Metropolia
University of Applied Sciences

Hochschule für Technik
und Wirtschaft Berlin
University of Applied Sciences

"Custom Home Building: (Integrating Design, Procurement, and Construction Management to a Digital Ecosystem)"

Master's Thesis

Master of Science in Construction and Real Estate Management

CONREM

Faculty 2

from

Mohammad Ismail

Date:

Berlin, 24.12.2024

1st Supervisor: Prof. Dr.-Ing Nicole Riediger

2nd Supervisor: Prof. Papon Dev Kumar

Acknowledgement

I would like to express my deepest gratitude to those who have supported and guided me throughout this interesting journey of completing this thesis.

First and foremost, I am profoundly thankful to my supervisors, Prof. Dr.-Ing. Nicole Riediger and Prof. Papon Dev Kumar for their time, guidance, encouragement, and expertise. Their expert guidance and feedback have helped me to add quality to my work and research of this thesis.

A special thanks to my family and friends as they supported me emotionally by encouraging me to achieve my goals with this research even though it seemed impossible at certain times.

I am also grateful to my colleagues and peers at HTW-Berlin for creating a collaborative environment around the campus which gives a lot of inspiration. The people who took part in testing have shown a great gesture by taking spending their valuable time on understanding the research, testing the platform and providing feedback. Therefore, I extend my sincere thanks to them as well.

To everyone who played a role in this journey, whether through direct involvement or moral support, I am deeply thankful

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Copy of Proposed Conceptual Formulation

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Conceptual Formation
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Date:

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Introduction

The construction industry is undergoing very important developments, driven by advanced technologies and shifting consumer preferences. Considering this, the custom home building segment presents a unique opportunity to utilize technology for creating highly personalized living spaces. Unlike mass-produced homes, custom-built homes cater to individual preferences, lifestyles, and specific needs, making each project distinct. This thesis explores a need for specific platform dedicated to facilitating the custom home building process, offering users an intuitive and comprehensive tool to design, plan, and visualize their dream homes.

Context and Background

The traditional custom home building process involves a series of complex steps, including detailed planning, design, budgeting, and construction, requiring close collaboration between homeowners, architects, and builders. However, the traditional approach often faces challenges such as miscommunication, misalignment of expectations, and inefficiencies in project management.

Emerging technologies such as Artificial Intelligence (AI), Building Information Modeling (BIM), augmented reality (AR), virtual reality (VR), and advanced 3D rendering offer new possibilities for enhancing the custom home building experience. Leveraging these technologies, a dedicated platform can provide users with a seamless and interactive interface to conceptualize their custom homes, bridging the gap between their vision and the final product.

Importance of the Study

The importance of this study lies in its potential to revolutionize the custom home building process by providing a digital platform that bridges the gap between initial concepts and final construction. By offering an interactive and user-friendly tool, the platform aims to reduce hassle and miscommunications between contractor and the end-user, because of end-users limited knowledge of construction. This not only benefits the end-users by enabling them to better visualize and plan their dream homes but also assists

architects and builders in managing projects more efficiently, ultimately advancing the custom home building industry.

The Importance of Digital Ecosystems

A digital ecosystem is a collection of platforms and technology that complement one another to improve bespoke home planning, design, construction, and management (Smith & Tardif, 2009). The emergence of digital technologies has sparked a radical change toward more streamlined and effective procedures throughout different industries including construction. But the custom home building sector has always relied on manual processes and in-person interactions in both, planning and construction phases.

Building information modeling (BIM), Artificial Intelligence (AI) Internet of Things (IoT), augmented reality (AR), virtual reality (VR), and cloud computing are examples of digital technologies and platforms that are integrated into several architectural, engineering and planning processes to form a digital ecosystem in the professional and technical spectrum of the industry (Eastman et al., 2011; Gubbi et al., 2013; Azuma, 1997).

These tools make it easier to collaborate in real time, optimize workflows, and enhance decision-making. The ecosystem not only enhances productivity and accuracy but also fosters better communication among stakeholders, including architects, builders, clients, and suppliers (Love et al., 2011).

Current Challenges

Despite the potential benefits, the adoption of digital ecosystems in custom home building faces several challenges. These include high initial costs, resistance to change from traditional practices, lack of standardization, and the need for specialized skills (Becerik-Gerber & Rice, 2010). Additionally, the integration of various digital tools into a cohesive system remains a complex task, requiring a clear understanding of how each component interacts within the ecosystem (Kensek & Noble, 2014).

Problem Statement

Despite the technological developments in construction on the professional end such as planning, designing and collaboration software's and platforms, the industry faces several challenges when it comes to communicate with the end-users, particularly in the initial conceptual formulation phase of their home building. These challenges include effectively capturing client preferences, managing expectations, and integrating sustainable and innovative design elements from the beginning. The absence of a streamlined and user-friendly platform worsens these issues, leading to project delays, increased costs, and client dissatisfaction.

Objectives

The primary objective of this thesis is to develop a comprehensive framework for a digital platform dedicated to the planning, designing and managing the construction of custom home building projects by end-users with little to no knowledge of construction. This platform aims to enhance user experience, improve communication among stakeholders, and integrate advanced technological tools to facilitate the design and planning process.

To achieve the mentioned objective, the thesis will focus on:

1. **Analyzing Current Practices**: Review existing digital platforms and methodologies in custom home building, with a focus on an end-user's home building process.
2. **Identifying User Needs**: Conduct research to understand the needs and preferences of potential users, including homeowners, architects, and builders.
3. **Suggesting Platform Features**: Propose a set of features and functionalities of a platform that addresses the identified challenges in home building for the end-users.
4. **Validate the Platform**: Interview related to the proposed platform as user feedback, case studies that will be carried out throughout literature review and data analysis.

Research Questions

Are there any custom home building software's or platforms that serve homeowners?

To what extent custom home building is digitalized already?

How would digital integration of design, procurement and construction, improve home building for homeowners?

What kind of solution is to be provided for achieving custom home building digital ecosystem?

How to implement the Custom home building digital platform and make it user friendly?

What digitalization framework or a mix of these, such as, AI, Machine Learning, AR, VR or a Desktop software, will be the optimum selection for the Platform of custom home building?

Furthermore, with authentic study and research during the whole thesis period, numerous technicalities and key points of this topic will be discovered.

Methodology

Conceptual Framework

The methodology for this thesis will be focusing on the theoretical observations and practical applications of digital ecosystems in custom home building. The research will be structured around the following key components:

1. **Literature Review**
    - Conduct an extensive review of existing literature on digital ecosystems, AI, IoT, AR, VR, and other relevant technologies (Smith & Tardif, 2009; Eastman et al., 2011; Gubbi et al., 2013; Azuma, 1997).
    - Identify best practices, success stories, and challenges faced by the industry in adopting these technologies (Love et al., 2011).

- Analyze case studies of custom home building projects that have successfully implemented digital ecosystems (Becerik-Gerber & Rice, 2010).

2. **Stakeholder Analysis**
   - Identify the key stakeholders involved in the custom home building process, including architects, builders, clients, and suppliers (Kensek & Noble, 2014).
   - Expectations and challenges related to digital ecosystems.
   - Map out the interactions and dependencies among stakeholders within the digital ecosystem (Eastman et al., 2011).
3. **Technology Integration**
   - Develop a conceptual model for integrating various digital technologies into a cohesive ecosystem (Gubbi et al., 2013).
   - Explore the technical requirements, interoperability issues, and potential solutions for seamless integration (Azuma, 1997).
   - Assess the impact of technology integration on project timelines, costs, and quality (Love et al., 2011).
4. **Implementation Framework**
   - Propose a step-by-step framework for implementing a digital ecosystem in custom home building (Smith & Tardif, 2009).
   - Outline the necessary phases, from initial planning and stakeholder engagement to technology deployment and continuous improvement (Succar, 2009).
   - Highlight the critical success factors and potential risks associated with each phase (Becerik-Gerber & Rice, 2010).
5. **Evaluation Metrics**
   - Develop a methodology for measuring improvements in productivity, efficiency, communication, and client satisfaction (Love et al., 2011).

- Propose a feedback mechanism for continuous refinement and enhancement of the digital ecosystem (Smith & Tardif, 2009).

Data Collection and Analysis

The Data collection of this thesis will be extracted from the review of literature and research done on custom home building and its digitalization. However, in this section further practical developments will also be considered and used as a benchmark or source for further development, such as, combining all observations and taking a step further with the selection of right content of the home building platform and its development phases.

To prove the need of a digital solution for custom home building and then in return integrate it with construction management, design and procurement, all available data will be analyzed by using mixed methods. Statistics, future potential, problems, innovation gap and other such answers will be discovered to the research questions by the analysis of all the data collected. Hence, a comprehensive understanding of custom home building and its digital integration will be provided. Furthermore, the analysis will serve as stepping stone and foundation to the digital platform for custom home building as all the factors would indicate an ideal solution and integration.

Expected Outcomes

The goal of the thesis is to create a prototype based on suitable framework for building a custom home digitally. This framework would discuss and present the ideal digital platform that will integrate construction management, designing and procurement with custom home building. That platform will be catering end-users or homeowners where numerous home construction related activities would be easier for them to understand and carry out without the need of experts. It is also expected that this research findings would provide the construction industry and private residential construction market stakeholders with useful advice on how to use digital technology to improve efficiency and creativity in custom home building projects.

Planned Schedule		
Tasks	**Estimated completion date** **November 2024**	**Estimated completion date** **November 2024**
Basic research on the topic	June	
Submitting Drafts	June	
Conceptual Formulation Draft	July	
Submit Final CF	August	June Re-submission
To write Literature Review	September	
Data Analysis and Collection	October	
Data Analysis and Collection		October
Developing the solution		November-December
Assessment and feedback of the digital solution		December
Submit Thesis		December
Thesis Exam/Assessment Interview		T.B.D.
➢ Important Dates: July 2024 - Thesis submission deadline, December 2024 -		

Resources

- Library Website of HTW-Berlin: https://bibliothek.htw-berlin.de/en/about-us/use-library/library-from-a-to-z/
- Library Website of Metropolia UAS: https://metropolia.finnia.fi/
- Google Scholar: https://scholar.google.com/
- https://Sciencedirect.com
- https://constructionjournal.com
- Previous findings in the area of study.
- Related Academic books.

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Abstract

This thesis explores the possibility of integrating a custom home building platform to the construction digital ecosystem. It is aimed at integrating procurement, construction management and designing of custom home buildings to a digital solution that enhances the construction of customized homes. The solution developed is a prototype of the proposed platform. However, during the development of the research complete framework for a fully functional platform is covered. Programming, financial and duration limitations restricted the development of the platform to mere a prototype. The prototype does convey the functions of the proposed framework and is proven through validation in this thesis.

Extensive literature research on the digitalization in construction and the importance of custom home buildings is combined to analyze current digital developments in custom home buildings. In this way, the latest technological developments are assessed to be included in the proposed framework. The framework includes technologies like Natural language processing (NLP), Artificial Intelligence (AI), live 3D model viewer etc. Technologies that support the goal of this thesis i.e., achieving the integration of procurement, designing and construction management to the custom home building ecosystem, are selected and utilized in the development of the prototype.

The result shows that the prototype is functional and allows a user to select different materials and designs displayed in a 3D viewer along with cost details. The user can make selections and generate a final report which shows the project details i.e., price, materials, duration and a 3D model. To fulfill the construction management aspect, the prototype is currently displaying a minimal window that allows contractors and users to update the progress of the project. With the help of professional coding and further development of the existing prototype, according to the framework mentioned in the thesis, a fully functional and robust platform could be developed that will allow its users to create 3D custom home models with architectural, planning and budget details.

Keywords: Ecosystem, Custom Homes, Framework, Prototype, Integration, End-users perspective.

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List of Abbreviations

Fig.	Figure
IEA	International Energy Agency
3D	Three Dimensional
AI	Artificial Intelligence
ML	Machine Learning
NLP	Natural Language Processing
BIM	Building Information Modeling
AR	Augmented Reality
VR	Virtual Reality
API	Application Programming Interface
LLM	Large Language Models
IMS	Integrated Management System

1. Introduction

Custom home building is a very important sector of the construction industry and holds great significance to its stakeholders, Custom homes construction demands a direct involvement of stakeholders and is therefore a very detailed process. There are numerous digital tools that are being used nowadays in the ecosystem of custom home building. These tools are used by the contractors, designers and suppliers during a custom home building project to increase efficiency and productivity but somehow there is a huge gap when it comes to involving the end users. The digital ecosystem of construction services can directly be used by the contractors and designers in custom home building projects because it is a construction process, but it requires human interaction to deliver that information to end users. The end users or homeowners that are looking to build a custom home assess the construction plan and budget with little to no knowledge of the construction market.

This research aims to focus on findings to bridge this gap between the contractors and end users with the help of research and proposing a solution. The desired solution will be an example of a custom home building digital ecosystem in the form of a platform that can serve both contractors and homeowners. This digital platform will be expected to help the contractors to understand the requirements of a homeowner remotely. The platform will be able to develop and gather information regarding a project and compose it automatically for the contractor. Whereas the homeowners can provide the requirements and specifications of their home or project in a very easy manner. The end users or homeowners are expected to be benefitting in the planning and budgeting phase of the project because the interface of this platform will be designed to simplify providing home requirements and receiving approximate cost and duration of the construction in return.

This will be achieved by analyzing some suitable latest digital tools to see whether any integration is possible in the proposed solution. Moreover, there have been some platforms that will be researched and analyzed as case studies in this thesis to understand the status of digitalization of custom home building ecosystem and to propose improvements and the implementation of proposed platform or its framework. However, the

outlook of these platforms shows that these platforms are either recommending contractors by receiving some basic information about a project which is followed by manual handling and site visits or homeowners are restricted to just design a visual outlook of their home as a simple 3D plan by drag and drop feature in a window.

This field also needs more research because of the faster than ever evolution in digital ecosystems and the latest developments and integrations of technologies such as, Artificial Intelligence (AI), advanced applications, software and automated workflows for business processes. This has resulted in changing trends, fierce competition, and improvised practices across industries worldwide, only innovation and progressive approaches keep an industry alive. Digitalizing industries is one of the most innovative ways that has helped industries to thrive. Digitalization has provided solutions to some of the most impossible problems of this modern-day world.

When it comes to construction, digitalization is the core of every project but mainly on the enterprise level. However, it is yet to be adopted innovatively to make the industry more accessible, business-friendly, and user-friendly. Software development for designing and/or managing projects is not a target of this thesis because those advancements are already at an optimum level. Henceforth, the digitalization for construction professionals will be studied only to help draw conclusions and assess the data obtained.

The target of this thesis is the custom home building sector of the construction industry. The consumer end of this sector will play an important role because custom homes are often built by private clients with little to no knowledge of construction. Therefore, taking their needs and perspective into account is a very vital factor in developing this thesis.

1.1. Research Questions

- Are there any custom home building software’s or platforms that serve homeowners?
- To what extent custom home building is digitalized already?

- How would digital integration of design, procurement and construction improve home building for homeowners?
- What kind of solution is to be provided for achieving custom home building digital ecosystem?
- How to implement the Custom home building digital platform and make it user friendly?
- What digitalization framework or a mix of these, such as, AI, Machine Learning, AR, VR or Desktop software, will be the optimum selection for the Platform of custom home building?

Furthermore, with authentic study and research during the whole thesis period, numerous technicalities and key points of this topic will be discovered.

2. Methodology

2.1. Research Design

This study incorporates a mixed-methods research design to comprehensively explore how custom home buildings could benefit from a certain digital ecosystem that can comprehensively integrate design, procurement, and construction management in the custom home building industry. This approach basically allows a deep understanding because it combines qualitative insights from literature and quantitative data from existing trends and platforms.

2.2. Research Objectives

The primary objectives of this research are:

- Identifying key components and features of digital ecosystems used in custom home building.
- Evaluating the impact on digital tools by integrating design, procurement, and construction management.
- Analyzing the benefits and challenges of using digital ecosystems in custom home building projects.

Developing a framework and a platform prototype for the effective implementation of digital ecosystems that can be useful for custom home building.

2.2.1. Tools and Instruments

A detailed protocol will be developed to guide the literature review process which will include research from following sources:

1. Books
2. Articles
3. Journals
4. Case study of platforms in digital ecosystem.

The rewriting or incorporation of the information scrapped from these sources will follow standard referencing and in-text citation ensuring a systematic and comprehensive approach relative to the subject of thesis.

A comprehensive list of secondary data sources will also be compiled to get help in the development of data analysis and then the solution. Secondary data availability is very wide and sometimes unreliable; therefore, only reliable and relevant information or data will be analyzed.

2.3. Data Collection Methods

- **Qualitative Data Collection:** Qualitative data collection will only include literature review in which a comprehensive review of existing literature, including academic journals, industry reports, and case studies, will be conducted to gather qualitative insights on the use of digital ecosystems in custom home building.

- **Quantitative Data Collection:** Quantitative data will be sourced from existing research, such as industry surveys, facts and figures, and case studies of the available custom home building services. These datasets will provide information on effectiveness, and outcomes of digital tools in the custom home building industry.

2.4. Data Analysis Methods

- **Qualitative Data Analysis:** To analyze the collected information and research from literature review a simple thematic analysis will be adapted. In such analysis the themes, patterns and the current integration of digital ecosystems will be identified.

- **Quantitative Data Analysis:** To carry out Quantitative Data Analysis following two approaches are selected:

1. **Descriptive Statistics:**

Descriptive statistics will be used to summarize the secondary data. This will provide an overview of the use of digital tools in custom home building and construction markets.

2. **Comparative Analysis:**

Comparative analysis will be conducted to compare findings from different data obtained from research. By this comparison, common trends, limitations and services provided of construction and custom home digital ecosystem, will be identified.

2.5. Analysis or Procedures

Analysis will include two following main steps:

Preparation Phase

In this phase observations and conclusions from the literature review will be drawn in support of the research questions. All the findings from primary and secondary data sources will be compiled to continue with a solid development towards the objective of this thesis.

Integration Phase

In this phase, the observation and conclusions from preparation phase will be applied to develop a solution to achieve the research objective. This will be done by identifying a suitable framework for the solution and implementing it to develop a custom home ecosystem.

Validation Phase

In this phase, a total of three testing professionals are selected who will test the prototype of the platform. The solution or prototype will be evaluated by them to draw a fair conclusion, and further suggestions will be made by them. This will validate the research by providing solid evidence of achieving the objectives and set foundation for further development.

2.6. Ethical Considerations

Confidentiality: Maintain the confidentiality of all data sources, ensuring that any sensitive information is not disclosed. The corporate aspects to this research and prototype make the information vulnerable to be utilized commercially. This could be done only with the permission of the HTW review board and the author.

To store data securely for data privacy matters and access limited to the review team and board. Any process that involves institutional board approval will be brought forward to obtain the approval to ensure the following of ethical guidelines.

3. Literature Review

Custom home building is a detailed and complex process, where every phase, from the architectural design to the final coat of paint, is personalized to suit the client's vision. Unlike large-scale housing developments, where homes are built in bulk and to a pre-determined plan, custom home building requires a unique collaboration between homeowners, architects, builders, and numerous other subcontractors. This review explores the intricacies of this ecosystem and finds out how digitalization is incorporated in custom home building. Useful aspects, such as sustainability, the role of specialized subcontractors, the challenges of managing material supplies, and the growing influence of digital platforms in design and construction will be evaluated carefully. It also focuses on how online tools are helping clients to take a more active role in shaping their dream homes and to what extent online or digital ecosystems have been developed to help the clients make their decisions rationally.

Digitalization in construction and real estate industry has revolutionized the industry. Over the years, digitalization has become an essential part of the construction and real estate industry. Digitalization has brought about significant changes to the construction and real estate industry; from the way projects are managed to the way customers search for properties. This literature review will also explore the impact of digitalization on the construction and real estate industry to help understanding digital developments in custom built homes.

Chapter 1: Custom Home Buildings

In 2018, the Washington post published an article by Wydler and Wydler about custom homes which explains that custom home building is the process of designing and constructing a home specially tailored to meet the homeowner's preferences, needs, and lifestyle. This means that every phase and aspect of building the home, from its floor plan to its finishing materials is customized. It is a highly customized and personalized construction process where the homeowner is directly involved in the decision-making process. It involves close collaboration between homeowners, architects and builders to create a unique living space. This type of construction offers a high level of flexibility, allowing homeowners to incorporate design elements that suit their needs, whether that involves creating open spaces, adding energy-efficient systems, or accommodating family-specific layouts, such as multi-generational homes (Wydler & Wydler, 2018).

Moreover, custom home building allows for the integration of latest trends and technologies, both during construction and for the home's long-term operation. For example, many custom-built homes today feature smart systems that manage energy consumption, lighting, and security, which follows the trend of sustainable and energy-efficient housing. Custom homes are not only a personally designed or selective process but also a very practical and long-term investment (Cesaris & Mandolesi 2013).

One of the biggest advantages of custom home building is its ability to follow sustainable techniques into the design from the start. Many custom homes are being designed energy efficient, incorporating solar panels, geothermal systems, and high-performance windows to reduce energy consumption. This is becoming highly important with time, as homeowners tend to build homes that not only reflect their personal preferences but also help lower their carbon emissions (IEA, 2022).

3.1. Fundamentals of custom homes:

The following factors are important to understand before proceeding with this research because the integration of construction management and designing to a custom home building ecosystem is highly dependent on the fundamentals of custom homes.

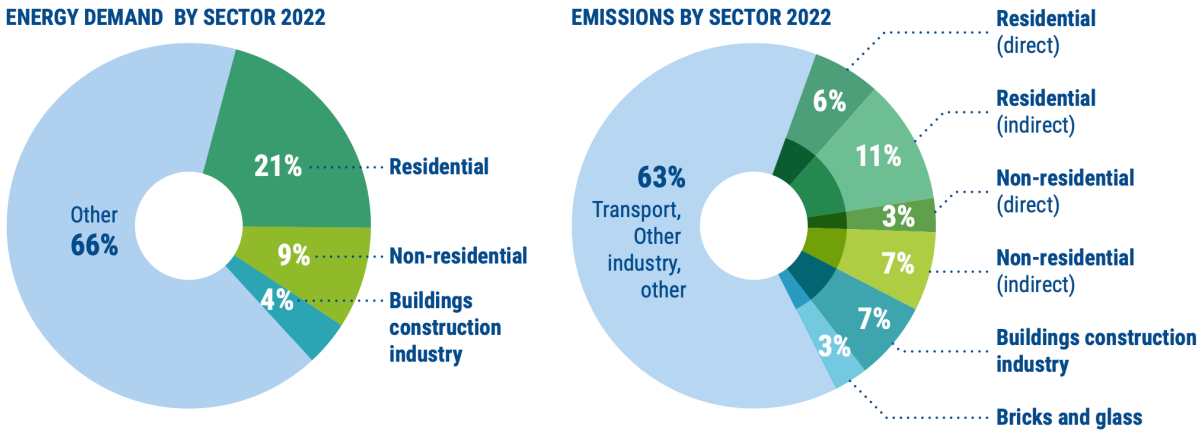
3.1.1. Client focused Design and Sustainability

The design phase of any construction project is the most important phase. It helps the client to realize the vision and is often supported by a strong focus on sustainable building practices. Nowadays, homeowners are highly interested in eco-friendly materials and energy-efficient designs. According to Svajlenka and Kozlovska in 2022, the trend towards sustainability is not just a passing phase, it's here to stay. More and more clients want homes that are both beautiful and environment friendly, choosing features like energy efficient windows, solar panels, and sustainable materials such as bamboo flooring or reclaimed wood. Architects are now expected to utilize such environmentally friendly elements into their designs and create a perfect balance between aesthetics and energy efficiency (Svajlenka & Kozlovska, 2022).

Sustainable custom homes are more than just using green materials. It also means designing homes that are energy efficient and environmentally friendly in their operation. According to Yong and Annie in 2007, minimizing carbon footprints of a house started as a niche but has gradually become mainstream. This shift points out the awareness of the impact of climate change and the role that our homes play in it. As a result, builders and architects are learning to work with new regulations and frameworks while prioritizing their client's vision simultaneously (Yong & Annie, 2007).

The below figure. 1 shows the importance of the residential sector when it comes to energy demand and emissions. Globally, the residential sector demands 21% of the energy produced whereas this sector emits almost 17% of the total emissions produced globally. (Tracking Clean Energy Progress, IEA, 2023)

Figure 1: Share of Residential sector in energy demand (left) and emissions (right) in 2022. (Source: IEA, 2023)



3.1.2. The Role of Subcontractors

Building a custom home is a very special process in which the general contractor oversees the project, and numerous subcontractors, each with their own area of expertise, work in different phases of the project to finish the house building. According to Borg and Scott-Young (2022), these subcontractors, whether they specialize in electrical systems, plumbing, or carpentry, are very critical to delivering the level of detail and perfection that clients expect in a custom home. These skilled and specialized subcontractors ensure that every phase of their job is executed perfectly. However, assigning specific jobs to these subcontractors also adds layers of complexity to the project (Borg & Scott-Young, 2022).

Coordinating all these subcontractors requires accurate project management. Builders must manage timelines, budgets, and the availability of various resources, making sure that each part of the process is completed without delays. This coordination is one of the most challenging aspects of custom home building. For example, delays in one area, like plumbing, can have a ripple effect which results in slowing down of other different construction processes, such as drywall installation or interior finishes. The interdependency between tasks and activities of a project means that careful planning

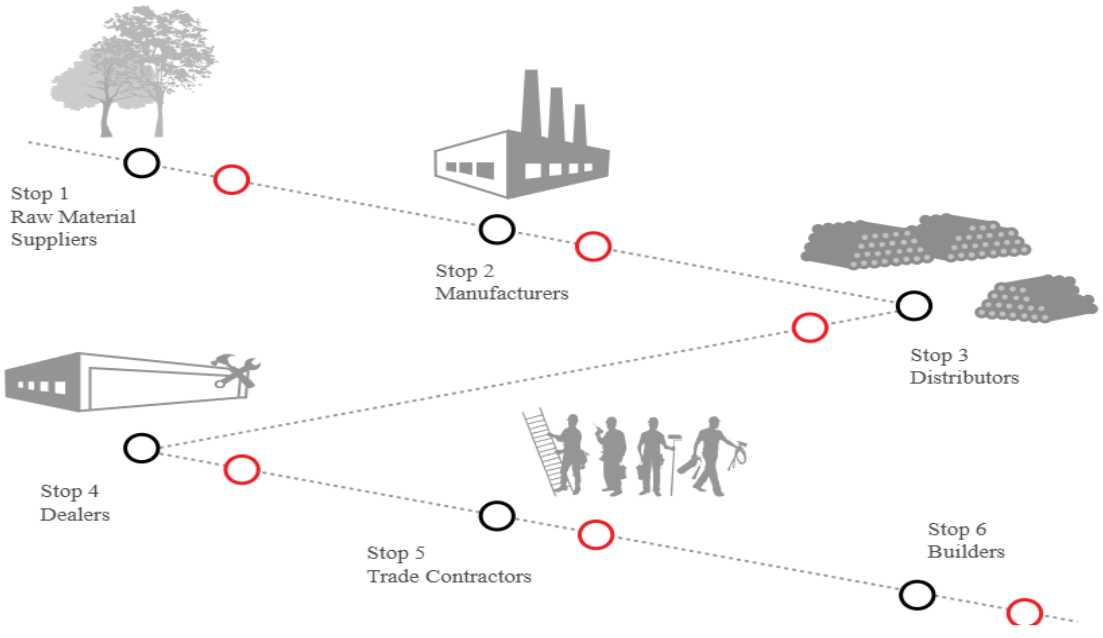
and communication are essential for keeping the project on track (Costantino et al. 2001).

3.1.3. Supply Chain Management and Procurement

Sourcing material for building custom homes is also a challenge faced by many contractors. Since each home is unique, the materials used are often tailored to the client's preferences and could be rarely available. For example, imported marble or custom fixtures that need to be specially ordered. The logistical challenges that builders face when trying to source these unique materials are real. Issues like fluctuating prices, supply shortages, and transportation delays are a few examples of the challenges that can delay the construction timeline (Xu, 2024).

These challenges have been immensely affected by the current supply chain global interruptions. Builders are finding it more difficult to source shortages in important materials like wood and steel, which leads to delays and cost increases. According to Osho et al. (2024), many builders are trying to build stronger relationships with local suppliers to try to mitigate these issues. By sourcing materials locally, builders can sometimes avoid the delays associated with international shipping. This also allows them to have more direct control over the quality and availability of the materials (Osho et al. 2024).

Figure 2: Supply Chain Management (Builderonline.com)



https://www.builderonline.com/building/operations/the-supply-chains-worst-pain-points_o

3.1.4. Digital Tools for Collaboration and Efficiency

Custom home building highly incorporates traditional methods because of direct client and contractor interaction and this direct interaction is even more enhanced since digital tools have been introduced in the construction of a custom home building. According to Smith et al. (2021), Building Information Modeling (BIM) is one of the most important technologies that custom homes benefit from. BIM allows builders, architects, and clients to visualize the home in a three-dimensional digital model before the construction process starts. This technology not only helps the designers to identify potential issues early on but also allows the clients to visualize how their home will look and hence adjust if needed (Smith et al., 2021).

For example, if a client wants to shift a wall or change the layout of a room, BIM makes it easy to make the change and update the plans without causing major disruptions. This level of flexibility is highly needed in custom home projects, where changes during the design phase are common. BIM also improves communication between the builder and the client, ensuring that both parties are always on the same page. By reducing misunderstandings and errors, this technology can save both time and money over the course of the project.

3.2. Importance of Custom Home Building

Building a home in lifetime is a dream for most of the population and is often very important for many homeowners. Therefore, a custom home will always prove to be a very personal choice as it allows maximum degree of personalization. Unlike standard homes from large developers, custom homes allow for a tailored design process that meets unique tastes, needs, and lifestyle preferences. While embarking on a custom home journey may seem complex, the benefits it offers go beyond aesthetics, accommodating specific needs and prioritizing sustainability. The difference between Customized homes and Prebuilt homes can be seen in table 1 below to proceed further with understanding the importance of customized homes in the construction industry.

Table 3: Comparison of Custom homes vs Prebuilt homes. (Ismail, 2024)

Feature	Custom Homes	Pre-built Homes
Personalization	Complete control over design and features	Limited customization options
Energy Efficiency	Tailored energy-efficient solutions available	Retrofitting required for energy upgrades
Material Selection	Ability to choose sustainable materials	Limited to builder's material options
Cost Over Time	Long-term savings due to energy efficiency	Higher long-term costs due to renovations
Resale Value	Higher due to unique features and quality	Standard resale value
Adaptability	Designed for future needs (e.g., aging in place)	Less flexibility for future modifications

3.2.1. Personalization

Personalization is at the heart of custom home building. Homes are intimate spaces, and people want them to reflect their identity. Customization allows homeowners to work with architects and builders to design homes that match their style, whether that means an open-concept kitchen, a luxurious master suite, or an office space. Customization in these homes goes far beyond surface-level choices like paint and fixtures as it extends into functionality that meets their lifestyle needs.

Patil *et al*, discusses the importance of personalization in achieving sustainability because it enables the use of eco-friendly materials and technologies that lower long-term energy consumption. As discussed in the literature, homeowners can achieve comfort, adaptability and save energy costs by opting for custom homes (Patil *et al*, 2024).

The ability to shape a home to fit one's specific requirements is especially valuable for families with unique needs or those seeking multi-generational living spaces. The National Association of Home Builders (NAHB) in 2023, found that home contractors pointed out custom design as the main concern of homeowners. As, 72% of people choose custom homes because they can be designed to meet different family needs, such as multigenerational living or accessibility for elderly family members (NAHB, 2023).

This trend of personalization is becoming more important nowadays because more and more clients need homes that fulfill both aesthetic preferences and functional needs, whereas pre-designed homes are not flexible enough. Custom homes allow homeowners to dictate every detail, from layout and rooms to energy efficiency systems. Flexibility is crucial for families who may require features like accessible bathrooms or separate living areas for extended family members. Moreover, custom homes maximize space efficiency. Unlike pre-designed homes with awkward layouts or unused spaces, every corner of a custom home can be designed for a purpose. Builders and homeowners collaborate to create areas that are both functional and aesthetically pleasing, optimizing every square foot to suit the occupants' lifestyle.

3.2.2. Sustainability and Energy Efficiency

Sustainability has become a central priority for many homeowners, and custom home building offers an ideal platform for incorporating green features from the start. Unlike older properties that may require extensive upgrades, custom homes can integrate the latest energy-efficient technologies, helping reduce environmental impact. As Piroozfar et al. point out, there is a growing preference for eco-friendly designs, and custom homes present the perfect opportunity to include energy-saving features like solar panels, efficient appliances, and superior insulation. (Piroozfar et al.,2010).

Sustainability is becoming the focal point of custom home building, and the literature clearly shows this correlation. According to a report by (IEA) International Energy Agency in 2022, green building technologies are efficiently integrated in custom

homes, and it is started from the design phase. Custom homes can include solar panels, energy-efficient windows, and insulation from the design phase which results in better integration and energy efficiency. These design choices not only reduce the carbon footprint but also contribute to long-term cost savings on utilities. This report also includes that homes that incorporate energy-efficient systems can achieve energy savings of up to 40% compared to traditional homes. This research is critical as it shows that modern homeowners are environmentally and financially conscious at the same time and are adapting sustainable choices to display their values in the homes they build. (IEA, 2022).

The financial aspects of energy efficient homes can be understood by studies from Patil *et al*, as their research suggests that investing in energy-efficient custom homes reduces both environmental impact and future costs for homeowners. Therefore, custom homes not only mean comfort and aesthetics but also long-term financial savings through energy efficiency. Furthermore, homes built with eco-friendly methods often command higher resale values, as buyers increasingly seek properties that support sustainable living. Custom homes designed with energy-efficient materials and systems tend to attract more interest, ensuring that the investment not only benefits the environment but also yields long-term value (Patil *et al*, 2024).

3.2.3. Long-Term Financial Value and Investment

Although the upfront costs of building a custom home may be higher but the long-term financial benefits often outweigh those initial expenses. Custom homes usually appreciate more quickly than pre-built homes. It could be justified by considering reasons such as high-quality materials, advanced technologies, and unique designs that make them more desirable in the real estate market, later. Homes are often seen as an investment for the future. By designing and building a home that caters to the specific needs whether it is more energy-efficient or a home that can accommodate a family for ages. Future remodeling costs are minimized by these approaches. However, a prebuilt home may require costly upgrades or renovations based on the inhabitant's needs and requirements (Lorenz & Trueck, 2007).

According to a report on resale value of homes with customized features, published by Zillow.com in 2022, homes with custom features generally hold a higher resale value because the features such as smart home technology, luxury finishes, and energy-efficient designs tend to attract more buyers and sell faster at a higher price. Buyers are often willing to pay a premium for a unique home that stands out in the market. This makes custom homes a smart financial investment over the long term (Zillow.com, 2022)

3.2.4. Future Renovations

Flexibility is key when it comes to custom homes. Features like wider doorways, step-free access, and changeable spaces can make the home easier to live in as family members age. The ability of a house to be future-proof is very useful i.e., easily adapt to future changes. A well-designed custom home can be adapted as the inhabitants' needs evolve. For example, many homeowners now plan for multi-generational living. With custom homes, it's easy to include a separate living space for aging parents or adult children. Similarly, modern technology like smart home systems is much easier to do in a custom home where there is better control over the design and wiring from the beginning. Moreover, custom homes allow to design spaces that can easily change in function. A room that serves as a nursery today can be renovated into an office or guest room later during the house lifecycle. This flexibility gives homeowners peace of mind knowing that their home can grow and change over time, without the need for costly and disruptive renovations (Jenei *et al*, 2024).

3.2.5. Emotional Attachment to Custom Homes

There is always a strong emotional aspect involved when it comes to owning a custom home. A sense of pride for the homeowners exists because of their in every decision, from the floor plan to the final fixtures. Custom homes often bring greater satisfaction to the homeowners compared to those who purchase pre-built homes. The personal connection to the house makes it feel like a true reflection of their lifestyle and taste.

Living in a home that the homeowners customized to their needs and aspirations, could foster a deeper sense of commitment to maintaining it. It can also have positive impacts

on the long-term value of the house. Therefore, custom home inhabitants tend to stay longer in their homes because of their specific needs being met by the house, and this reduces the chances of moving out of the house in the future (Piroozfar *et al*, 2010).

Custom built homes are more than just houses because they represent a very deep sense of personalization, desired sustainability, and value long-term investment. By opting for custom built homes, homeowners are offered the opportunity to design a space that perfectly matches their lifestyle and future needs. From energy efficiency to financial value, custom homes stand out as a fulfilling choice in today's housing market. As more people look for homes that reflect their unique preferences and provide sustainable living options, custom home building will continue to grow in popularity and shape the future of residential construction.

Chapter 2: Overall Construction Ecosystem

3.3. Digitalization in the Construction and Real Estate Industry:

Digitalization is transforming the construction industry, spanning everything from project management to the actual design and construction of buildings. The potential for digitalization to significantly boost productivity and efficiency. These changes are seen not only in faster project timelines and reduced costs but also in improved construction quality, which is crucial in today's competitive environment (Intelligent Construction, 2023).

One of the most impactful areas is building design and construction, where digital tools like Building Information Modeling (BIM) play a leading role. BIM enables architects and engineers to create detailed 3D models of buildings. This technology helps identify and resolve design issues early, often long before construction starts, minimizing errors and rework. BIM has shown remarkable success in reducing time and costs while fostering better communication among stakeholders, all of which contribute to higher-quality outcomes (Azhar, 2011).

Digitalization also brings significant benefits to project management in construction. argue that tools such as project management software streamline project tracking, reducing the risk of delays and budget overruns. Digital tools make it possible to monitor each phase of construction closely, resulting in improved efficiency and adherence to deadlines, which are critical in the industry (Robert *et al*, 2013).

The impact of digitalization in real estate sector was figured by Manko (2021), by studying web design of Zillow.com. The way buyers find properties as compared to how theses are marketed by digital platforms, holds a strong connection. With such e-commerce platforms, customers can browse listings and learn about properties online. This online approach reduces the need for physical visits and makes the search process far more convenient and accessible, even for customers located remotely (Manko, 2021).

3.3.1. Importance of Digitalization:

Nikmehr *et al*, (2020) indicate that digitalization does not only help the construction sector to boost sales but also minimize costs. Digitalization is helping organizations to improve operations, services, and customer services. Digital tools have become indispensable in today's economy, allowing companies to reach more people, reduce operational costs, and increase profitability (Nikmehr *et al*, 2020).

Additionally, digitalization can deliver a more personalized customer experience and tailored services. It also improves customer satisfaction and loyalty. The COVID-19 pandemic further emphasized the role of digitalization, as it enabled organizations to continue operations, support remote work, and maintain customer engagement through digital channels (Wu *et al,* 2021).

In the real estate and construction sectors, the digital transformation is underway, but the progress has been quite slow. Many organizations still rely on traditional methods but are increasingly investing in technology to automate operations and enhance services. Digitalization can improve efficiency, reduce costs, and ultimately result in better service delivery in these industries (Ershadi & Lijauco, 2024).

On the other hand, the facility management sector is also seeing digitalization as main driving factor. The companies are using digital tools to automate and streamline the property management processes which helps them in improving both service and efficiency. Therefore, digitalization in real estate is enabling remote services easier such as buying, renting, and managing properties. These digital features are expanding the market reach. Although challenges such as infrastructure limitations and the need for cultural adaptation within organizations remain. (Naeem *et al*, 2023)

3.3.2. Role of Digitalization in Real Estate and Construction:

Nowadays, digitalization is playing a vital role in real estate and construction sectors as it is facilitating improvements in services and operations through automation and task efficiency. BIM is a great example of such digitalization and is used in every sector of construction. In construction, digital tools enhance project scheduling, collaboration, and equipment management, resulting in better project outcomes (Naji *et al*, 2024).

On the other hand, E-commerce is also rapidly becoming influential in construction and real estate as it has improved accessibility and service quality. Online property transactions in real estate allow customers to conduct business with ease. E-commerce has also simplified property management by enabling real-time updates and online payment solutions. This Made buying properties easier for customers (Zhang *et al*, 2016).

E-commerce has expanded beyond building materials and it now includes project management tools, scheduling systems, and team collaboration platforms, which enhance efficiency and control costs in the construction industry. Online equipment rental services have also gained traction, helping companies optimize equipment use and maintenance (Love *et al*, 2001).

3.3.3. Implementation:

Implementing the solution of digitalization and e-commerce integration in the construction and real estate industry requires careful planning and execution.

The integration of Building Information Modeling (BIM) and an Integrated Management System (IMS) to enhance construction project management. They propose a BIM-enabled IMS framework that includes four modules: project management, quality management, environmental management, and safety management. The authors also provide a case study to demonstrate the effectiveness of their proposed framework (Hmidah *et a*l, 2022).

The slow adoption of BIM technology by SMEs was discovered by Awwad *et al* in 2020. This lagging resulted in slow growth and less profits. They conducted a survey among construction professionals to enhance the implementation process of BIM and 15 new

factors were identified. The critical factors include top management support, project team collaboration, and technical expertise, organizational culture, technical infrastructure, human resources, and regulatory environment. The authors provide recommendations to overcome the challenges of e-commerce implementation. The authors provide recommendations to overcome the challenges of BIM implementation (Awwad *et al,* 2020).

Wu *et al*. in 2021, provide a review of critical success factors and implementation strategies for e-commerce implementation in the construction industry. They conducted a literature review and identified six critical success factors, including leadership support, technical infrastructure, user acceptance, security, logistics, and regulations. The authors provide recommendations for implementing e-commerce in construction (*Wu et al*, 2021).

3.4. Current Digital Technologies:

The construction industry has been slower to adopt new technologies compared to other sectors. Digital ecosystems utilize various digital tools and platforms that are important to understand and study before proceeding further in this research. These tools facilitate the integration of design, procurement, and construction management processes. This extension of literature review explores the existing research on digital ecosystems in overall construction, focusing on their components, benefits, challenges, and implementation strategies (Naji *et al*, 2024).

Digital ecosystems in construction currently encompasses around following tools:

1. Building Information Modeling (BIM).
2. Cloud-based project management software.
3. Digital procurement platforms.
4. Internet of Things (IoT) devices.

Building Information Modeling (BIM): BIM is a digital process that generates and manages the digital representations of physical and functional characteristics of construction. Its significance in construction lies in its ability to provide a collaborative model

over a collaborative platform where architects, engineers, and construction managers can work together seamlessly (Sacks *et al*, 2018).

BIM involves working on various aspects of construction such as 3D (geometry), 4D (scheduling), 5D (cost estimation), etc. as it facilitates a holistic approach to project management. For example, 3D BIM allows for the visualization of the structure in three dimensions with design precision and error reduction aid (Azhar, 2011).

Cloud-based Project Management Software: Platforms such as Procore, Buildertrend, and Autodesk Construction Cloud are enabling real-time communication and collaboration among project stakeholders, in the current digital ecosystem. These tools help in document management, task scheduling, and progress tracking which enhances project coordination and transparency. The cloud-based nature of these tools ensures that project data is accessible from anywhere and therefore, there is a more integrated and efficient workflow. By centralizing project information, these platforms reduce the chances of miscommunication and ensure that all team members are working with the most up-to-date model or information (Susatyo *et al*, 2024).

Digital Procurement Platforms: Digital procurement platforms streamline the process of sourcing and purchasing materials for a construction project by connecting builders and homeowners with suppliers through online marketplaces. These platforms offer tools for tracking orders, comparing prices, managing inventory, and ensuring compliance with procurement policies. For example, Coupa and SAP Ariba are platforms that provide analytics and insights that help procurement managers make informed decisions and hence, potentially reduce the procurement times and costs. The automation of procurement processes also minimizes human errors and increases efficiency (Eadie *et al*, 2013).

Internet of Things (IoT)**:** IoT devices and sensors provide real-time data on various aspects of the construction site, such as equipment usage, environmental conditions, and worker safety. This data can be integrated into project management systems to optimize operations and improve decision-making according to Becerik-Gerber *et al.* (2012). For example, IoT sensors can monitor concrete curing conditions in real-time,

providing data that helps ensure the quality and durability of the construction. Similarly, wearable devices can monitor workers' health and safety, alerting supervisors to potential hazards and preventing accidents (Becerik-Gerber *et al*, 2012).

3.4.1. Benefits of Digital Ecosystems in Construction

The benefits of Digital Ecosystem integration to construction practices must be studied too. The integration of digital ecosystems in custom home building offers multiple benefits as it enhances various aspects of project management and execution.

Enhanced Collaboration and Communication: Digital tools are helping the construction processes immensely and is now a very integral part of construction because these tools provide a centralized platform for information sharing, reducing misunderstandings and errors. BIM is a very good example of these tools that facilitates such collaboration by providing a shared, detailed visual model that all stakeholders can simultaneously edit and review. This ensures that architects, engineers, and construction managers are aligned which in return reduces the likelihood of costly errors and rework. The use of cloud-based project management software further enhances communication by allowing team members to access project updates and documents in real-time, regardless of their location (Azhar, 2011).

Cost Savings and Efficiency Improvement**s**: Digital procurement platforms help reduce material costs through competitive pricing and efficient inventory management. By automating the procurement process, these platforms minimize the administrative burden and reduce human errors, leading to cost savings (Eadie *et al*, 2007).

Moreover, BIM and project management software help identify potential issues early in the design phase, reducing rework and delays. For instance, clash detection in BIM allows for the identification and resolution of design conflicts before construction begins, saving time and money (Namli *et al*, 2019).

Improved Project Outcomes: Projects that use digital ecosystems are often executed closer to schedules and budgets, higher quality construction, and increased client satisfaction. Digital tools provide greater reporting into project progress and performance. Moreover, It allows timely interventions when issues arise. For example, real-time data from IoT devices can help project managers make informed decisions, optimizing resource allocation and ensuring that the project stays on track (Migilinskas *et al*, 2013).

Sustainability and Environmental Benefits: Digital tools can also contribute to more sustainable construction practices. BIM can be used as an example again which is used to simulate and analyze the environmental impact of different design options, helping architects and engineers choose more sustainable materials and construction methods. IoT sensors can monitor energy usage and waste generation on construction sites, providing data that can be used to implement more efficient and environmentally friendly practices (Becerik-Gerber *et al*, 2012).

3.4.2. Challenges in Implementation

Despite the above-mentioned benefits, there are several challenges associated with the implementation of digital ecosystems in custom home building.

Resistance to Change: One major challenge is the resistance to change within the industry. Many construction professionals are accustomed to traditional methods and are hesitant to adopt new technologies. This resistance can stem from a lack of familiarity with digital tools, fear of the unknown, or a belief that the current methods are sufficient. Overcoming this resistance requires not only demonstrating the tangible benefits of digital ecosystems but also providing adequate training and support to ease the transition (Gu & London, 2010).

High Initial Costs: Integrating digital tools requires investment in software, hardware, and training which can lead to higher initial costs and act as a barrier to digital ecosystem adoption. Especially, small and medium-sized enterprises (SMEs), may struggle

to afford the upfront costs associated with digital transformation. Additionally, the cost of maintaining and upgrading digital systems can be substantial, posing a financial challenge for many companies. However, it is important to note that these initial investments often lead to long-term cost savings and efficiency gains (Ahuja *et al*, 2009).

Interdependencies: Interdependencies between different digital tools and platforms can hinder seamless integration. Ensuring that various systems can communicate effectively and share data without loss or misinterpretation is critical for the success of a digital ecosystem. Proprietary software and data formats can create silos, making it difficult to integrate systems from different vendors. However, adopting open standards and promoting the use of APIs can help mitigate these interoperability challenges (Eastman *et al*, 2018).

Data Security and Privacy: As the use of digital tools and platforms grows, concerns about data security and privacy also rise. Construction companies must ensure that sensitive project data is protected from cyber threats and unauthorized access. Implementing strict cybersecurity measures and following data protection regulations are essential to maintaining the integrity and confidentiality of project information (Sacks, *et al*, 2018)

3.4.3. Implementation Strategies

After discussing the benefits and challenges of digital ecosystems, it is important to discuss how digital tools could be implemented in the custom home building ecosystem. The strategic approach for implementation is as follows:

Stakeholder Engagement and Training: Engaging stakeholders early in the process and providing comprehensive training programs can help overcome resistance to change. Training should focus not only on how to use digital tools but also on how these tools can add value to their work. Demonstrating successful case studies and involving key stakeholders in the planning and implementation phases can also foster buy-in and support (Gu & London, 2010).

Testing: Starting with a pilot project as testing allows companies to test the digital environment of the adaptation and adjust before a full-scale rollout. This approach helps identify potential issues and provides an opportunity to refine processes and workflows. For example, a company might start by implementing BIM on a single project to gain experience before expanding its use across multiple projects (Ahuja *et al*, 2009).

Software compatibility: Adopting open standards and APIs can facilitate smoother integration of different digital tools. Organizations should prioritize selecting platforms that are compatible with other systems they use or plan to use. Additionally, fostering collaboration between software vendors and encouraging the development of interoperable solutions can help address interoperability challenges (Eastman *et al*, 2018).

Building a Digital Culture: Creating a culture that welcomes digital transformation is essential for the successful implementation of digital ecosystems. This involves promoting a mindset that values innovation, continuous improvement, and the use of technology. This will enhance efficiency and quality. Leadership also plays a crucial role in driving this cultural shift, setting the tone for the organization and championing the benefits of digital ecosystems (Migilinskas *et al*, 2013).

Digital ecosystems hold significant importance for transforming custom home buildings by integrating design, procurement, and construction management processes. While challenges such as resistance to change, high initial costs, interoperability issues, and data security concerns exist, strategic implementation and stakeholder engagement can mitigate these obstacles. Continued research and case studies on successful integrations will further explore best practices and propose better adoption strategies in the industry. By leveraging the power of digital tools and platforms, the construction industry can achieve greater efficiency, cost savings, and improved project outcomes. This will surely pave the way for a more sustainable and innovative future.

Chapter 3: Custom Home Building Ecosystems

3.5. The Custom Home Building Ecosystem

The custom home building ecosystem includes all different technologies, professionals and construction companies involved in creating a custom-built house. Architects, builders, engineers, and contractors are at the core of this ecosystem and are responsible for designing and executing the construction. However, to hold this ecosystem together and ensure smooth workflow, technology such as advanced design software, online platforms, and sustainability consultants play an important role.

According to (Piroozfar *et al*, 2010), this ecosystem is growing to become extremely complicated as it keeps integrating new technologies and methods that improve efficiency and sustainability in home design. For example, many custom home builders now use Building Information Modeling (BIM) software. This allows them to create highly detailed, digital 3D models of homes before the construction begins. These models help both homeowners and builders to visualize the project in precise detail and understand any potential issues before the construction begins. This minimizes design costs and future change requests. Custom homes building ecosystem not only facilitates personalized living spaces, but also allows for better management of resources, budget, and time. Well-coordinated ecosystems can lead to smoother project management, fewer delays, and lower overall costs. Moreover, homeowners benefit from a process that can be adjusted to meet environmental, financial, or personal requirements (Piroozfar *et al*, 2010).

The introduction of online platforms has reshaped custom home design ecosystem, bringing homeowners and contractors closer. In addition to professional tools like Building Information Modeling (BIM), platforms such as Houzz, RoomSketcher, and Chief Architect now empower clients to play an active role in shaping their homes. These tools simplify the visualization process, enabling homeowners to explore layouts, experiment with styles, and select designs for their future home.

For instance, Houzz has become a central resource for clients who want inspiration at their fingertips. Manko (2021) finds out about other online platforms while carrying out research on Zillow.com. Clients can save and organize images and designs on Houzz

according to their desired aesthetics because Houzz functions like a digital mood board. In this way, it is easier for clients to explain their vision to architects. Houzz also features a marketplace for interiors, which allows clients to browse materials and finishes according to their preferences. All these features streamline the decision-making process. Meanwhile, platforms like “RoomSketcher” and “Chief Architect” take customization to a new level by allowing homeowners to create detailed 3D models and virtual floor plans. Houzz is serving as an inspirational tool for homeowners whereas RoomSketcher and Chief Architect helps in creating simple layouts by allowing users to adjust wall placements, position windows, and arrange furniture and virtually experiencing their future home before construction even begins. This approach helps clients to make informed decisions and finalize details in the project planning phase. (Smith, 2023)

3.5.1. Trends in Custom Home Building

The custom home industry is continuously evolving, driven by new trends and technologies. Among the most transformative is the rise of smart home technology. Today’s homeowners increasingly desire systems that allow seamless control over lighting, climate, and security from their devices. According to Yong and Annie, home automation has shifted from being a luxury to a standard feature in high-end custom homes, with demand for these technologies growing consistently. Homeowners now view smart systems as essential, reflecting a broader trend of blending comfort with innovation. (Yong & Annie, 2007)

Another exciting trend is the development of net-zero homes, which are designed to produce as much energy as they consume. With advances in renewable energy and storage technology, clients are seeking homes that not only minimize their environmental impact but also generate sustainable power. Solar panels, energy-efficient HVAC systems, and high-performance building materials allow for homes that reduce utility costs while supporting green initiatives. Custom builders are increasingly integrating these elements from the outset, addressing both environmental and financial considerations (Patil *et al,* 2024).

Modular construction is also gaining popularity as a solution to improve building efficiency while maintaining custom design features. In this approach, parts of a home are

constructed off-site in a controlled setting and then assembled on location. While modular techniques may seem at odds with the idea of a fully tailored home, Cesaris and Mandolesi (2013) highlight that modular builds can still be personalized to client specifications. This method offers faster build times and less waste, appealing to clients who want a blend of customization and sustainability (Cesaris & Mandolesi, 2013).

The custom home building landscape is intricate and rapidly progressing. From the initial design stage, where clients increasingly participate through online platforms, to the precise construction phase supported by BIM and other digital tools, the industry is moving toward a model of enhanced client involvement, efficiency, and sustainability. The demand for smart homes and energy-efficient design reflects broader societal shifts, while builders continue to navigate challenges such as supply chain management and specialized trade coordination. As technology and trends reshape the sector, the custom home building industry is poised to offer more personalized, future-focused living spaces.

3.5.2. Characteristics of Custom Home building ecosystems

Custom home building has been viewed as a highly individualized process where homeowners work closely with architects, designers, and builders to build a house tailored to their specific needs and preferences (Piroozfar *et al*, 2010). The increasing demand of custom home building shows us that personalization, sustainability, and long-term value is desired by the end-users, this is also supported by other studies (Jenei *et al*, 2024).

4. Analysis

This part of the research focuses on the breakdown and simplification of all the information gathered in literature review about digital ecosystems of custom home building. The first step of the analysis would be to understand trends and user impact of digital ecosystem overall construction because that would provide basis for further development of analysis. The digital ecosystem of construction is of great importance to develop the research further. To begin the analysis, the trends and end user impacts of digital tools in construction will be discussed:

4.1. Trends in Custom home construction ecosystem

Numerous factors play a role in custom home ecosystems and to evaluate those, the digital trends of digital construction tools, its adaptation and trends are considered. These trends are observed from the previous data collected in this research to support further development in digital ecosystem of custom home building industry. The detailed analysis is as follows:

4.1.1. Increasing Adoption of Digital Tools

The construction industry is gradually adopting digital tools, with BIM and cloud-based project management software leading the way.

- **Building Information Modeling (BIM)** has become the most important technology, facilitating detailed visualization and collaboration among stakeholders. Its multidimensional approach (3D, 4D, 5D) provides comprehensive project insights which enhances design accuracy and reduces errors.
- **Cloud-based project management platforms** like Procore and Autodesk Construction Cloud are transforming project coordination. These tools enable real-time updates and remote access to project data which means improved communication and efficiency.

The increase in use of these technologies reflects a shift towards embracing digital solutions to improve project development and its outcomes.

4.1.2. Enhanced Collaboration and Communication

Digital ecosystems significantly improve collaboration and communication among project stakeholders.

- The use of BIM and cloud-based platforms centralizes project information, ensuring that all team members work with the most up-to-date data. This reduces misunderstandings and errors, leading to smoother project execution.
- Real-time communication tools integrated into these platforms allow for immediate updates and swift resolution of issues, which is particularly beneficial in the dynamic environment of construction projects.

This trend highlights the importance of digital platforms in facilitating effective collaboration and streamlining project workflows.

4.1.3. Cost Savings and Efficiency Gains

Adoption of digital ecosystems leads to substantial cost savings and efficiency improvements.

- **Procurement platforms** optimize the sourcing and purchasing process for various elements of a custom home, offering competitive pricing and efficient inventory management. This reduces procurement times and costs, as well as minimizing administrative burdens.
- **Management software** helps identify potential issues early in the project lifecycle. Therefore, the rework and delays are reduced.

These efficiency gains and cost savings are crucial for improving the profitability and quality of custom home construction firms.

4.1.4. Improved Project Outcomes

Projects utilizing digital ecosystems will achieve better adherence to schedules, budgets, and quality standards. The real-time data integrated from IoT devices into project management systems allows early decision-making. It also optimizes resource allocation and ensures timely project completion. This underlines the value of digital ecosystems in delivering high-quality custom-built homes that meet client expectations.

4.1.5. Challenges to Adoption

Despite the benefits, significant challenges hinder the widespread adoption of digital ecosystems in the construction industry.

- **Resistance to change** remains a major barrier, with many construction professionals hesitant to adopt new technologies due to a lack of familiarity or perceived adequacy of traditional methods.
- **High initial costs** associated with software, hardware, and training pose financial challenges, particularly for SMEs.
- **Interoperability issues** between different digital tools can complicate integration efforts, requiring the adoption of open standards and APIs to facilitate seamless data exchange.

Addressing these challenges requires strategic implementation, training, and developing a culture that values innovation.

4.1.6. Strategic Implementation and training

Effective implementation strategies that focus on stakeholder engagement.

- **Slow implementation**, starting with pilot projects, allows firms to test digital tools and refine their processes before full-scale rollout. This approach helps mitigate risks and build confidence among stakeholders.
- **Team training** is critical for overcoming resistance to change. Demonstrating the tangible benefits of digital tools and involving team memebers in the implementation process fosters buy-in and support.

These strategies highlight the need for a phased and inclusive approach to digital transformation in the construction industry.

4.1.7. Building a Digital Culture

Cultivating a culture that embraces digital transformation is essential for long-term success.

- Promoting a mindset that values continuous improvement and the use of technology to enhance efficiency and quality is crucial. Leadership plays a vital role in setting the tone for digital adoption and championing the benefits of digital ecosystems.
- Creating a supportive environment that encourages innovation, and experimentation can accelerate the adoption of digital tools and practices.

The analysis of the literature review reveals a clear trend towards the increasing adoption of digital ecosystems in custom home building, driven by the benefits of enhanced collaboration, cost savings, efficiency gains, and improved project outcomes. However, challenges such as resistance to change, high initial costs, and interoperability issues must be addressed through strategic implementation, incremental adoption, and building a digital culture. By leveraging these insights, the construction industry can continue to evolve and harness the full potential of digital ecosystems, ultimately leading to more sustainable and innovative practices.

4.2. End User Impact

The trends in Custom Home Building ecosystem holds a significant importance to its users. Therefore, the same trends shall be evaluated from the end user's perspective.

4.2.1. Increasing Adoption of Digital Tools

- **Enhanced Visualization and Understanding**: Homeowners and clients benefit from BIM's detailed 3D models, which provide a clearer understanding of the design and construction process. This transparency helps clients visualize their custom homes more accurately and make informed decisions.
- **Real-Time Updates and Access**: Cloud-based project management tools offer clients real-time access to project progress, schedules, and updates. This transparency builds trust and allows clients to stay informed and involved throughout the project lifecycle.

From the end user's standpoint, the adoption of digital tools translates to greater clarity and involvement in the project, reducing uncertainties and enhancing satisfaction with the outcome.

4.2.2. Enhanced Communication

- **Improved Communication**: Clients experience more consistent and clear communication with builders, architects, and contractors. Digital platforms ensure that all parties are aligned, reducing the chances of miscommunication.
- **Timely Issue Resolution**: The ability to address and resolve issues quickly through real-time communication tools means fewer delays and smoother project progression.

For clients, the enhanced collaboration facilitated by digital ecosystems ensures a more cohesive project experience, with fewer disruptions and better alignment with their expectations.

4.2.3. Cost Savings and Efficiency Gains

- **Cost Transparency and Savings**: Digital procurement platforms enable more transparent pricing and competitive sourcing of materials, potentially reducing overall project costs. Clients can benefit from these savings and have better insight into where their money is being spent.
- **Efficient Project Execution**: The efficiency gains from BIM and project management software reduce the likelihood of costly delays and rework, ensuring that projects stay on budget and on schedule.

Clients appreciate the cost savings and efficiency improvements, as these translate to more reliable budgeting and timely completion of their custom homes, reducing financial stress and enhancing overall satisfaction.

4.2.4. Improved Project Outcomes

- **High-Quality Construction**: The integration of digital ecosystems leads to higher quality construction, as issues are identified and resolved early. This results in a better-finished product that meets or exceeds client expectations.
- **Adherence to Schedules**: Improved project management ensures that timelines are met, providing clients with a clear and predictable move-in date.

From the client's perspective, the promise of high-quality construction and adherence to schedules ensures a smoother experience and increases confidence in the construction process and the final product.

4.2.5. Challenges to Adoption

- **Learning Curve and Adaptation**: Clients may initially face a learning curve in understanding and interacting with new digital tools and platforms. Adequate guidance and support from the construction team are essential to mitigate this.
- **Trust in New Technologies**: There may be skepticism about the reliability and effectiveness of new digital tools. Building trust through transparent communication and demonstrating the benefits is crucial.

While there are challenges, clients who receive proper support and see the tangible benefits of digital ecosystems are likely to overcome initial reservations and embrace the new technologies.

4.2.6. Strategic Implementation and Incremental Adoption

- **Pilot Projects and Feedback**: Incremental implementation allows clients to see the benefits of digital tools on smaller scales before full adoption. This phased approach can build confidence and provide valuable feedback for continuous improvement.
- **Stakeholder Engagement**: Involving clients in the early stages of implementation and providing thorough training on digital platforms enhances their engagement and comfort with the new processes.

Clients appreciate a thoughtful and phased approach to adopting digital ecosystems, as it demonstrates a commitment to ensuring the technology works effectively and enhances their overall experience.

4.2.7. Building a Digital Culture

- **Culture of Innovation**: Clients benefit from working with construction teams that value innovation and continuous improvement. This culture ensures that the latest and most effective technologies are employed, enhancing project outcomes.

- **Enhanced Customer Experience**: A digital culture promotes a proactive approach to customer service, with teams being more responsive and adaptable to client needs and feedback.

For clients, a construction company with a strong digital culture represents a forward-thinking and customer-centric approach, leading to a more positive and personalized building experience.

From the end user's perspective, the adoption of digital ecosystems in custom home building offers numerous advantages, including enhanced visualization and understanding, improved communication, cost savings, and high-quality construction outcomes. While there are challenges such as initial learning curves and trust in new technologies, strategic implementation and a culture of innovation can significantly enhance the overall client experience. By leveraging digital tools and platforms, construction companies can deliver more transparent, efficient, and satisfying custom home building projects, ultimately meeting or exceeding client expectations.

4.3. Applications of Custom Home building ecosystem

Several online platforms and applications cater to connecting individuals or businesses with construction builders. Here are a few popular ones:

1. **Thumbtack**: Thumbtack allows users to find and hire local professionals for various services, including construction and remodeling. Users can submit a request with details about their project, and interested builders can respond with quotes and proposals.
2. **HomeAdvisor**: HomeAdvisor matches homeowners with pre-screened and customer-rated service professionals for home improvement projects, including construction work. Users can browse profiles, read reviews, and request quotes.
3. **Angi**: Angi is a platform where users can find and review local service providers, including construction contractors. It provides verified reviews and ratings to help users make informed decisions.

4. **Houzz**: Houzz is a platform focused on home remodeling and design. Users can explore photos of projects, find local professionals, and connect with construction builders who specialize in various types of projects.
5. **BuildZoom**: BuildZoom helps users find and hire licensed contractors for construction projects through a bidding process. It provides information about contractors' licenses, experience, and customer reviews to help users make hiring decisions.
6. **Bark**: Bark is a service marketplace where users can find professionals for various services, including construction work. Users submit their project details, and Bark matches them with relevant professionals who can provide quotes.

These platforms vary in terms of their features, geographic coverage, and specific focus areas within the construction industry. It's a good idea to explore multiple platforms and compare options to find the best match for your needs.

The type of services that most of these platform’s offer are as follow:

1. **Project Posting**: Users typically start by posting details about their construction project on the platform. This may include the type of project (e.g., home renovation, new construction, remodeling), project size, budget, timeline, and any specific requirements or preferences.
2. **Contractor Matching**: Platforms use algorithms or manual processes to match users with relevant contractors based on their project details and location. This ensures that users receive proposals from builders who have the expertise and availability to meet their needs.
3. **Reviews and Ratings**: Many platforms allow users to read reviews and ratings of construction builders submitted by previous clients. These reviews provide insights into the quality of work, professionalism, communication, and overall satisfaction with the contractor's services.
4. **Portfolio and Project Galleries**: Users can often browse through portfolios and project galleries of construction builders to view examples of their past work. This helps users assess the quality, style, and range of services offered by the contractors.

5. **Quotes and Estimates**: After reviewing project details, contractors may submit quotes or estimates for the construction project. Users can compare these quotes to evaluate costs, services included, and timelines before planning.
6. **License and Insurance Verification**: Platforms may verify the licenses, certifications, and insurance of construction builders to ensure that they meet legal requirements and industry standards. This gives users peace of mind knowing that they are hiring qualified and insured professionals.
7. **Communication Tools**: Some platforms offer communication tools to facilitate direct communication between users and contractors. This allows users to ask questions, discuss project details, and clarify expectations before hiring a builder.
8. **Payment Processing**: In some cases, platforms may provide payment processing services, allowing users to securely pay contractors for their services. This can include options for milestone payments, escrow services, or secure payment gateways.
9. **Dispute Resolution**: In the event of any disputes or issues during the construction project, platforms may offer dispute resolution services to help resolve conflicts between users and contractors in a fair and efficient manner.

By offering these services and features, online platforms aim to streamline the process of finding and hiring construction builders while providing transparency, accountability, and quality assurance for both users and contractors.

4.4. Impact of existing services Custom Homes Ecosystem:

The services provided by online platforms are having a significant impact on custom homes ecosystem by having following advantages and disadvantages:

Advantages:

1. **Convenience**: Users can easily access a wide range of construction builders from the comfort of their homes, saving time and effort compared to traditional methods of searching for contractors.
2. **Access to Reviews and Ratings**: Users can read reviews and ratings of construction builders from previous clients, helping them make informed decisions based on the experiences of others.
3. **Increased Transparency**: Platforms often provide detailed information about contractors, including licenses, certifications, insurance, and portfolios, increasing transparency and accountability in the hiring process.
4. **Comparison Shopping**: Users can receive multiple quotes and estimates from different contractors, allowing them to compare costs, services, and timelines to find the best fit for their project and budget.
5. **Quality Assurance**: Many platforms vet construction builders through background checks, license verification, and screening processes, ensuring that users relate to qualified and reputable professionals.
6. **Communication and Collaboration**: Online platforms facilitate communication between users and contractors, enabling them to discuss project details, ask questions, and clarify expectations before and during the construction process.
7. **Dispute Resolution**: Some platforms offer dispute resolution services to help users and contractors resolve conflicts or issues that may arise during the construction project, providing a mechanism for fair and timely resolution.

Disadvantages:

1. **Overwhelming Choices**: The abundance of construction builders on online platforms can be overwhelming for users, making it challenging to narrow down options and decide.
2. **Risk of Misinformation**: While platforms strive to provide accurate and reliable information about contractors, there is a risk of misinformation or false reviews, which may mislead users in their decision-making process.
3. **Lack of Personalized Service**: Online platforms may lack the personalized service and attention-to-detail that users may receive from in-person interactions with local contractors or recommendations from trusted sources.
4. **Potential for Miscommunication**: Despite communication tools provided by platforms, there is still a risk of miscommunication between users and contractors, leading to misunderstandings or delays in the construction project.
5. **Transaction Fees**: Some platforms may charge transaction fees or service fees for connecting users with contractors or processing payments, which can increase the overall cost for users.
6. **Limited Scope**: Online platforms may have limitations in terms of geographic coverage, or the types of construction services offered, potentially excluding users from accessing certain contractors or services in their area.

Overall, while online platforms for finding construction builders offer numerous benefits in terms of convenience, transparency, and access to a wide range of options, users should be mindful of potential drawbacks and conduct thorough research before making hiring decisions.

4.5. Case study: Comparison of current home building platforms

The integration of technology in custom home building has shifted much of the design process online, making custom home design more accessible and easier to understand. Several online platforms like Houzz, Homebyme, and Chief Architect are currently the key players and are playing a critical role in bridging the gap between end users and professionals. These platforms mainly streamline communication, design visualization, and cost management. Furthermore, discussion of these platforms separately, is as follows:

4.5.1. Houzz:

As previously mentioned, Houzz is a major player in the online custom home building space, offering extensive visualization tools, a wide network of professionals, and user-friendly design interfaces. Users of Houzz experience few unique features such as, browsing millions of images, collecting inspirations in “idea books,” and communicating directly with contractors and designers. However, the main goal of Houzz is to facilitate collaboration by having a large database of contractors that users can select for a certain job. This enables exchange of ideas between homeowners and builders, thus reducing the time spent on in-person consultations and design revisions.

Houzz also provides cost estimation, offering budgeting tools according to the market standards and trends which helps the users while exploring contractors. By comparing project costs and reviewing contractors, homeowners can make informed decisions early in the process, avoiding cost overruns. The success of Houzz as a platform can be validated by its 85% user satisfaction rate, as surveyed in 2023 (Houzz, 2023).

To conclude the platform’s features, the methodology of the collaboration and cost estimation provided by this platform must be discussed. These processes involve a manual approach as it is only the contact details and previous jobs of the contractor that are found on the platform for collaboration whereas cost estimation is done mainly by the rate provided by different contractors which is in return compared by user.

4.5.2. Homebyme:

Another digital platform that is part of custom home building ecosystem is Homebyme. This platform focuses on providing intuitive tools for 3D home design. Homebyme is really ease of use as it is designed for both professionals and beginners. It basically

allows the users to visualize every room in 3D before contacting builders or contractors. This platform is particularly valuable for people who want to take a more hands-on approach to the design process.

Homebyme’s has a user-friendly interface and offers flexibility. It allows users to modify layouts, furniture, and finishes in real time and to visualize those modifications. This visualization at an early stage allows the users to mitigate design changes during construction but that often contributes to delays and increased costs in custom home projects. The platform's ability to export designs for professional use makes it a valuable tool in both the design and execution stages of custom home projects.

4.5.3. Chief Architect:

This platform is more of a software that is part of custom home building ecosystem. Chief Architect is developed for technical and professional use because it provides sophisticated design tools used by architects and builders. Unlike Houzz and Homebyme, which cater to end users and non-professionals, Chief Architect is aimed at professionals. It offers precise drafting tools for structural design, CAD integration, and material takeoff calculations.

This software allows custom builders to integrate both architectural and interior design elements, providing complete floor plans, 3D models, and virtual tours. It also supports cost estimation and material tracking which ensures that designs are not only aesthetically pleasing but also practical i.e. timelines and budgeting.

It is mainly known for its professional-grade tools, and it remains a top choice for contractors and architects because it allows us to create detailed plans that meet specific building codes and standards. This platform allows high level of customization for complex designs and is only ideal for contractors or experts use. Although Chief Architect can be a very useful platform for highly specific custom home projects designed by architects or developers, but it does not provide any benefit to the homeowners because of its technicality and professional use limitations.

Table 4: Comparison of Online Custom Home Platforms (Ismail,2024)

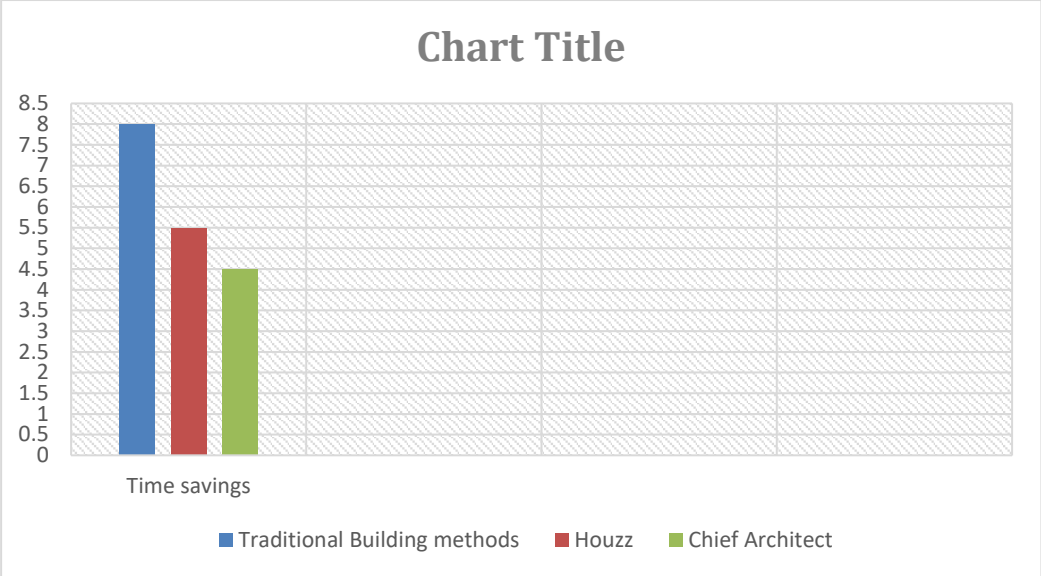
Platform	Users	Key Features	Strengths	Weaknesses
Houzz	Homeowners, Designers	Visualization tools, collaboration, cost estimation	Strong professional network, user-friendly interface	Limited technical depth for complex architectural designs
Homebyme	Homeowners	3D design, easy customization, room layouts	Useful interface, user-friendly design process	Lacks advanced tools for professional builders
Chief Architect	Professional Architects, Builders	CAD integration, detailed drafting, structural design	Professional-grade software, high level of precision	Steep learning curve for non-professionals

4.5.4. Key Metrics

To understand the effectiveness of these platforms, it's essential to look at key performance metrics, such as user engagement, project completion rates, and the time saved in the design process.

- **User Engagement:** Platforms like Houzz and Homebyme are highly engaging due to their visual nature. Houzz reported over 40 million monthly users globally, many of whom actively participate in discussions and project sharing (Houzz, 2023). This level of engagement highlights how online platforms are becoming essential in the custom home ecosystem.
- **Time Savings:** Research shows that using online platforms can reduce the custom home design timeline by up to 30% compared to traditional processes (NCHBA, 2022). This reduction is primarily due to the quick turnaround in design revisions, immediate cost estimations, and faster communication between all parties involved.
- **Budgeting:** Platforms like Chief Architect and Houzz help homeowners manage their budgets effectively. On average, custom homes designed using these platforms stay within 10-15% of their projected budgets, compared to an industry average of 20% for projects without digital tools (Zillow, 2022).

Figure 3: Time Savings in Custom Home Design Process Using Online Platforms (Source: Data from multiple secondary sources and an estimate. Ismail,2024)



The above graph. 1 shows that traditional custom home design methods take the longest (8 months on average), largely due to time-consuming in-person meetings and manual design revisions. Online platforms like Houzz reduce this timeline to 5.5 months by offering efficient communication and real-time design updates. Professional-grade tools like Chief Architect, used by contractors and builders, further reduce the design time to 4.5 months due to their integration of precise architectural tools and faster drafting capabilities.

The literature on custom home building provides an extensive insight into the growing demand and importance of personalization, sustainability, and long-term savings through designing and building custom homes. Furthermore, the detailed analysis on digital construction ecosystem shows the importance of digitalization in construction and in return for custom homes too. However, the custom home building ecosystem is mainly dominated by online platforms like Houzz, Homebyme, and Chief Architect these platforms have adapted and catered to the demands because they are offering tools that ease the design process and make custom home building more accessible. These platforms are catering to the custom homeowners and builders by having a major share in custom homes ecosystem by streamlining communication, improving visualization, enabling cost-effective design changes, and cost comparisons, thus reducing the time and effort required in the traditional custom home building process.

However, each platform has features that offer unique services. For example, Houzz and Homebyme are ideal for homeowners looking for services and ideas with the help of user-friendly interface, while Chief Architect offers professional-grade software for builders and architects. The integration of these platforms into the custom home building ecosystem not only improves efficiency but also helps homeowners and professionals achieve higher satisfaction levels, better budget control, and more innovative designs

The role of above-mentioned platforms in the custom home construction has improved the efficiency of project management and the design and construction of buildings. Hence, further innovations and development in this ecosystem will benefit homeowners as well as builders. Findings of literature, analysis results and thorough understanding of the current custom home building ecosystem, helps us to understand the importance of developing a more advanced platform that will add more value to the ecosystem and serve the homeowners and contractors. In the next chapter of Integration, framework of such platform will be provided along with its integration and implementation to a feasible prototype as a solution.

5. Integration

After a thorough research and analysis on the current custom home building digital ecosystem, next step will be achieving the main goal of this thesis which is to identify the needs of custom homes clients and integrate these into a digital platform solution. Assessment of the current major platforms under review shows that they are not up to date because of their limited functionality and manual services. For example, if a service is selected, the user must wait for contractors to respond with designs and quotations.

However, to make a completely digitalized and automated platform, a user must be able to get designs and quotations beforehand within a few clicks.

The process of receiving results from the platform is demonstrated by following figure:

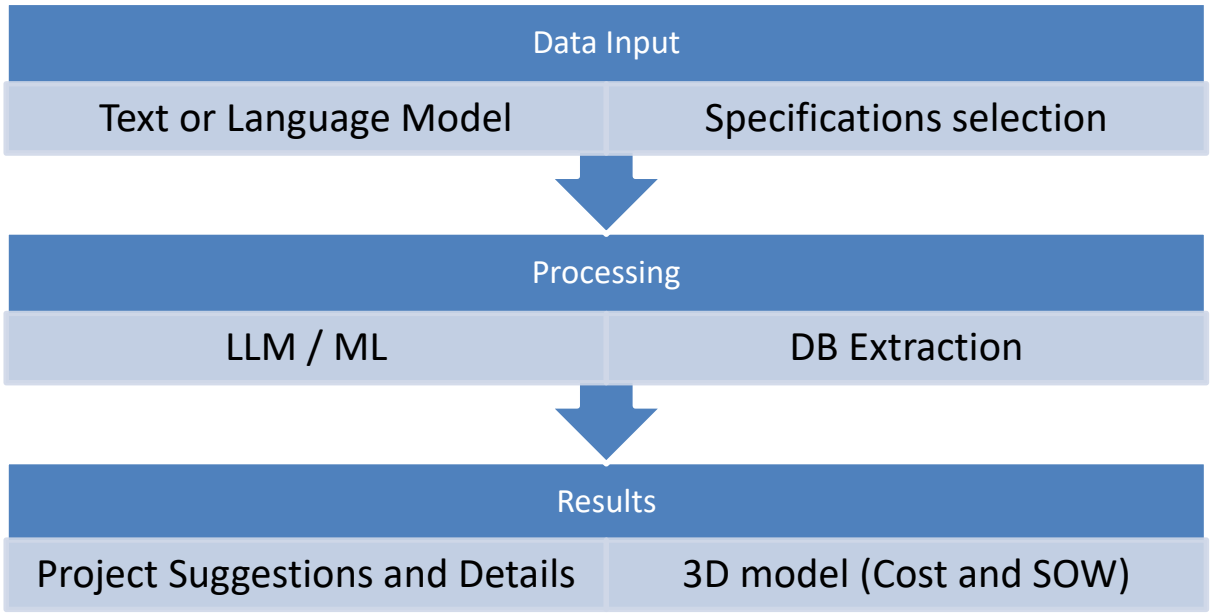


Figure 4: Platform Specifications and Process Diagram

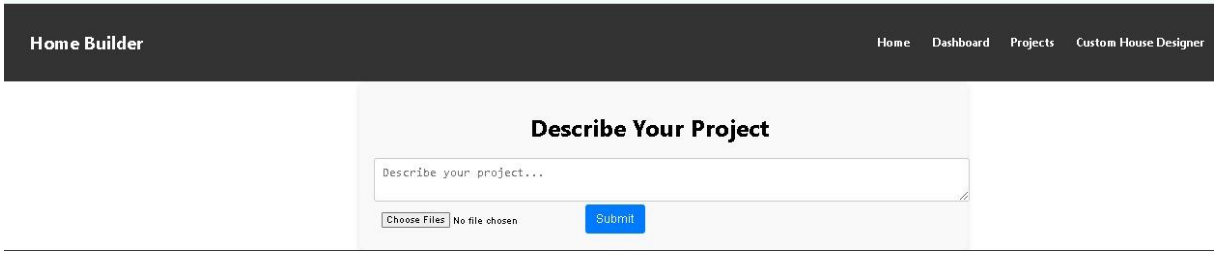
5.1. Data Input:

Users can input their requirements or the project description in the form of language model or options selection integrated in the UI (user interface). These processes are further explained below:

5.1.1. Natural Language Processing by integrating AI and ML:

NLP techniques will be used to analyze the project descriptions provided by users. The key information such as project type, budget, timeline, and specific requirements can be entered in the “describe your project” box as shown in figure. 4 below. Then, it will be extracted through NLP and made ready for further processing (as shown in figure 4).

Figure 5: NLP using AI and ML (Refer to Appendix A for complete desktop image)



Further processing is done by using AI (artificial intelligence) and ML (machine learning) that will help the NLP to provide accurate suggestions based on the trained data sets. In this way, the platform assists the users in understanding their project better and finding the ideal suggestions for their projects, such as design, timeline and budget.

5.1.2. **Specifications selection**:

In this feature, the user will be able to see different options on the interface to input the project description for further processing. The UI of the platform will display these selections as job and materials type required for different steps of the construction with additional details from the data library, so that the user can provide project description easily as shown in figure. 5 below.

Figure 6:Specifications selection interface (Refer to Appendix A for complete desktop image)

In the above figure. 5, it can be noticed that there are separate options to select from such as multiple options with pricing in interior and architecture. By selecting these the user can view the details in the window located to the right of the options panel.

5.2. Processing of data:

The second step will be to process the project description input, and this will be done by encrypting the input. The processing will be done through matching the requirements or input with the stored data from the library, for example, price, contractor and design/build specifications considering all the final inputs. This processing could be linked with the help of coding or be executed through Machine learning models (MLM).

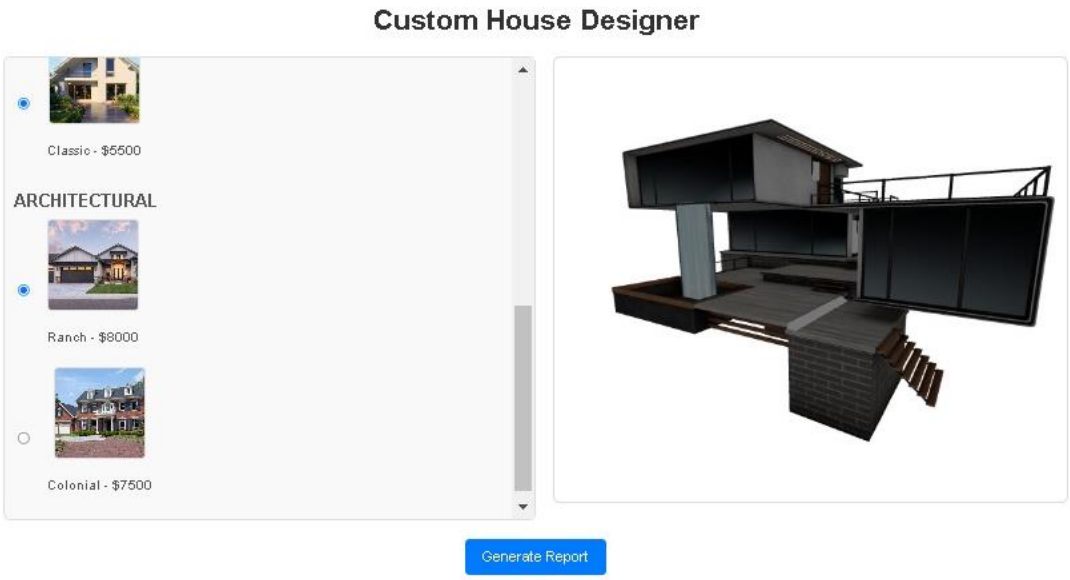
5.2.1. Machine Learning Models:

Machine learning models are trained to predict the most suitable contractors for a given project based on historical project data and contractor profiles. You can use supervised learning techniques such as classification or regression, where the input features are project details, and the output is a prediction of contractor suitability.

5.2.2. 3D model generation (using renders):

After the input of data such as materials, design elements, and exterior designs, the finished product is shown as a complete 3D model as shown in the figure. 6 below. The input data will pick up corresponding renders and details from the data library to create this visual model. Hence, the set of selections on the left can select a set of renders from the library and combine to give a final 3D model along with material and pricing details as shown in the figure. 6 below:

Figure 7: 3D model window using renders (Refer to Appendix A for complete desktop image)



5.3. Results:

The results will follow the processing of data, and it will include the output from the platform's database which will utilize MLM, AI and 3D model generator. The user will see the budget, duration and 3D model of the project in a pdf format as shown in the figure. 7 below:

Figure 8: PDF Report showing details of the project

Custom House Design Report

EXTERIOR

Name: Wood

Price: $4000

Wood

INTERIOR

Name: Classic

Price: $5500

Classic

ARCHITECTURAL

Name: Ranch

Price: $8000

Ranch

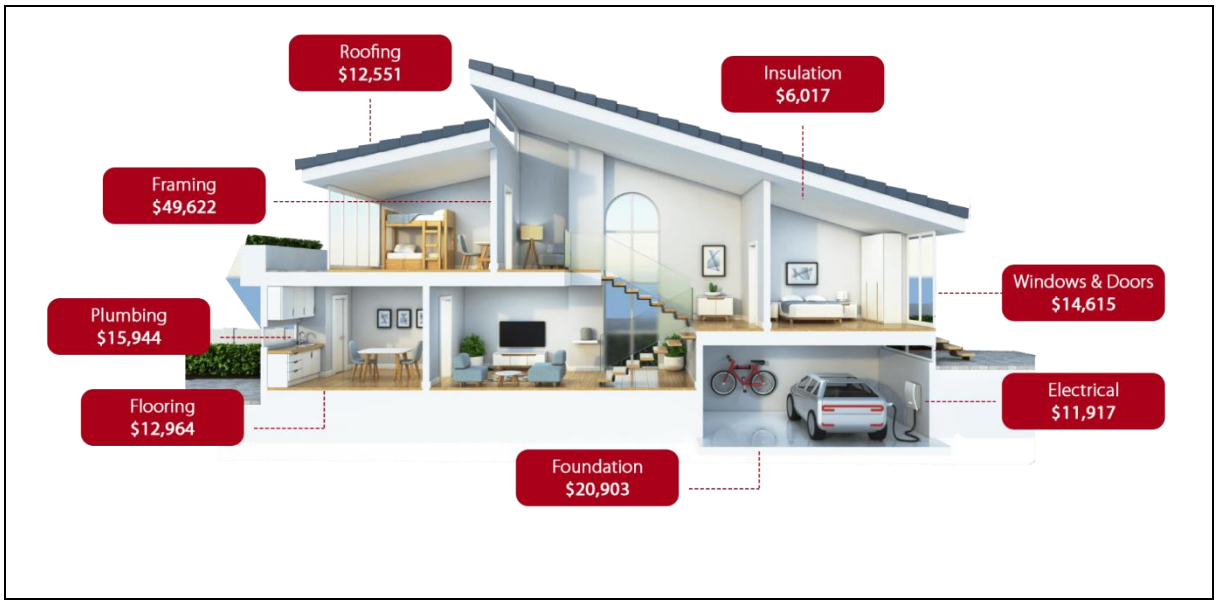
Total Cost: $17500

5.3.1. Information Delivery

Figure. 7 below, demonstrates graphically how user shall receive the details of cost, work scope and materials selected by them. This information is not part of the prototype generated results (Fig. 7) and hence, is a feature that will help generate more feasible results so that users get more clarity to go forward with the project. These details will be based upon market standards. Providing this information is one of the core processes as this will allow the homeowners to choose the best combination

Figure 9: Cost and design Information, Source: https://todayshomeowner/cost-of-building- a-home

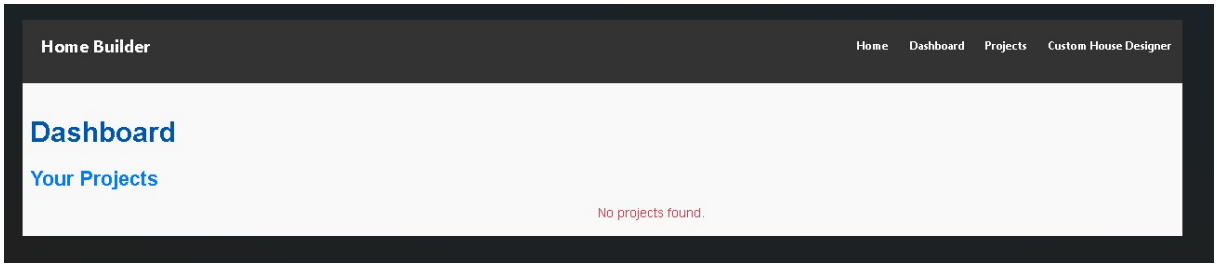
scope of work and materials for their home.



5.4. Integration of Construction management

The figure. 9 below shows the interface of a dashboard where the contractor and end user can upload files and keep track of the project's progress.

Figure 10: Dashboard for Project management



5.4. Contents of the platform

Based on the framework of integration, the prototype for the custom homes building is developed using following tools and technologies:

Frontend Development

The user interface (UI) for the platform is coded using React native, and JavaScript. This includes designing the layout, navigation, forms for submitting project details, and displaying search results and administrative controls.

Backend Development

The backend of the platform handles the business logic, database interactions, user authentication, and communication with external services. Node.js is used to program the backend of this platform's prototype.

Database Management:

The platform of such nature could use MySQL, PostgreSQL or MongoDB for Database Management. The database management application. Is not incorporated in the prototype. Database is required to store cost of materials, a certain job scope, renders, user accounts, project details, contractor profiles, and other relevant data. LLM models could be outsourced from an LLM API provider or libraries like SPACY or NLTK can be used for text processing and analysis.

Request Processing Algorithm

When a client requests or submits an inquiry, providing certain data there are algorithms developed to provide the best results which will be extracted from the database. These algorithms verify the project specifications, location and nature of job and its market.

Reviews and Ratings

Client feedback is crucial for the improvement of the platform. This feature will make sure that the process, results and algorithms are up to date and functional. This also helps improve the performance of the platform.

Security

To secure the platform, preventive measures such as HTTPS encryption and protection against common web attacks are taken into consideration.

As we can notice from the above details of the platform is that building this online platform at full scale involves a multidisciplinary approach. It requires collaboration of construction managers, designers, developers, database administrators etc.

5.5. Further Development

After the development of basic functions of the platform, it is optimized with further innovative features integration to provide a result oriented custom home building ecosystem:

Recommendation Systems: Implement recommendation systems to suggest contractors to users based on their project requirements and preferences. Collaborative filtering or content-based filtering algorithms can be used to generate personalized recommendations for users.

Image Recognition: If users provide images or sketches of their project, you can use image recognition algorithms to analyze and understand the visual aspects of the project. This could help in matching users with contractors who have experience in similar types of projects.

Chatbots: Develop AI-powered chatbots to assist users in posting projects, answering questions, and providing recommendations for contractors. Natural language understanding (NLU) models can be used to process user queries and generate appropriate responses.

Continuous Learning: Implement mechanisms for continuously learning from user interactions and feedback to improve the AI models over time. This could involve retraining machine learning models periodically with updated data and incorporating user feedback into the recommendation algorithms.

Data Privacy and Security: Ensure that user data is handled securely and in compliance with data privacy regulations. Implement encryption, access controls, and anonymization techniques to protect sensitive user information used by the AI models.

By integrating AI, ML and 3D models into the platform, the process of understanding the requirements of the users could be automated and enhanced. Receiving visual results, project details and approximate budget by users (as shown in fig. 4), will improve the decision making and make custom home building a transparent process. Therefore, the users and contractors can begin the project hassle free with a personalized new home that costs a standard and transparent price. This platform will provide a more efficient and personalized experience for both parties involved. However, it is essential to carefully design and evaluate the AI models to achieve accuracy and transparency in the results. Moreover, the users must be communicated that the role of AI is recommending and suggesting, and these results could be selected only if the homeowner has no specific preferences. The accurate results will be given by the selection input method because the results will be by construction industry standards and taken directly from the library as selected by the user. Additionally, due to the use of AI, users will be given the option to control their data privacy.

6. Limitations

6.1. A prototype with limited features:

The research answers its questions in a very detailed manner and provides a framework for a solid and transparent platform that will serve both enterprises and end users. However, only the prototype of this platform is developed as part of this thesis as it needed a lot of financial resources and/or coding skills. Therefore, the prototype displays limited features but shows that the research has practical application.

6.2. Creating database:

Creating and storing databases requires expertise of a team as this platform requires renders of design elements of houses and complete house templates which are needed to be in a specific format to be able for integration. Similarly, market research needs to be conducted to create the budget and costing database. The NLP has limited functionality because AI needs further training in LLM models of architecture and construction.

6.3. Legal compliance:

Another important requirement is regulating this platform in accordance with the legal and regulatory laws. Compliance with data protection laws is also an important legal aspect. To achieve this, privacy and data protection compliance is an important legal requirement.

6.4. Construction management integration limitations:

The platform can only incorporate a simple project progress or communication tool between the contractor and end users (Fig. 9). It was not possible to integrate the complete project management features into the platform’s framework or the prototype.

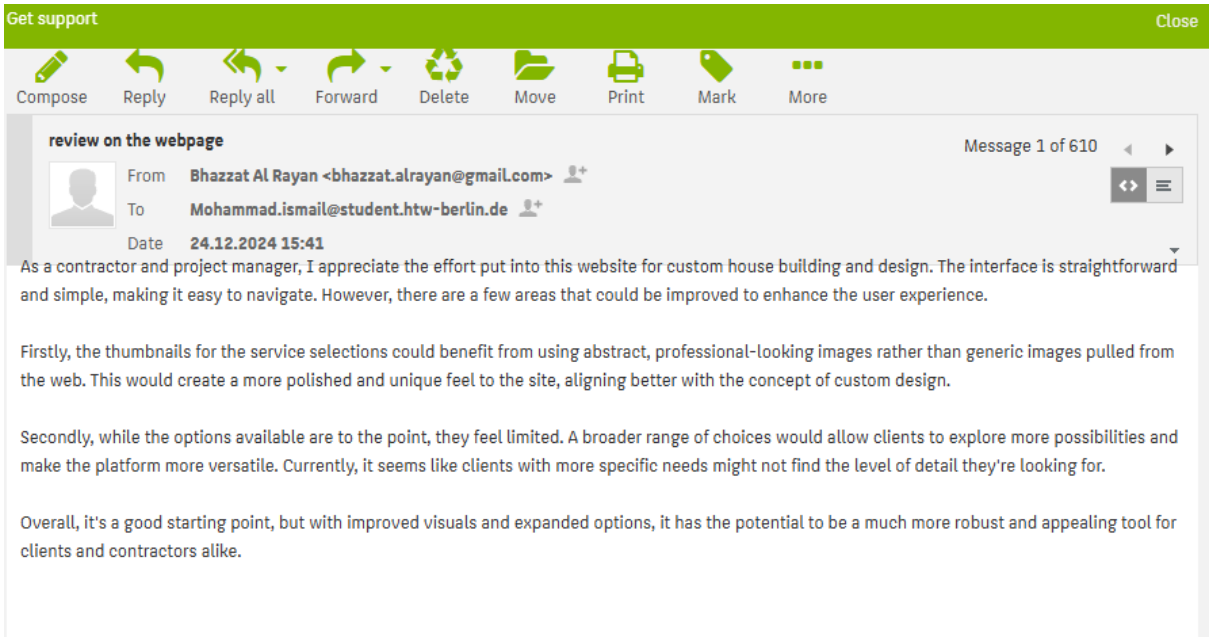
7. Validation of the Results

To validate the results of this research, the protype is tested by three professionals. The idea behind this testing was to ensure that the research has met its objectives, and the perspective of end-users and contractors is aligned with the development of this research. It is highly important to consider such feedback and validations for this platform to develop further because of its dependency on the use of end users.

Total number of selected testers were 3 and their email response or feedback can be:

- **Bhazzat Al Rayyan (Contractor):**

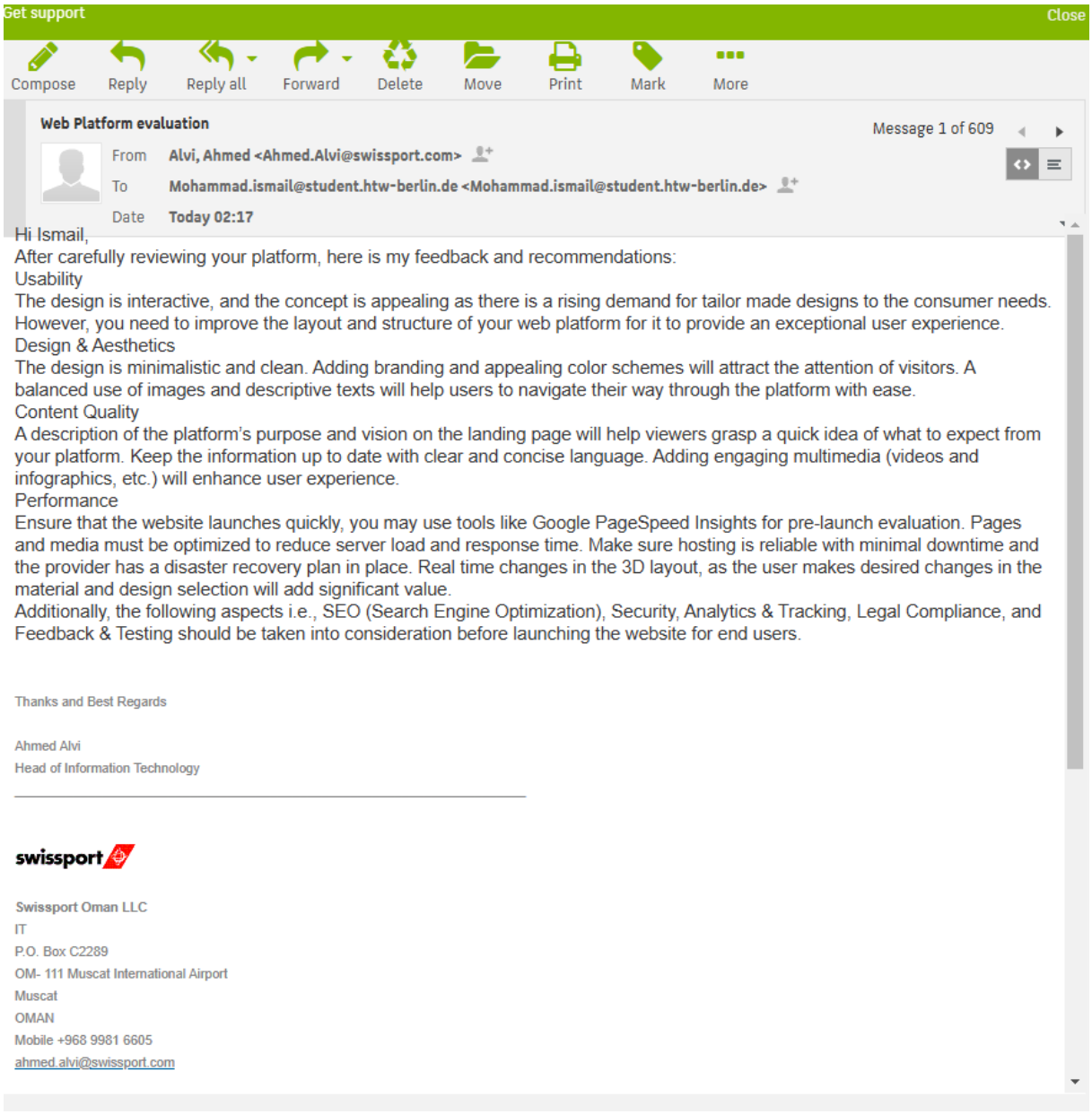
Figure 11: Tester Feedback (Refer to the Appendix for PDF of Email)



In Fig. 10, The tester wants the platform to have professional and customized renders and an enhanced user experience. According to this tester the number of details and specifications need to increase, and more detail could be included. However, the tester believes that the platform is an important custom homebuilding digital tool for both contractors and end users.

- **Ahmed Alvi (Head of IT, Swissport Oman)**

Figure 12: Tester response (Refer to the Appendix for PDF of Email)

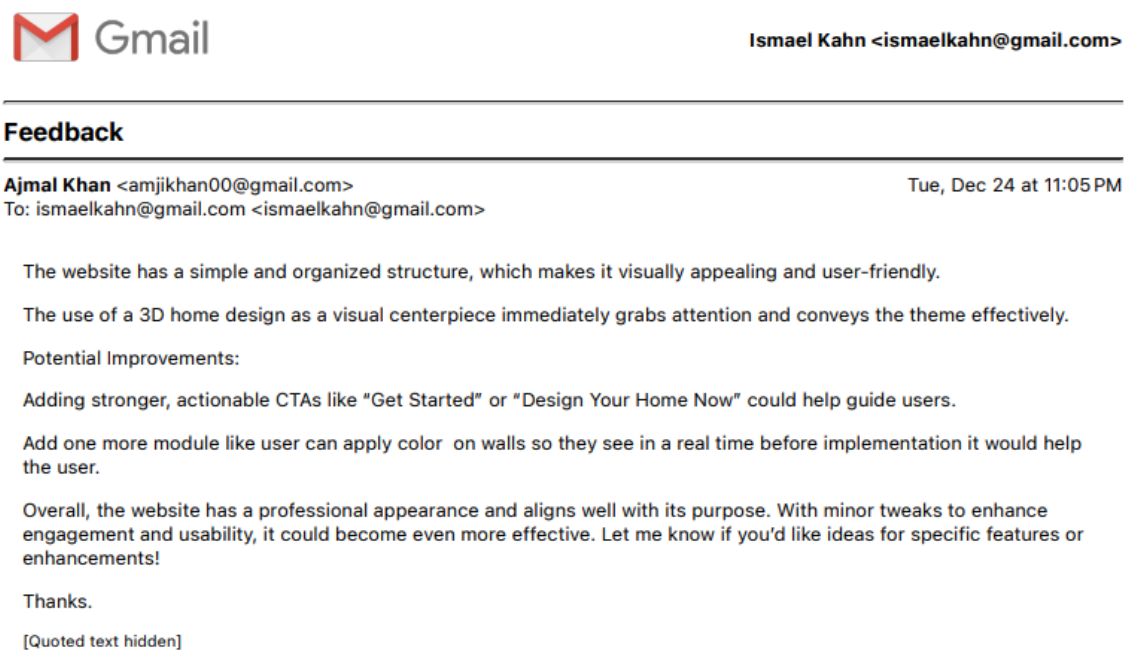


The above figure. 11 shows the email response for testing the prototype and the tester is content with the results of this research but being an IT professional further digital tools and technologies have been recommended for better results.

- **Ajmal Khan (IT)**

In the figure. 12 below the response of third tester explains that the developed prototype of the platform is easy to comprehend and provides latest digital tools for the users. Although further technological developments are being advised because of the IT background of the tester. The overall research and development are appreciated.

Figure 13: Tester response (refer to the Appendix for PDF)



Gmail

Ismael Kahn <ismaelkahn@gmail.com>

Feedback

Ajmal Khan <amjikhan00@gmail.com> Tue, Dec 24 at 11:05 PM
To: ismaelkahn@gmail.com <ismaelkahn@gmail.com>

The website has a simple and organized structure, which makes it visually appealing and user-friendly.

The use of a 3D home design as a visual centerpiece immediately grabs attention and conveys the theme effectively.

Potential Improvements:

Adding stronger, actionable CTAs like "Get Started" or "Design Your Home Now" could help guide users.

Add one more module like user can apply color on walls so they see in a real time before implementation it would help the user.

Overall, the website has a professional appearance and aligns well with its purpose. With minor tweaks to enhance engagement and usability, it could become even more effective. Let me know if you'd like ideas for specific features or enhancements!

Thanks.

[Quoted text hidden]

8. Conclusion

The main objective of this thesis was to provide a digital solution that will improve the custom home building ecosystem and facilitate both homeowners and contractors to carry out maximum number of tasks digitally in the planning phase. To achieve this, current custom home ecosystem was researched and analyzed. As a result of this research, it was discovered that professionals or contractor companies utilize digital tools like designing, management and engineering software for Custom home building. These technologies and tools are used in overall construction and not just home building. Therefore, the overall digitalization in construction and real estate sector was also researched to understand and draft framework for the objective of this thesis. The custom homes ecosystem lacked a solution for homeowners involvement as it was more about making the job easier for the professionals, engineers, architects and contractors involved. Due to which, the objective of providing a framework for platform where both homeowners and contractors could exchange details and plan the project digitally, became a viable and much needed tool. It was discovered in the research that building a custom home is a very personalized process and needs a lot of in person follow-ups, that is how a selection process was started to try and include as much as possible features from all the areas in question i.e. designing, procurement and construction management, into the final platform framework.

The current ecosystem of custom homes includes platforms that either link contractors to clients or help the clients select from past projects and contact the contractor. There are platforms that let users design a plan of their house which is used only for visualization purposes. Latest technologies like AI and ML are very uncommon in the custom home ecosystem. It can also be seen that the current home building platforms can provide budget and design details but only after talking to the contractor. Hence, the research question was valid that custom home building ecosystem has the potential of using digitalization and automation through an integration of advanced platform.

The results taken from the literature review and analysis shaped the outlook and framework of the platform respectively. The features, processing and UI/UX of the platform are suggested for an ideal custom home building platform backed by analysis. The

technical specifications of this platform could however be changed and is not final i.e. programming languages such as python or Laravel could also be used for backend programming. The current platform supports this thesis as a prototype and has immense room for improvements based on this thesis findings and framework. If the implementation is done according to the complete framework presented in this thesis, a viable platform could be integrated to the digital ecosystem of custom home building that will allow the homeowners and contractors to automate the processes of planning, budgeting and designing. Integration of construction management had some limitations both in the framework and the prototype as the analysis and results did not support this integration. It was mainly because of the advanced project management tools already available in the construction market that would be more suitable for managing a custom home building process.

As per the suggested framework in integration phase of this thesis, the features of the platform are:

- Remote Planning and communication remotely.
- Budgeting and material details.
- Architectural design or 3D model.
- AI suggestions.

The prototype offers limited functionality but uses the same principal features. The backend development of the prototype was done by using Node.js whereas, the frontend development uses React native. Examples of Image generation, AI suggestions, budgeting and material details are all achieved in the prototype.

The result shows that the prototype is functional and allows a user to select different materials and designs displayed in a 3D viewer along with cost details. The user can make selections and generate a final report which shows the project details i.e., price, materials, duration and a 3D model. To fulfill the construction management aspect, the prototype is currently displaying a minimal window that allows contractors and users to update the progress of the project. With the help of professional coding and further development of the existing prototype, according to the framework mentioned in the thesis, a fully functional and robust platform could be developed that will allow its users to create 3D custom home models with architectural, planning and budget details.

Therefore, it can be concluded that the main goal of this research is achieved by developing a workable solution that answers the research questions. The credibility of the prototype is proven as a useful development through validation. As a further development of this research, the platform development must be done completely according to the framework using professional programmers. Whereas integration of this platform to the custom home building ecosystem is more needed than ever, as the research suggests. The developed prototype could be used as a reference for a complete functional platform of a custom home building ecosystem and the framework for such fully functional platform is already provided in integration phase of this thesis.

Declaration of Authorship

I hereby declare that the attached Master's thesis was completed independently and without the prohibited assistance of third parties, and that no sources or assistance were used other than those listed. All passages whose content or wording originates from another publication have been marked as such. Neither this thesis nor any variant of it has previously been submitted to an examining authority or published.

Berlin, 24.12.2024

Location, Date

Signature of the student

Appendix

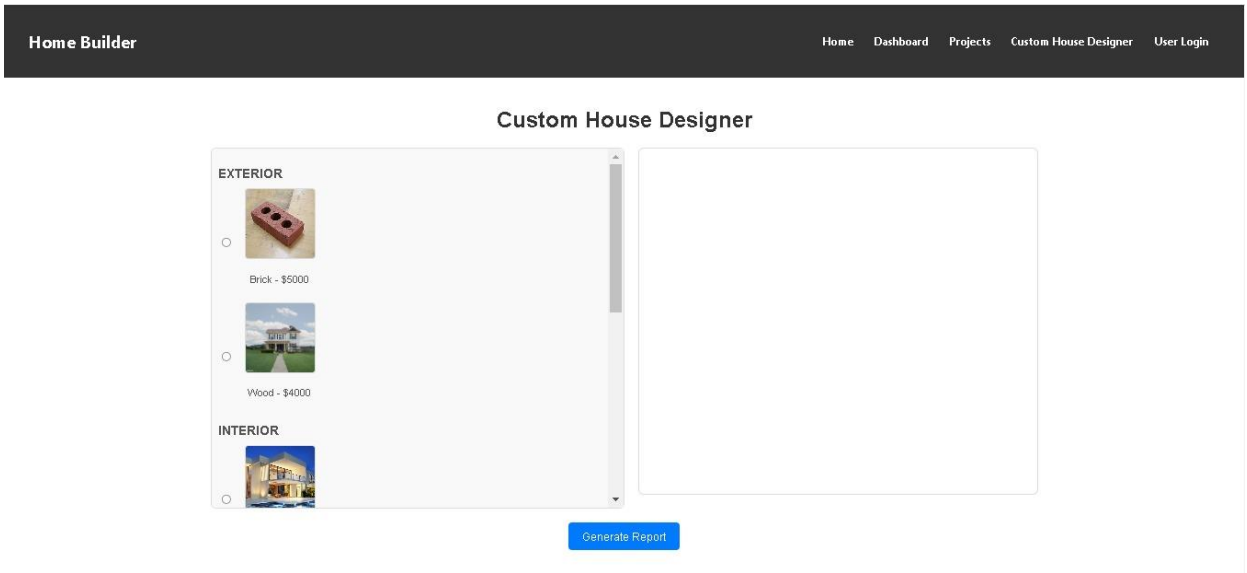
581325 Ismael Spec signed.pdf

Alayyan testing feedback.pdf

Test 1- Email Alvi.pdf

Test 3- Feedback.pdf

14: Complete Interface window of the platform



15: 3D Model viewer of the platform

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