part of the procedure, leading to the decision to present it under the Procedure Design section in the adequacy framework.

In this context, it was observed that all the configurators reviewed in the study, except for the one provided by Firm D, have integrated some form of summary feature into their systems. As a matter of fact, this lack appeared to be the most frequent criticism from participants regarding Firm D's configurator. Herein, from the criticism of the participants, it is also inferred that the summary screens are considered as wrapping-up points in the process that customers would like to see to

understand that they have the completed product. Herein, the configurator provided by Firm C, which presents an overview via a pop-up on the interface (which also shows price estimation), despite offering a summary, was found to provide a less than satisfactory experience in this regard.

In the case of Firm A's configurator, the summary provided is long and detailed, exemplifying the company's elaborative approach throughout the process. Although participant feedback indicated mixed feelings about this approach in summary provision, it still functioned as an effective feature. Yet, a better experience is provided by Firm B's configurator as it's inferred from the participants' feedback. Presented as a simple interface, Firm B's summary page had high readability and traceability, clearly summarizing the alternatives selected by customers during the process, showing the final price and the extras that affected the price, and explaining the post-order process through graphics. This successfully met most participants' expectations (Figure 5.10). The only drawback herein, as expressed by a few participants, was the lack of visualizations of the final product.

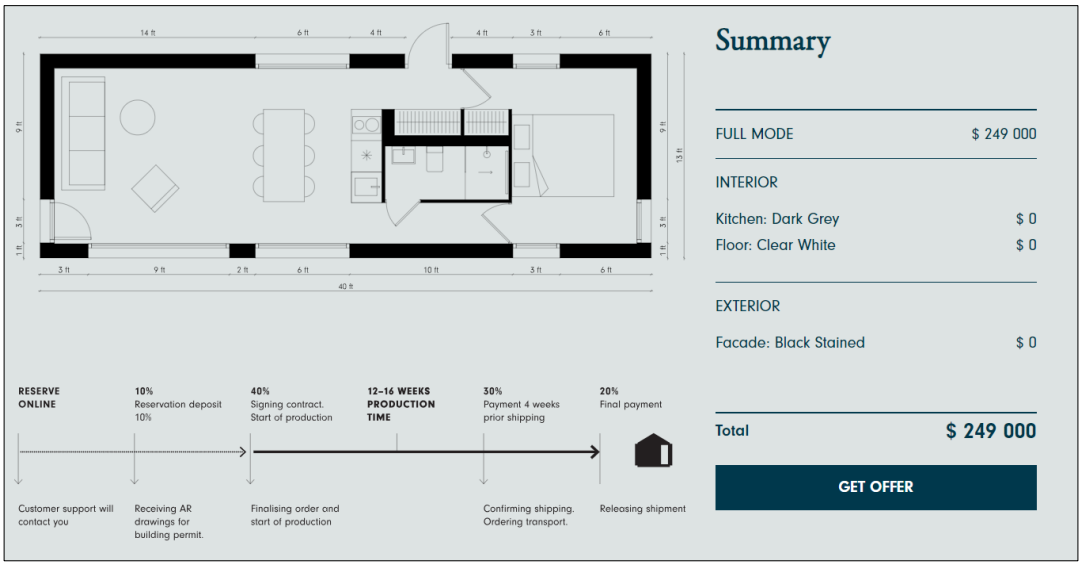

Figure 5.10. The summary provided by Firm B's configurator (URL-3)

Based on participant feedback, a clear conclusion can be drawn about the qualifications a configurator should have to meet the *Providing a Record of Work*

criterion. By adding product visuals to the example offered by Firm B, a summary that meets expectations could be achieved.

Offering a Recommendation System (d.3)

In the study, another criterion evaluated by participants under the Collaboration Design section was *Offering a Recommendation System*. It is important to note that recommendation systems are designed to yield favorable outcomes in product purchases, especially in cases where customers are indecisive and need motivation and guidance through the configuration process. These systems are developed to recommend specific options and scenarios, as previously discussed in the literature review chapter of the study.

From the feedback provided by participants in the interviews, it is evident that while the participants are familiar with recommendation systems, they lack a clear idea of how these systems should be integrated into the process. This is reflected in their inability to articulate specific requests or details about the system that they thought they needed. One reason for this issue is that none of the configurators presented in the study, except for Firm D, included a recommendation system. In the case of Firm D, although recommendations were provided through alternatives, these were found to be of low quality and did not significantly influence participants' choices or make a difference in their experience. Consequently, it is inferred that there was a noticeable gap in creating a discussion base for this adequacy criterion due to insufficient material.

The only conclusion that can be drawn from the limited feedback of participants about successfully meeting this criterion is derived from the statement made for Firm A's configurator: "It would have been better if the computer had made suggestions based on the customer's needs or did not present certain options at all" (Participant #9). Herein, analyzing participants' experiences reveals that they often struggled with decision-making, on technical matters, and sometimes resorted to blind selection. At such points, they expect the system to prepare the ideal scenario for them. From this perspective, it can be said that a recommendation system addressing technical and

building performance issues would facilitate their decision-making and make the process easier. As a result, although feedback from participants did not clarify how the recommendation system should be implemented, it is clear that a recommendation system is a necessity, particularly for configurators offering extensive configuration and design processes to guide customers on technical matters.

Building the Collab System Between the Customers (d.1), and

Providing a Segment to Leave and Review Comments (d.4)

For the criteria *Building the Collab System Between the Customers* and *Providing a Segment to Leave and Review Comments*, no discussion or substantial impact from participants was evident. Thus, these criteria were found to be less critical in defining the Collaboration Design section. Consequently, they have been removed from the revised list of adequacy criteria and will not be included in the custom navigation methodology and configurator qualification framework (Table 5.1).

Table 5.1 The Final Adequacy Criteria Revised Following the Feedback

Customer Navigation Adequacy Criteria	Procedure Design (a)	1. Step by Step Increase of Challenge in Task 2. Providing Multiple Pathways 3. Following a Flexible Design Procedure 4. Task Following a Top-Down Hierarchy in Significance 5. Showing the Path of Process 6. Any-time Save Possibility 7. Providing a Record of Work
	Design Guidance (b)	1. Providing a Standard Library Consisting of Modules with Prices 2. Providing a Base / Default Model in the Process 3. Providing Information About the Choices Made 4. Offering a Recommendation System
	Direct Manipulation (c)	1. Allowing Customers to Manipulate the Model / Visuals

5.1.5 Wrap-Up Questions

In the interviews with the participants, the first part of the conversation was focused on explaining the aspects of each configurator that the participants liked and found insufficient, based on their experiences. Owing to this conversation the evaluation of the identified qualification criteria and the determination of the features that will offer the best performance in these specific criteria were made within the discussion conducted.

In the following and final stage of the interview, two wrap-up questions were posed to the participants to summarize the discussion and reach a verdict. At this point, the first question asked, “Based on your usage experience, can you rank the configurators you tested?” aimed to determine whether the qualification criteria identified had an impact on the users' configurator experiences and preferences. As a result, as mentioned at the beginning of the chapter, it was found that there is indeed a linear relationship between the qualification criteria and the customers' experiences.

The other wrap-up question asked to the customers at the end of the interview was, “When the customization process was completed, did you obtain the final product you requested? If not, what were the reasons?” This question aimed to answer the critical question in mind, “Does a better experience truly result in a better product?” which has great importance for the development of the proposed methodology and features framework.

When the participants' responses to this question were examined, it was first observed that the configurator providing the experience they liked the most also offered the product that best met their expectations. Many participants confirmed this by stating that they were only satisfied with the modular house that they personalized through Firm B’s configurator. On the other hand, a common inference among the participants was that the other configurators failed to meet their expectations in this regard, which emerged as one of the study's outputs.

At this point, Firm D’s configurator steps forward as a noteworthy example for further examination. Although the customization experience offered through it was appreciated by participants and received a high score based on the adequacy criteria, it was observed that customers were not satisfied with the final product they obtained at the end of the process. Upon reviewing the participants' explanations, it became clear that the main reason for this dissatisfaction was the limited number of alternatives and restricted customization options. Since the problem seemed to be related to the solution space provided by the firms, it was concluded that this does not contradict the assertion –supported by Firm B’s example– that a better experience leads to a better product in terms of configurators.

Again, one of the highlights of the study was that the shortcomings cited by participants when discussing the failure of other configurators to deliver products that matched their customization requests were qualifications evaluated within the scope of the adequacy criteria. Based on the responses provided, it can be inferred that, in the context of modular homes, configurators need to possess the following features to offer a product customization service that meets customer expectations from the product:

- Offering a detailed design process,
- Providing substantial visualizations,
- Providing customers with sufficient information about the process, default settings, and alternatives offered,
- Having a mechanism that offers guidance, particularly on technical matters where customers are assumed to have limited knowledge.

These demands, which conclude the discussion on the qualification criteria, clearly articulate the expectations of the participants and the users they represent regarding the configurators they have experienced and will experience in the future.

At this point, the fact that customers' expectations significantly align with the adequacy criteria that tools need to meet for a good configurator experience allows us to conclude that “a better experience leads to a better product”. It is also evident

that the adequacy criteria to be used for the qualification features framework, which will be presented in the final stage of the research along with the custom choice navigation methodology for modular house configurators, provide a solid foundation.

5.2 Proposal

Within the scope of the research, a new choice navigation model tailored to the modular house industry is proposed to increase customers' satisfaction with the process and the final product. Herein, the developed model provides a choice navigation methodology and a set of features that meet the identified adequacy criteria. This methodology and features are intended to be employed in developing configurators for mass customization services offered in modular houses. In this context, participants' reviews and further expectations regarding the identified adequacy criteria are revisited under the methodology and framework subjects. Ultimately, a new configurator is developed following the adequacy criteria and the findings through modifications made to Firm B's web-based modular house configurator, which was most favored by participants and presented to the interviewees to validate the adequacy of the model.

5.2.1 Choice Navigation Methodology

Considering the cases examined in the study, regardless of their strengths or shortcomings, it is apparent that all of them offer a certain level of customization through a similar strategy based on providing choices at multiple levels. According to this strategy, users select from various housing typologies that vary in design style, spatial layout, number of bedrooms, area, and finishes. The configurator then systematically guides homebuyers through structured decisions regarding exterior and interior (Eid Mohamed & Carbone, 2022).

While this strategy has the significant advantage of presenting the design of modular houses, which are quite complex industrial products, as a relatively straightforward process to customers, it also appears to be the source of many shortcomings and problems mentioned by the participants during the interviews.

At this point, researchers like Eid Mohammed and Carbone suggest methodologies that aim to redesign the entire system and allow customers to reach the final product with minimal decisions after expressing their needs as much as possible at the very beginning of the process (2022). Yet, herein, it is also important not to overlook an example like Firm B's configurator, which was found to be quite successful based on participant feedback in the study although conventionally provided the customization process.

Considering this, a methodology has been developed using the navigation schema of the configurator provided by Firm B as the foundation. The developed methodology aims to integrate contemporary technologies more easily and to meet the expectations and demands expressed by participants more effectively. Figure 5.11 represents a schematic diagram of the proposed choice navigation methodology developed for modular house configuration. As it's seen in the diagram, the proposed framework has some additions to the conventional scheme encountered with the examples presented to the interviewees.

Initially, in the developed methodology, instead of having customers directly enter the design process, as advocated by Eid Mohammed and Carbone, they were asked to introduce their basic expectations from the product to the system. This approach aimed to prevent customers from getting lost in the design process and ending up with an aesthetically pleasing product that does not meet their needs and demands. Although such a situation did not arise within the interviews since participants were not required to make their choices according to a budget or need, however, the participants' constant desire to check the estimated price and layout throughout the process indicated that incorporating such a step would be beneficial to the process.

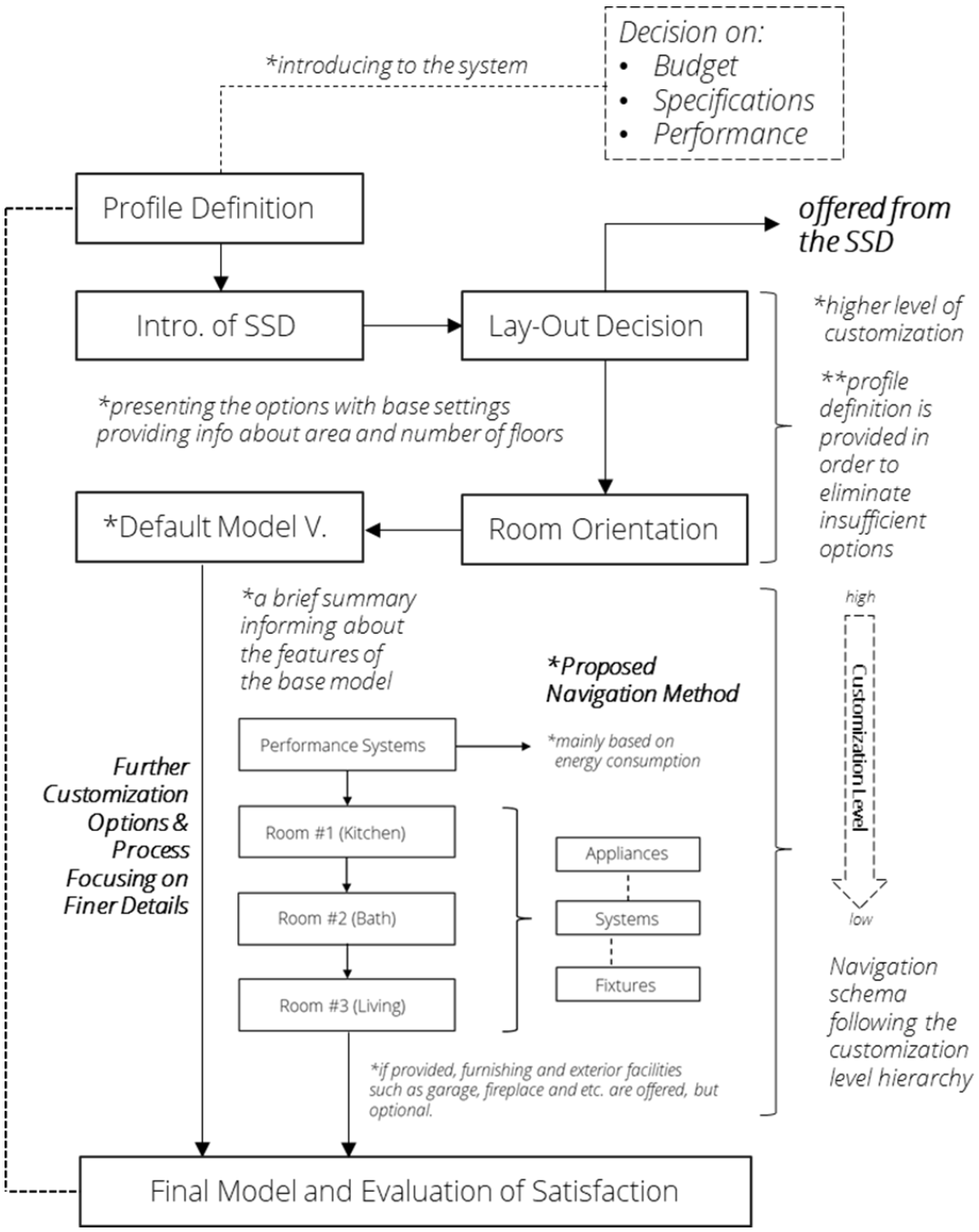

Figure 5.11. The diagrammatic representation of the choice navigation methodology developed within the scope of the study

For the configurator developed within the research, it was decided to integrate a Search and Filtering bar into the tool, instead of creating a separate screen for this profile definition process. This allows customers to input their basic expectations, such as area, number of rooms, and floors, into the system in the simplest way.

Secondly, a new procedure design was proposed within the newly developed model with specific alterations made on the conventional navigation scheme encountered in the currently available examples. Among the adjustments made, the most prominent difference herein was about how the navigation scheme is divided into steps/stages. As a matter of fact, the detail level of the customization offered through the configurator was one of the most frequently mentioned subjects by participants in their evaluations. As this subject was elaborated on during the development of the exemplary configurator it's seen that only the navigation scheme of Firm A's example stood out from other configurators. It was observed that all the other configurators preferred to simplify the customization process by grouping similar components to reduce the number of criteria that must be decided by the customers (Figure 5.12). Offering packages and palettes for the entire level like interior and exterior, rather than offering them room by room, was the most prominent characteristic of this approach.

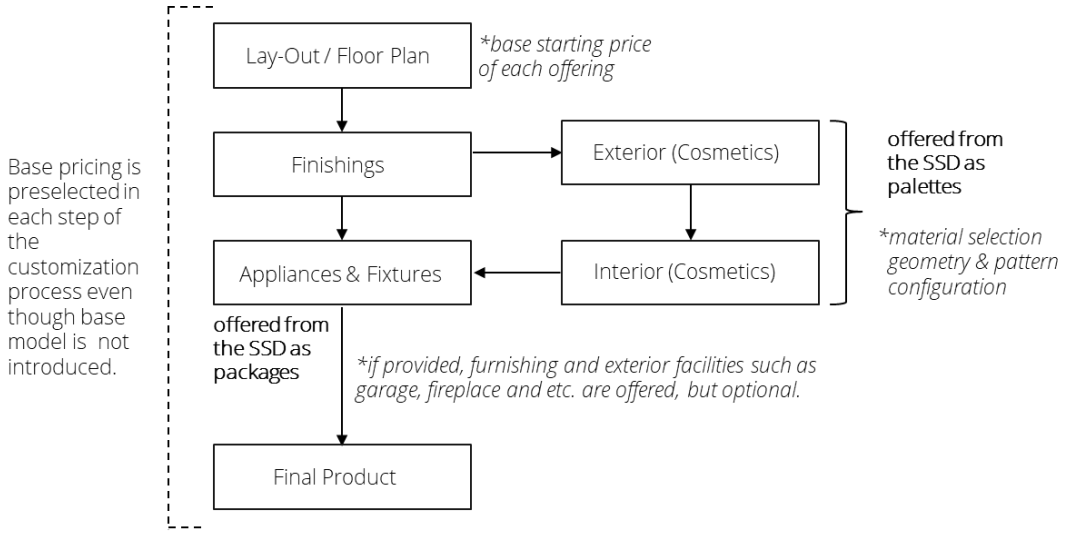

Figure 5.12. The diagrammatic representation of the simplified navigation method

In contrast, the configurator offered by Firm A provides a more extensive navigation scheme that allows users to focus on every component of the modular house that they are customizing. The difference here is not merely defined by the number of options and components customers are asked to decide on, but rather by the ability to be involved in design at smaller levels and details. Since this involvement required a step for each decision made on a component, the navigation scheme of this approach is more extended considering simplified versions. The common schemes are depicted as follows (Figure 5.13):

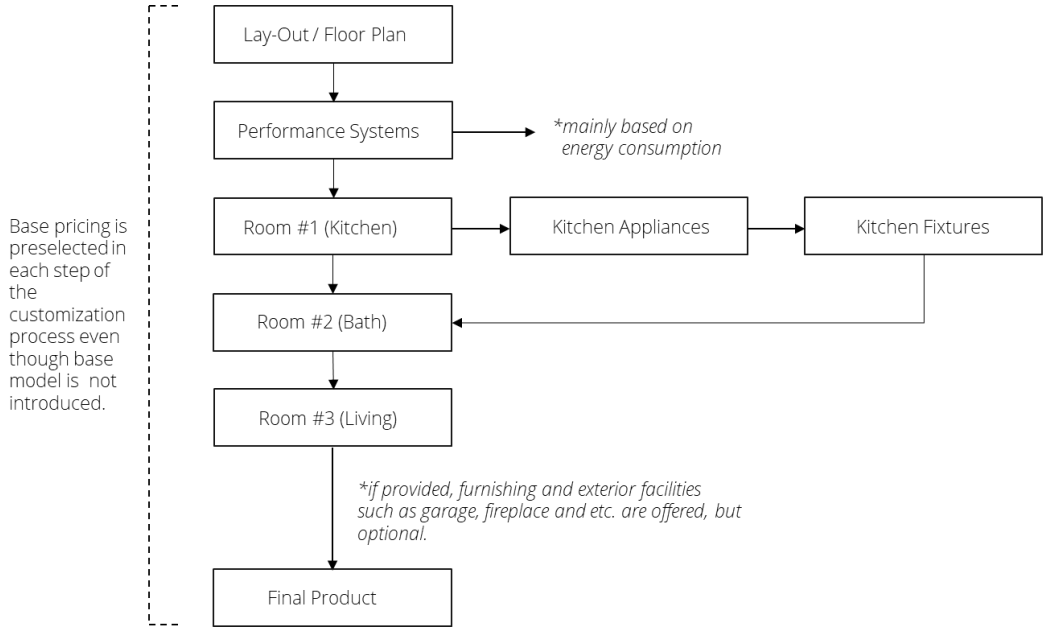

Figure 5.13. The diagrammatic representation of the detailed navigation method seen in Firm A's configurator

At this point, both navigation schemes encountered have their advantages and disadvantages, as identified in the interviews conducted. Participants frequently mentioned in their reviews that simplified navigation schemas did not give customers enough design authority, while Firm A's approach of defining separate steps for each appliance and system was found to be intimidating and hard to follow. For the proposal, a new scheme has been developed by focusing on the beneficial aspects of both sides. According to the new scheme, the layout and exterior steps in the configurators are arranged following the one used by Firm B, while the interior

design process is divided into rooms similar to Firm A's. According to the new scheme, each room is presented as a stage in the process, while lower-level customization components are listed as sub-stages under them. As a result, users can perform much more detailed customizations without encountering as many steps as in the detailed navigation schemes (Figure 5.14).

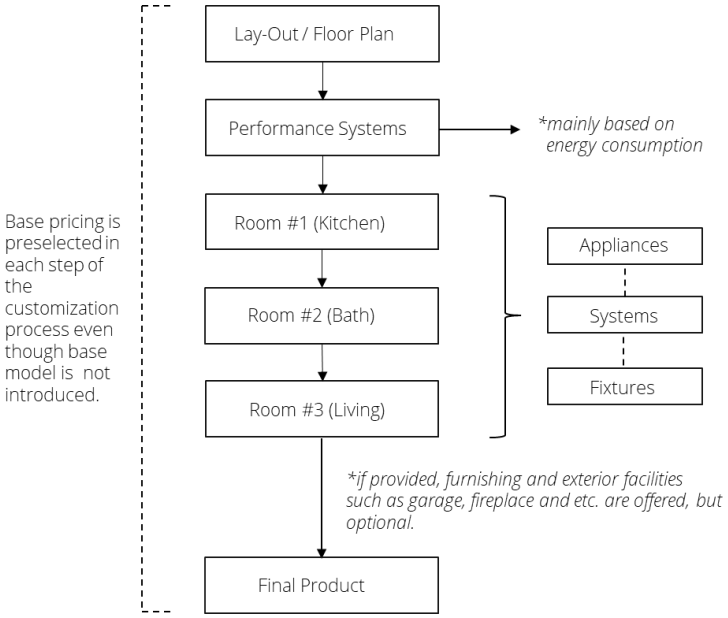

Figure 5.14. The diagrammatic representation of the proposed navigation method employed in the configurator developed

As the last major adjustment made in the proposed methodology, an additional step has been included in the process for the introduction of the base models offered to the customers. Based on the methodology developed, it was recommended that customers be presented with the default model offered by the system through a screen similar to the summary, once they had chosen the layout and orientation of the rooms, which are considered the highest level of customization in housing. The reason behind this addition is that many participants in the interviews failed to notice the presence of the default model offered in the configurator, which led them to approach the process as if they were designing a house from scratch, making it more difficult for themselves. This step aims to help the customers understand what they do not like about the standard model and focus on those components. Additionally,

they will receive direct information about the starting price, allowing them to better keep track of their preferences, which may bring additional fees.

Apart from these additions and modifications, the overall process, as mentioned, is similar to the choice navigation methodology offered by Firm B. This methodology, developed on an already functioning and well-regarded foundation, promises a much more adequate and satisfying experience with these changes. However, to offer a truly comprehensive proposal and ensure that customers get the best possible results from modular house configurators, this methodology must also include certain features within the configurator. These features have been examined and exemplified within the proposal, outlining a framework.

5.2.2 Features Framework

In the proposal, a framework of features has been presented that are identified based on the adequacy criteria in order to ensure a satisfactory configurator experience. To demonstrate the practical application of the proposal, the features mentioned here have been adapted to the web-based configurator developed based on the one provided by Firm B. The features identified, which have also guided the developed configurator, are illustrated in the following diagram (Figure 5.15)

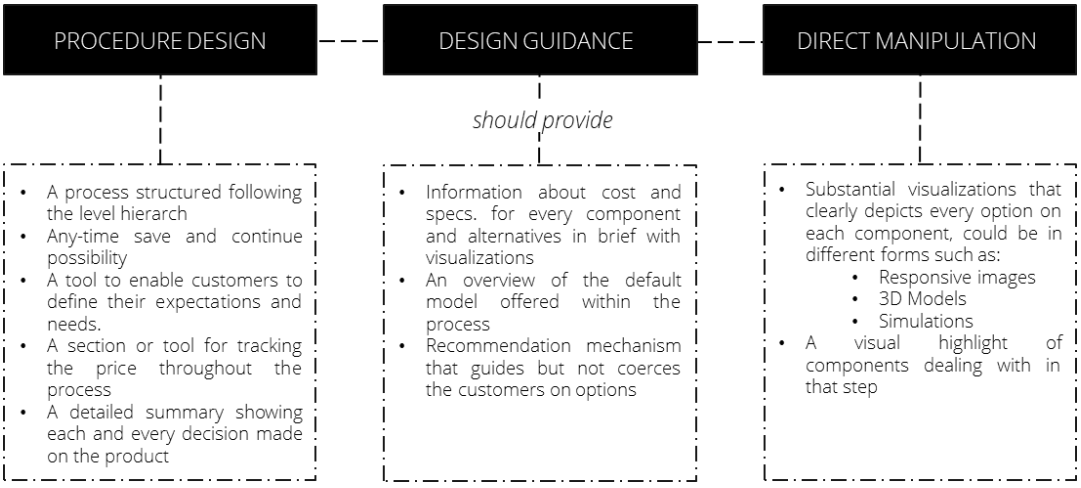

Figure 5.15. The diagrammatic representation of the identified features

As previously mentioned, although Firm B's web-based configurator meets many of the criteria presented here, a series of additions and modifications have been made to address its shortcomings and provide users with a better experience. The points where the proposed example differs from the original tool due to these changes are listed as follows:

- The navigation scheme has been redesigned to align with the proposed methodology's approach, dividing the interior customization steps into rooms to facilitate detailed customization (Figure 5.16).

Figure 5.16. The new navigation scheme of the developed configurator

- A Search and Filtering bar has been added to enable customers to express their needs and demands for the house they design. Herein, the development of the tool is made in accordance with the discussion made in the methodology. The filtering subject is provided for the parameters of the number of stories/bedrooms/bathrooms, area, price range, and lastly, heating and cooling systems (performance systems). (Figure 5.17)

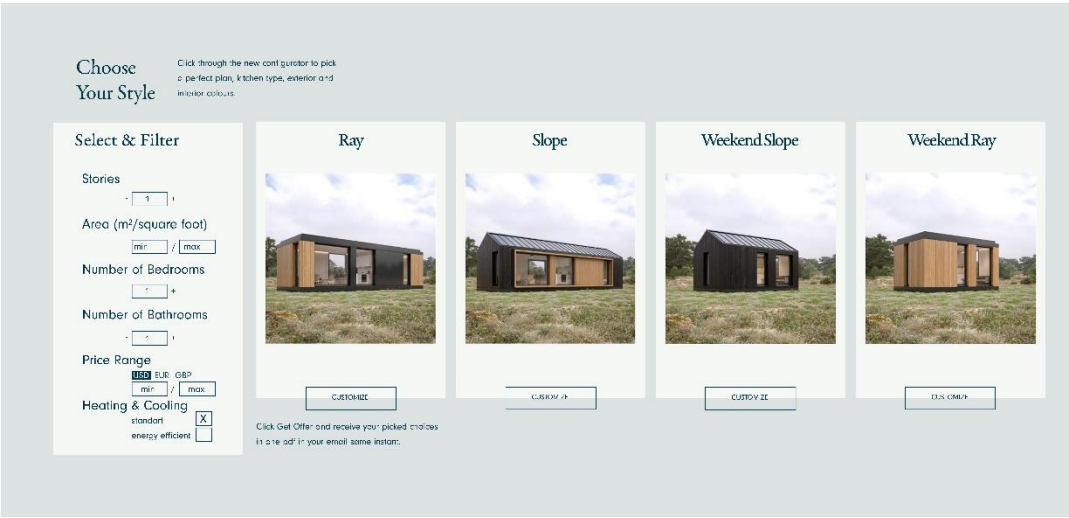

Figure 5.17. The newly added Search and Filtering bar can be seen at the left of the interface

- An introductory screen has been added for the default model after passing through higher levels of customization stages. (Figure 5.18)

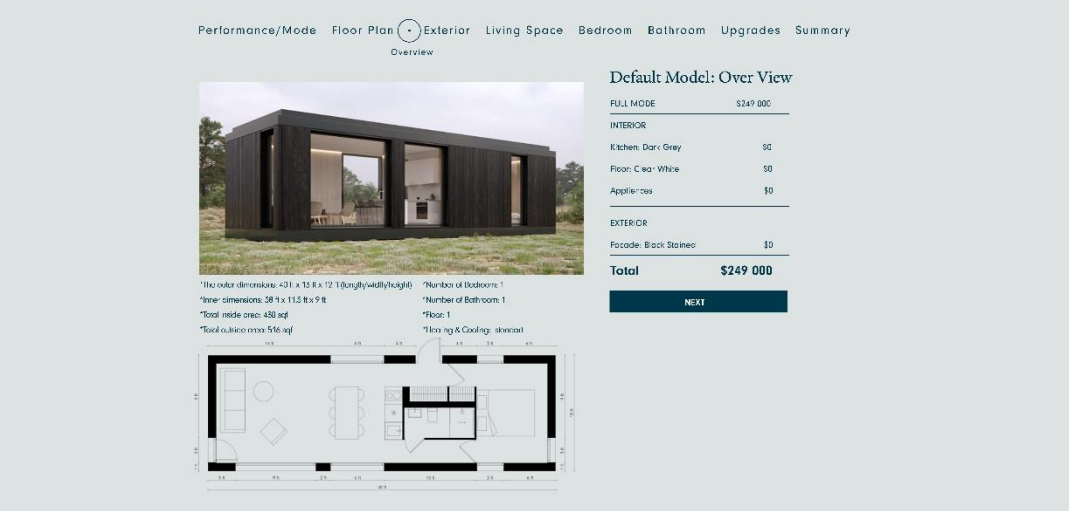

Figure 5.18. The introduction screen for the default model which is included in the newly developed configurator

- The number of visual elements and information boxes has increased for the newly developed configurator. Also, visual elements have been added to sections like the info box and summary, which participants found informative but visually insufficient previously (Figure 5.19).

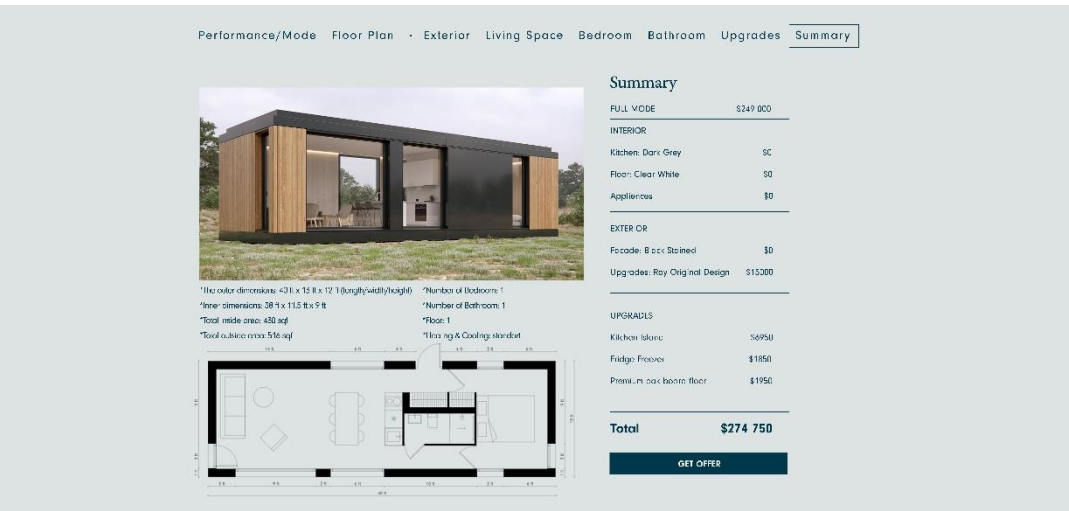

Figure 5.19. The updated version of the summary screen with the rendering

- Lastly, an animation has been added to highlight the components customized by participants, ensuring that the currently manipulated visual is noticeable (Figure 5.20).

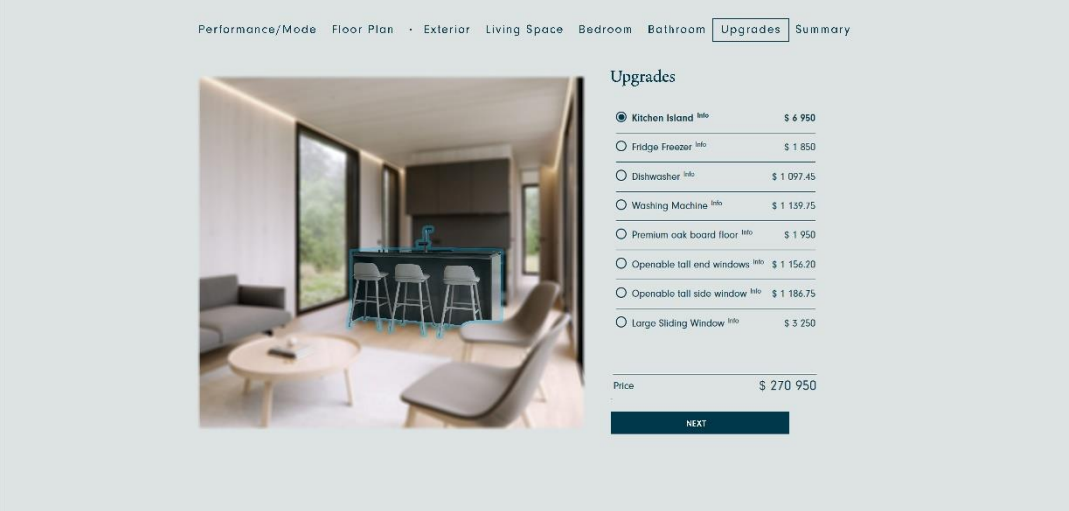

Figure 5.20. The kitchen island highlighted on the screen

The developed configurator including these abovementioned changes was presented to the randomly selected 5 of the participants previously interviewed, and the proposed methodology and features framework were examined through their feedback to the developed configurator.

5.2.3 Reactions and the Validation

The first thing that caught the participants' attention in the configurator was the new stages added to the interface and the new steps included in the process. After encountering the newly added stages of the interface, and completing the process without any trouble, participants expressed their satisfaction with the more detailed configuration process. Despite the limited customization options provided in these stages due to the constraints of the manufacturer's solution space, the new navigation scheme noticeably increased participant satisfaction. As noted by some participants, the new scheme successfully enhanced their sense of control over both the product

and the process, as intended, while not making the process more complex and harder to complete.

Although the first thing that caught participants' attention on the interface was the updated navigation bar, it didn't take them long to notice the other features. The first feature they encountered among these was the search and filtering tool provided on the main page. Even though this tool wasn't a highly functional feature due to the limited number of layouts available, it was still appreciated by the users based on the potential it has. In the end, positive feedback received from the participants regarding this tool validated its use for the profile definition step, even though it would have been a stronger conclusion if the tool was fully functional with the increased number of options provided to the users.

The next feature that the participants encountered in the configurator turned out to be the most controversial as well, which was an introduction to the default model. The reason behind this controversy here was about the interface designed for the introduction. While some participants appreciated this kind of overview as it provided a reference point for the design process, others mentioned that this screen could be confused with the summary and caused interruptions in the process. Although the idea was generally considered as beneficial, it became clear that a different approach during implementation might be more appropriate. Lastly, the addition of more renders and visual animations throughout the process was positively received by all participants.

Based on the participants' feedback, it was inferred that the newly developed configurator provides a better experience compared to the one provided by Firm B. Herein, despite features like the recommendation tool which could not be presented and therefore made it impossible to reach a conclusion, or the search and filter tool which could not be fully tested, the interviews have still led to a conclusion. This conclusion is that the choice navigation model developed following the adequacy criteria within the study provides a reference-worthy example for configurator building.

CHAPTER 6

CONCLUSION

Today, modular housing has become the only application area in the construction industry where mass customization, recognized as the production paradigm of the 21st century, stands out. Despite numerous studies and trials conducted over decades in this field, a fully adequate case where this strategy has been successfully adapted into a production scheme has yet to be encountered. The research done on this subject has revealed that the issue stems from the choice navigation factor, which has been overlooked in adaptation efforts toward mass customization. While choice navigation models in mass customization applications need to be customized and optimized according to the industry, product, and customer base, it has been observed that this optimization has been neglected in the trials conducted for modular housing. Indeed, when examining the web-based configurators used for choice navigation in modular housing today, it is known that most are built on an elementary methodology and possess only the most basic features. With this awareness, this study delved into establishing a new choice navigation model tailored to the modular housing industry to overcome this deficiency.

As part of the research methodology designed to develop this model, the adequacy criteria were first identified through a literature review, defining the qualities that web-based configurators must possess to offer a satisfactory experience to users. In the next stage, to verify the effectiveness of these criteria and understand the features and strategies customers wish to see, a series of interviews was conducted in which currently available web-based modular house configurators were compared and evaluated. Based on the outcomes of these interviews, the proposed choice navigation model was developed. This model, which includes a choice navigation methodology and a set of features necessary for the proper functioning of this methodology, was further tested through a series of interviews conducted within the

scope of the study to determine whether it truly meets customer expectations. Thus, the functionality of the developed model was validated at the end of the research.

Based on the study's outcomes, it was first found that users' expectations from configurators can be formulated into a set of criteria. The methodology and features developed and offered according to these criteria elevate the customization experience that users will have through the configurator. Another finding of the research is that most of the currently available configurators are insufficient in providing a satisfactory experience for their users. However, there are successful examples that offer an enjoyable process and adequate end products, even if they employ conventional features and methods. Considering this, it has been understood that, contrary to the expectations, newly developed models do not need to be revolutionary. Instead, satisfactory results can be achieved easier and faster by making modifications to conventional methods and features that have been successfully implemented.

Although the study aimed to be built and advanced on a solid foundation as much as possible, certain limitations can still be mentioned. The first and most significant limitation is that many of the participants interviewed were not modular housing customers. While configurators are designed to be used by users from all profiles, it is anticipated that users who have genuine intentions of purchasing a product would be much more selective and attentive regarding the process, tools, and final product. However, reaching such a demographic is quite difficult in our country, where the number of modular home sales is currently very limited.

Another limitation encountered in the study is the lack of sufficient data in the market and industry for developing a new choice navigation model. If there were more sales more data would be gathered in terms of customer profiles and decision patterns which would facilitate the testing of advanced features and methods like collaborative filtering during model development. However, the ability to build a successful example based on the data and examples available within the study suggests that there is not an urgent and significant need for such different features

and methods at this point. As a matter of fact, the employment of examples like the model developed in this study in mass customization applications could positively impact sales numbers, thereby helping to overcome some of the current limitations. In this way, the outcomes of this study can be seen as a steppingstone for many further advancements that could be made in the future.

In conclusion, this study provides valuable insights into the development of a choice navigation model for implementing mass customization in the modular housing industry. By addressing the identified adequacy criteria and leveraging the new choice navigation methodology along with a set of features, firms can modify and optimize their configurators to overcome the deficits they face in choice navigation.

For future research, it could be focused on employing further advanced methods and features. However, as mentioned earlier, it is crucial for the industry to first see an increase in successful applications in this area and a rise in the sales of personalized modular houses.

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