An-Najah National University

Faculty of Graduate Studies

AN AHP BASED CRITERIA FOR ASSESSING AI ASSISTED DESIGNS AS PERCEIVED BY DESIGNERS

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Dedication

To my loving father, Mr.Aref Kayed, and mother, Mrs.Mujaheda Mukhiemer, whose unflinching faith in me and unceasing support have been the driving reasons behind my pursuit of this ambition. Especially at the most trying times, your love and support have been my pillars. You have my eternal gratitude for your unending sacrifices and for always being at my side.

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I sincerely appreciate your support, without which I could not have completed this thesis.

Declaration

I, the undersigned, declare that I submitted the thesis entitled:

AN AHP BASED CRITERIA FOR ASSESSING AI ASSISTED DESIGNS AS PERCEIVED BY DESIGNERS

I declare that the work provided in this thesis, unless otherwise referenced, is the researcher’s own work, and has not been submitted elsewhere for any other degree or qualification.

Student's Name: **Assel Aref Wajih Kayed**

Signature:

Date: **13/02/2025**

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Abstract

This thesis presents the development of an Analytical Hierarchy Process (AHP) framework to assess artificial intelligence (AI)-assisted architectural designs. The main objective is to construct a priority scale that reflects the experts' evaluation of the relative importance of different design elements. To this end, after an extensive systematic literature, four primary standards—authenticity, beauty, inventiveness, and harmony—were found to be crucial for judging architectural designs. Sub-criteria were derived from each of these primary criteria to offer a more detailed assessment.

A panel of professionals in the domains of architecture and artificial intelligence were administered a two-part questionnaire in order to inform the suggested framework. In the second section, the specified criteria and sub-criteria were evaluated.

The AHP results show that, inventiveness with (35.5%) weight is the most influential factor for assessing AI-assisted designs. Authenticity with a weight of (21.5%) and harmony with a weight of (24%) are, respectively, the next two most important criteria. Beauty was found to have a weight of (19%).

The most important sub-criterion for authenticity with their weights were found to be design consistency (36.1%), with material integrity (20.4%), authentic expression (22.7%), and historical context (20.8%). The top ranking factors for beauty are integration with the environment (43.7%), visual impact (22.1%), timelessness (20%), and detailing (14.2%). Emerged as the highest-ranking element of inventiveness is sustainable solutions (36.1%), with technical innovation (23.1%) and adaptive reuse (23.9%) also having significant effects. A smaller but still significant impact is made by spatial novelty (16.9%). Material coherence (28.3%), spatial harmony (21.2%), and proportionate balance (16.3%), environmental synchronization (34.2%) are the main components of harmony.

The contribution of this research is mainly for researchers, architects, and stakeholders to be able to quantitatively assess architectural designs that are produced by AI with a novel AHP based approach evaluation method.

This framework contributes to the ongoing discourse about the incorporation of Artificial intelligence in the field of architectural engineering, by prioritizing important design elements and providing a systematic method for upcoming evaluations. A thorough assessment of design quality is made possible by the framework's methodical approach.

Keywords: Analytical Hierarchy Process, Artificial Intelligence, AI Assisted Designs.

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Chapter One
Introduction and Theoretical Background

1.1 General Background

The construction sector has several problems that have delayed and oppressed its expansion which in turn resulted in low levels of productivity even more so when a comparison is made with the field of manufacturing, it can be considered to be one of the least fields to include digitization, and it's a commonly known fact that is stated by the stakeholders that the construction field has a strong resistance when it comes to change. (Sofiat, 2021) The result of the resistance to change in the field of construction and the lack of incorporation of digitization results in making the management of projects time and effort consuming needlessly. While productivity has gradually improved across numerous industries over the past 50 years, it has scarcely increased and may perhaps have dropped in the construction sector. (Delgado, 2019)

Due to the fact that the construction field not being adaptable to the new technologies and the resistance to enhance the digital skills many issues remain the same. For example the performance of the project not meeting the standards, making decisions that come from a place of ignorance that lead to wasting resources and lowering productivity, safety, and health. (Sofiat, 2021)

"One of the most significant economic sectors in the world is the construction sector. In most nations, expenditure on building accounts for (9%) to (15%) of GDP, and up to (50%) of a country's investment can be devoted to the built environment". (Delgado, 2019)

Due to the nature of the engineering field specially the architecture and construction sectors, it has always been a long life dream to include the use of new and creative technologies including robots in the field, but the various limitations always stood in the way of achieving that wither its social, or culture, etc., but even with these limitations this goal helped shape concepts, futuristic ideas and understanding of better future. (Sacks, 2020)

Traditional engineering and product design procedures are centered on the needs of the human being and demand specialist knowledge utilizing scientific, intuitive, experiential, and creative techniques. With the application of artificial intelligence in product and engineering design, along with all other engineering disciplines, this traditional method is evolving in recent years. Computer algorithms that mimic biotic brain processes or behaviors are referred to as artificial intelligence. It may be applied to activities like comprehending, estimating, solving problems, coming up with ideas, and making decisions in a variety of disciplines, including the engineering design process. (Yüksel, 2023) The goal of artificial intelligence, or AI, was initially to create intelligent beings in addition to just understanding what intelligence is. Since the 1950s, artificial intelligence has evolved as a science that combines constantly larger datasets with ever-increasing multitasking capabilities, processing capacity, and memory. Later, the areas of machine learning (ML), deep learning, and reinforcement learning were created that make use of AI algorithms, which are computing units that convert inputs into desired outputs. (Garibay, 2023)

Artificial intelligence, a disruptive technology, has advanced past its early phases and is prepared to alter many industries. The conventional human-centered methods to engineering in design, electrical, communication, and renewable energy are projected to be fundamentally transformed by this technology. Even though they are still in their infancy, AI-powered engineering apps may deal with ambiguous design specifications and find solutions to complex engineering issues that cannot be solved by utilizing conventional design, electrical, communication, or renewable energy techniques. (Khaleel, 2023)

When it comes to using artificial intelligence in the field of architecture, AI offers enhancing the precision, efficiency, and creativity. For example, the Redraw helps designers to transform simple sketches into finalized and polished renders of the design. Which saves precious time in the early stages of the design process. Another example is Archivenci which is used to enhance layouts and offers structural and environmental sound solutions. Architect AI takes into consideration past buildings and design and offers improvements where it’s not only aesthetically better but also functionally. Finally, T-Square focuses on reducing the tedious manual aspect of the design process.

All of these programs and many others that are currently in use contribute to eliminating the time consuming reparative work of the design process and to allow the space to experiment with new ideas, shapes and solutions. (Architectural Design AI Tools)

The goal of this study is to generate a framework that can numerically evaluate the acceptance of an AI assisted design based on the viewpoint of designers and what they think is vital based on their experience and practical knowledge gained from it. After the identification of the main criteria and sub criteria of the elements that the designers think is important to accept an AI design the Analytical Hierarchy Process is used to give numerical value and weight to each element and criteria which would create a hierarchy of importance and a priority for the elements over others, these weights would then be normalized and summarized in a framework that is dynamic in nature by the use of an Excel sheet, which would allow the entering of date and instantaneous results would be provided to the user, providing such framework for designers, organizations, and governmental organizations would help set a standard to evaluate AI produced deigns and also spread more confidence in the use of AI in the field of architectural engineering, specially that it gives quantitative measures for qualitative elements.

1.2 Problem Statement

Since the introduction of AI in the field of architectural engineering many improvements and tasks has been introduced, projects in the field of architectural engineering go through many long and repetitive tasks that were reduced with the use of AI, that leads to the increase in the productivity, plus, AI has allowed designers to experiment new ideas without wasting a lot of time, and its role is only increasing in this field. (Abioye, Oyedele, & Akanbi, 2021)

The research gap that this research fills is that the existing frameworks give focus to standards and guideline that are only practical like the cost, the required spaces and their areas, and functionality, which is a huge drawback when using AI in the field of architectural engineering, these frameworks neglect a very important viewpoint which is the viewpoint of the designers which are the targeted audience category for using AI and what they value when it comes to design based on their experience, and their long interaction with stakeholders. (Zhang, 2023; Lavdas & Salingaros, 2022)

The doubts that most designers have of the use of artificial intelligence in field of architecture comes from two things first, that there is no standards to adhere to when an AI produces an architectural design and the lack of set guidelines, which prompts an unease when using AI, second, AI programmers don’t take into consideration the designers views and practical experience as well as their artistic sense, those reasons could lead to the lack of desire to turn to AI in the field of architecture.

Due to the fact that the produced framework including criteria like authenticity, inventiveness, beauty and harmony, the framework can be considered wholesome when talking about the evaluation of architectural designs, this framework aims to create a link between architectural designers and AI programmers, and that’s the importance of this study. This study not only does it include the mentioned criteria but it also utilizes the Analytical Hierarchy method to give priority for some criteria over the other.

The goal of this research are is not only in the production of an evaluation framework but also in the academic and intellectual sense where by conducting this research a door is opened for other researchers to talk about the integration of artificial intelligence in the field of architectural engineering, and this research can hopefully set standards that are measurable to evaluate AI assisted designs and can decide on their acceptance, that way AI can be more trusted by stakeholders thus leading to the improvement of AI and its features and tools.

1.3 Research Objectives

The main objective of this research is to generate a framework that helps with the evaluation of AI assisted designs especially architectural AI assisted designs, the framework not only helps with the evaluation of the produced designs but also to the improvement of AI. The process of this research starts by identifying the elements that experts in the field take into consideration when evaluating designs, which their importance is then studied in depth. Then, a framework for the systematic ranking of these criteria is created using the Analytical Hierarchy Process. Investigated is also the degree of agreement or disagreement among designers while using this approach. In order to improve the integration of AI-assisted designs into engineering management procedures, practical insights and recommendations based on the findings are ultimately intended to be supplied. Together, these goals enable the development of a user-centric methodology for the assessment of AI-assisted designs in the world of engineering management.

1. To Identify Key Assessment Criteria for AI-Assisted designs.
2. To Develop an Analytical Hierarchy Process Framework to evaluate AI produced designs.

3. To Obtain Practical Understanding and useful Guidelines and workable suggestions.

1.4 Research Questions

1. What standards and sub-standards are most pertinent for assessing AI-assisted designs from the standpoint of engineers and architects?
2. How can AI-assisted designs be methodically assessed for quality using the Analytical Hierarchy Process in light of the requirements and preferences of designers?
3. How can designers use the AHP-based assessment methodology to assess AI-assisted designs in real-world situations? What useful advice or recommendations may be given?

1.5 Importance of The Study

Because of the inclusion of AI in many sectors and making changes, AI is become a household technology that has moved passed and evolved from its initial stages. Due to that fact it’s going to effect the methodologies of the conventional architectural engineering field which to this day is still amerced in the old fashioned human centered methods. The resolution of complex design problems, clearing uncertain parameters of the design requirements are some examples of the solutions that AI offers in the architectural design process instead of dealing with the conventional ways that would possibly never resolve these complicated issues.

AI techniques are used in engineering design applications to produce effective, quick, accurate, and thorough solutions. Situations where human talent is insufficient can be effectively handled, particularly using deep learning techniques and combinations. However, for such fruitful outcomes, picking the appropriate AI approach for a design challenge in question is crucial. (Yüksel, 2023)

“The application of AI in architectural design is not devoid of challenges. Deep learning models and extensive datasets cannot mimic human ways of thinking, such as “common sense”, i.e., the ability to generalize, create, and simulate abstract information. Thus, the progression of AI needs to coincide with enhancements in strategies to adapt to the rapid technological advancements and cultivate designers capable of effectively utilizing these tools.” (Zhang, 2023)

Creating an architectural design that is successful and new in terms of aesthetics, and usability and functionality is no easy task, it requires both experience and creativity, the design stage is in the initial stages of a project so including AI in this process is tricky because it needs to focus on investigating solutions to fulfill the required needs. When talking about the goal of the design it’s hard to measure because of the lack of standard guidelines and tools of assessment. (Pena, 2021)

1.6 Theoretical Background

1.6.1 Analytical Hierarchal Process (AHP)

One of the pioneers of operation research is Thomas Saaty, who developed the concept for the AHP. The AHP technique was developed in an effort to close the communication gap that Saaty saw between scientists and attorneys over a useful, methodical methodology for prioritization and making decisions while he was a professor at the Wharton School. (Mushtaha, et al., 2021; Saaty T. , 2008)

Since its creation, academics and decision-makers have employed the Analytic Hierarchy Process, which is one of the most popular multiple-criterion decision-making procedures. (Vargas, 1990; Zahedi, 1986) Because of its effectiveness and simplicity, this approach has been adopted by many businesses and taught in institutions.

It has been widely embraced and applied in a variety of applications, enabling individuals to make decisions even in the face of complicated challenges. (Mushtaha, et al., 2021; Forman & Gass, 2001).

Numerous excellent works based on AHP have been published; they comprise numerical expansions of AHP as well as applications of AHP in a variety of domains, including planning, dispute resolution, and allocation of resources, optimization, and optimal solution selection. (Vargas, 1990; Zahedi, 1986)

AHP is widely used when evaluating construction projects. For example, when creating a decision-support system that takes into account the relative preferences of the architect and owner among several important criteria, or when assessing building material suppliers while accounting for a large number of intricate and subjective factors. (Maceika, Bugajev, Šostak, & Vilutienė, 2021)

The procedure comprises the identification, organization, and assessment of certain criteria from the viewpoint of specialists. (Saaty T. , 2008) Pairwise comparison is employed by AHP to allocate weights to criteria and systematically rank alternatives. AHP provides a way to calibrate the numerical scale used in performance assessment, both qualitative and quantitative. The scale is as follows: 1/9 for "least valued than," 1 for "equal," and 9 for "more important than". (Vaidya, 2006)

AHP performs a hierarchical analysis of an issue, starting with a goal and moving on to criteria, sub-criteria, and options. The hierarchy helps professionals determine if pieces on the same level are comparable by providing them with a wide picture of the complex relationships within the context. Next, the elements' weights are determined by pairwise comparison on nine distinct level scales. (Liu, Ekert, & Earl, 2020)

1.7 Artificial Intelligence (AI) History

1.7.1 The Definition of Artificial Intelligence and Creativity

It is widely acknowledged that artificial intelligence lacks a universally recognized definition. (Monett, 2018; Bhatnagar, et al., 2018; Nilsson, 2009; Hearst & Hirsh, 2000; Allen, 1998; Kirsh, 1991)

As a result, the word "AI" has been employed both inside and outside of the field in a variety of contexts.

Many people don't think it's a major issue. Ultimately, a lot of scientific ideas are best defined later on in the research process rather than when the inquiry first starts. At this point in the research, it is unreasonable to assume a widely recognized definition of artificial intelligence given the complexity of intelligence. Many researchers would rather pursue any goal that is successful in theory or practice than waste time debating terminology; this is true whether or not the goal is referred to as "AI." (Wang, 2019)

Given the latest developments in deep learning, (Chen, 2025; Silver, et al., 2016; LeCun, Bengio, & and Hinton, 2015), Artificial Intelligence has gained significant traction and popular interest. The business community is developing plans to address this issue which is the lack of definition of Artificial Intelligence and opportunity. (Sachs., 2016)

Moreover, political and legal rules and policies pertaining to AI have been proposed. It is challenging for policymakers to predict what AI systems might be able to achieve in the near future and how the field might get there, given the absence of a specific definition of the word. The question of what kind of artificial intelligence systems are actually beneficial remains unanswered. (Wang, 2019)

In 1950, JP Guilford presented his article "Creativity," which he had delivered as the American Psychological Association's presidential speech. This marked the beginning of the contemporary study of creativity. (Engell, 1981)

Guilford presented "creativity" as a quantifiable psychological ability or tendency, apart from the more common concept of "intelligence." Guilford was a specialist in psychometrics, the measuring of the mind. It was posited as a force that might account for the "creative genius" output of Picasso and Einstein, as well as more commonplace innovations in the military and business, and the imaginative works of both children and adults. "The creative person has novel ideas," according to Guilford's definition of the term. (Guilford, 1950)

AI was first characterized as the challenge of programming a machine to act in ways that a person would be considered intelligent in 1955 by the Dartmouth Research Program. (McCarthy, 1955)

In a similar vein, Marvin Minsky, a cognitive scientist, defined artificial intelligence as the study of programming robots to perform tasks that would need human intellect. (Minsky, 1968)

Artificial intelligence is often defined in terms of human intelligence, meaning is the bio psychological capacity to analyze information to solve issues or produce goods that have cultural value. (Gardner, 1999)

Artificial Intelligence and psychology have adopted this definition of creativity, which emphasizes originality and worth. It’s the capacity to produce innovative and worthwhile concepts. (Boden, 2009)

Artificial intelligence is defined as a system's ability to comprehend external data effectively, to learn from such data, and to utilize those learnings to accomplish particular objectives and tasks through flexible adaptation. (Haenlein & Kaplan, 2019)

It is clear from these definitions how artificial intelligence differs from similar ideas like big data as well as the Internet of Things (IoT). (Kaplan & Haenlein, 2019) One particular method of getting the external data needed as input for AI is through the Internet of Things (IoT), which promotes the notion that objects all around us are outfitted with sensors and software to gather and share data. (Krotov, 2017)

An input for big data is the Internet of Things. (Lee, 2017) Which characterizes data sets with massive volumes of constantly updated data in a variety of forms, including text, numbers, photos, and videos variety. However, because big data also includes information gathered from other sources, including (mobile) social networking apps, it is more comprehensive than the Internet of Things. (Kaplan, 2012; Kaplan & Haenlein, 2010)

AI relies on machine learning techniques to find underlying principles and patterns by utilizing external data via the Internet of Things (IoT) and other big data resources. Machine learning, in its broadest sense, refers to techniques that assist computers to gain knowledge without explicit programming. These techniques can range from simple (such as deep neural networks, which are the foundation of deep learning technologies like Google's DeepMind) to incredibly complicated. Artificial Intelligence encompasses more than just machine learning; it also includes a system's ability to interpret data (e.g., processing natural languages or voice/image identification) and to control, shift, and alter objects (e.g., robots or different connected devices) according to learned information. (Kaplan & Haenlein, 2019)

1.7.2 The Beginning of Artificial Intelligence (AI)

In many respects, the world we live in now resembles the Wonderland that British mathematician Charles Lutwidge Dodgson—better known by his pen name, Lewis Carroll—described in his well-known books.

Developments in AI have made it possible for image recognition, smart speakers, and self-driving cars. When artificial intelligence was first developed as a field of study in the

1950s, it was mostly ignored by science and had no use in real life for more than 50 years. Today, AI is being discussed in public and corporate settings due to the growth of big data and advancements in processing power. (Haenlein & Kaplan, 2019)

It was quickly realized that having novel ideas alone was insufficient; they also needed to produce something worthwhile: The creative work is an original piece that is deemed viable or beneficial. (Stein, 1953)

In science-fiction literature and cinema, people sense terror and fascination at the same time when they are among intelligent machines. This is similar to Rudolph Otto's 1917 description of the unusual. (Geraci, 2007)

Science fiction authors have advanced the idea of sentient nonhumans and prompted us to consider our own human qualities by utilizing the potential of clever robots. Even though their performances were plainly restricted and meant more as curiosity pieces than as examples of thought processes, they gave mechanical theories of conduct and the notion that such behavior need not be feared some first credence. As the industrial sector grew increasingly automated, machinery advanced in sophistication and became increasingly prevalent. Still, it was all very much like clockwork.

Among the initial benchmarks are problem-solving exercises covering fundamental concepts in learning, knowledge representation, and inference, along with experiential learning programs showcasing language comprehension, translation, theorem proving, memory association, and knowledge-based systems. (Buchanan, 2006)

The history of artificial intelligence is replete with promises, visions, and demonstrations. The concept of creating intelligent devices that mimic human behavior has roots in a number of disciplines, including philosophy, literature, imagination, computer science, electronics, and engineering inventions. (Abioye, Oyedele, & Akanbi, 2021)

Since the 1950s, experts have forecast at frequent intervals that science would soon arrive at Artificial General Intelligence or systems with cognitive, emotional, and social intelligence that cannot be distinguished from humans. However, by seeing AI from the path previously taken, one might gain a clearer understanding of what is possible. Examining AI's past to determine how far this field has come by applying each season (spring, summer, fall, and winter) comparison. (Haenlein & Kaplan, 2019)

1.7.3 The Classification of Artificial Intelligence (AI)

We take reference from managerial literature and notably research examining the talents shared by effective managers and individuals with above-average performance to categorize various forms of AI, specifically related to their commercial usage. (Boyatzis, 2008; Hopkins & Bilimoria, 2008; Koman & Wolff, 2008; Luthans, 1988; McClelland & Boyatzis, 1982)

The consensus in this literature has been that exceptional performance is highly correlated with the presence of a trio of abilities or types of capabilities: social intelligence (e.g., sympathy, teamwork, motivating leadership), emotional intelligence (e.g., adaptability, confidence in oneself, self-awareness, and accomplishment orientation), and cognitive intelligence. (e.g., capabilities related to recognizing patterns and systematic thinking)

Depending on the cognitive, emotional, and social intelligence it demonstrates, artificial intelligence can be categorized as analytical, human-inspired, or humanized. Based on its evolutionary stage, AI can also be categorized as artificial narrow, general, or super intelligence.

The only traits shared by analytical AI are those of cognitive intelligence. These artificial intelligence systems create a cognitive picture of the environment and make judgments by learning from the past. These include the majority of AI systems that businesses employ today, such as those for image recognition, autonomous vehicles, and financial services detection of fraudulent activity.

Emotional and cognitive intelligence are combined to create human-inspired artificial intelligence. In addition to other cognitive functions, these systems can comprehend human emotions and take them into account while making decisions. The MIT-founded AI startup Affective employs sophisticated visual algorithms to identify emotions like happiness, surprise, and rage on par with—and sometimes even better than—human ability. These technologies may be used by businesses to identify emotions in customer encounters or when hiring new staff members.

All forms of competencies (cognitive, emotional, and social intelligence) are displayed by humanized AI. These systems are not yet accessible; they would be able to communicate with people while being self-conscious and aware of themselves. Although there has been progress in identifying and imitating human behavior, creating AI systems that have a basic understanding of the world remains a mission for the (perhaps) distant future.

While it seems simple to categorize AI using cognitive intelligence, emotional and social intelligence have many uses that need to be explained.

Psychology's conventional wisdom is that intelligence is often innate—that is, that it is a trait that people are born with as opposed to something that can be learned. However, some emotional and social abilities are linked to emotional and social intelligence, and both humans and AI systems are capable of learning these talents. Although AI systems and computers cannot feel emotions for themselves, they may be taught to identify them (for example, by analyzing little facial expressions) and then modify their responses appropriately. (Kaplan & Haenlein, 2019)

However, all of these kinds have one thing in common: when AI becomes widely used, it is often no longer regarded as such. The term "AI effect" refers to this phenomenon, which happens when observers dismiss an AI program's behavior by claiming that it lacks true intelligence. Any adequately advanced technology is unrecognizable from magic, as British science fiction author Arthur Clarke once observed. However, the mystique goes away when one grasps the technology. (Haenlein & Kaplan, 2019; Kaplan & Haenlein, 2019)

1.8 Artificial intelligence (AI) in The Architectural Engineering Sector

1.8.1 The Process of the Architecture Design Process

Architecture is different from other arts in that its creations must be both aesthetically beautiful and structurally sound as well as practical, as Ghaboussi, Song, Kwon have pointed out. (Hwayeon Song, 2016)

Establishing the form of a structure is the main task in the architectural design process. Architects frequently begin a design with a hazy idea of the design's outline and a disembodied notion, which serves as the foundation for their wide range of possible solutions. The original design will have an impact on several elements, including solar gain, light utilization, energy usage, layout arrangement, as well as shadow efficiency, acoustics, and practical accessibility. (Agirbas, 2019)

Both imagination and experience is needed when creating new architectural designs. Since the design criteria are still vague in the conceptual stage, applying artificial intelligence to this procedure should not be focused on locating a solution in a predefined search space. Rather, this procedure needs to be seen as an investigation of the objectives, as well as potential means of satisfying those needs. (Maher, 2000; Gero, 1994; Logan & Smithers, 1993)

Unquantifiable and measurable variables were taken into consideration when choosing the design components. Even with measurable and numerical representation of the problem it’s hard to determine design intents with no consistent assessment guidelines. (Choudhar & Michalek, 2005)

Different jobs within the digital and interactive art community are described by names such as artist, designer, engineer, programmer, technician, and creator. On the knowledge and use of technology, it would be simple to presume that these collaborators are in agreement. However, in practice, things can be very different, particularly when it comes to artificial intelligence.

When artificial intelligence was first developed, people in the creative disciplines accepted it and used it to create new media art via study and practice. Unfortunately, only a small portion of AI technologies machine learning (ML) and deep learning (DL) have been used in artworks in recent years. Differing views may also exist on the order of importance between creating an innovative procedure, a new algorithm, or an outcome that is visually striking. (Anton Dragan Maslic, 2021)

1.9 Artificial Intelligence-Assisted Designs

Soddu introduced the Generative Design method to architecture and urban planning in his work "Citta' Aleatorie" in 1987 using artificial DNA he made of Italian medieval towns. (Soddu, 2020)

Numerous methods have been developed since then, most notably Yeh's (2006) technique that used an annealed neural network to find answers to a building design challenge applied to a case study on hospital structures. (Yeh, 2006). In 2010 (Wen, Hong, & Xueqiang, 2010), Wen, Hong, and Xueqiang employed fractal algorithms in their design, as did Rian and Asayama in 2016 (Ria & S., 2016). In a related study, Chatzikonstantinou and Sariyildiz (2017) looked at the use of self-associated connectionist paradigms in the architecture of sustainable façades. (Chatzikonstantinou & Sariyildiz, 2017)

Currently being studied by a number of scholars is the link between artificial intelligence and architecture, specifically how this technology might enhance architects' creative design process through "augmented intelligence." (Leach & Campo, 2022; Chaillou, 2022; Bernstein, 2022; Leach & Campo, 2022)

When used in this sense, the term "augmented intelligence" refers to a kind of hybrid intelligence that blends artificial and human intellect in an effort to maximize both parties' strengths and minimize their flaws. (Yau, et al., 2021)

The correlation between artificial intelligence and architecture is not a recent development. Its origins may be seen in the 1960s when architects Cedric Price and Christoph Alexander utilized cybernetics to illustrate the dynamics and flows of how design challenges arise. Some architects, like Nicholas Negroponte, intentionally used AI to create systems that learn from their users and advance in harmony with them. (Steenson, 2017)

In modern architectural design practice, technological advances and algorithms like genetic and simulated annealing are often employed to investigate the ideas of optimally organized building plans, weigh and enhance the light structure's static performance at the lowest feasible cost, and identify the best architectural solutions to enhance the object's thermal, light, and other operations. (Zheng & Yuan, 2021)

The amount of published scientific publications on applying AI to tackle conceptual difficulties in architecture has increased recently, particularly after 2015. (Pena, et al., 2021)

The 1940s saw an acceleration of technological advancement in architecture with the emergence of new construction concepts, such as the use of mechanical mass production as well as modular and standardized elements, as demonstrated by the works of architects Buckminster Fuller, Walter Gropius, and Le Corbusier. The earliest computer-aided design concepts, such as Sketchpad, Urban 5, and Generator, appeared in the 1960s. Since then, digital tools have been continuously evolving, leading to the sophisticated software for computer-aided design, or CAD, that is available today, like AutoCAD. (Chaillou, 2022)

Both theory and execution in architecture changed in the 1990s due to the digital revolution. Novel architectural trends emerged as a result of the advancement of digital technologies; parametricism and computational design gained traction, altering the way that many architects perceived the design process. During this period, in the early 2000s, architects like Frank Gehry's work spearheaded and promoted the use of 3D ways of depiction in architecture. (Boland, Lyytinen, & Yoo, 2007)

Designers were able to create free-form settings with unprecedented degrees of geometric intricacy and depth when they switched to 3D representation technologies. New digital instruments and their application in architecture have since grown significantly. Building information modeling (BIM), computer-aided design (CAD), and algorithmic design (AD), in which architects use algorithms to create design descriptions, are the three main directions of developing software for architectural digital representation due to the growing number of tools available. (Castelo-Branco, Caetano, & Leitão, 2021)

According to recent studies, integrating several software programs—including Grasshopper and Dynamo, two visual programming tools—with BIM technologies like Revit Architecture, Digital Project, ArchiCAD, and Tekla helps achieve better results. (Mikhailov, 2020)

Theoretically and technologically, parametricalism in architecture came to a halt in the early 2010s due to worries among professionals that this approach would be too rigid and direct for the design process. (Chaillou, 2022)

Simultaneously with the criticism of parametric design, the field of architecture became more and more focused on free-form structures that explored the possibilities of parametric design tools. Artificial intelligence learning systems, which use neural networks to derive solutions from raw data, gained traction as a counter to expert-based parametrism. As a result, AI has become a new design tool that may help offset some of the drawbacks of parametric design by incorporating intrinsically digital logic into the design process, so overcoming the drawbacks of parametric modeling. (Leach & Campo, 2022)

Prominent scholars in the profession of architecture provide insight on the applications of intelligent systems in this domain. The main areas in this discipline were names architectural intelligence. Second, swarm intelligence third, Artificial Intelligence, Fourth, augmented intelligence, Finally, Cyborg Intelligence. (Yuan, 2020)

Even though artificial intelligence has been used in architecture for more than 50 years, the field is still in its developmental phase, with researchers continually exploring its possibilities. A number of studies examine how well computer vision and deep learning networks can be used to measure how similar architecture projects are to one another using aggregated photos. (Yuji Yoshimura, 2019)

Utilizing variable auto-encoders to maximize a building's shape for maximum thermal performance and provide a functionality-driven design is one of the other areas of AI study. (Malkawi, 2021)

Several articles explore the possibilities for resolving issues and casting doubt on AI's place in architecture at the nexus of these two fields. (Ji, 2022)

AI may be used for conceptual study architecture by means of design investigation, morphogenesis, building form study, ceiling shape layout, facade layout, and floor plan organization, according to some researchers. (Pena, et al., 2021)

Artificial neural networks are developed by a number of researchers as form-finding technologies that produce 3D object shapes in vector format after being trained using data from pre-existing buildings or specified parameters. (Zheng & Yuan, 2021)

1.9.1 The Interface Between Humans and Machines in Architecture

In his paper on boosting human cognition, engineer Engelbart presented the idea of an enhanced architect at work. He discussed the upgrading of human intelligence in the study in order to improve its ability to tackle difficult challenges, understand how to fulfill requirements in an appropriate manner, and boost its capacity to resolve certain difficulties. (Ji, 2022)

Architectural machines, in the words of Nicolas Negroponte, are dynamic design processes that take the shape of conversations between people and machines. (Steenson, 2017)

At its foundation, the idea of architectural machines is mutually beneficial: it entails a close bond between two diverse species (humans and machines), two distinctive procedures (design and computing), and two distinct intelligence systems (the architect along with the architectural machine). (Steenson, 2017)

The digital design evolution tools demonstrate the notion of enhancing human skills in the architectural profession.

From CAD's inception, Steven Coons' ideas have greatly influenced how design and architecture are thought about. In addition to developing the revolutionary CAD technologies within Coons' leadership, CAD Project engineers also thought about creativity and depiction in terms of computing, imagining a cooperative effort between people and computers to index different kinds of information. Furthermore, rather than automating design, he redirected CAD research efforts toward novel types of interaction and augmentation. (Cardoso Llach, 2015)

1.10Factors Affecting the Acceptance of an Architectural Design

Artificial Intelligence has brought about profound changes in a number of fields because of its computational powers, which improve established practices and encourage creative thinking. Notably, architecture is one of the domains where AI's transformational potential is being used, from design conception to design implementation. (As & Basu, 2021)

AI is becoming acknowledged as a revolutionary teaching tool in architecture in addition to its function in design development. With its ability to envisage unbuilt ideas and comprehend design concepts, artificial intelligence offers an enhanced learning experience exceeding traditional classroom approaches. (Ceylan, 2021; Maher, Bilda, & GÜl, 2006)

Aesthetic assessments are judgments that influence decisions in significant areas of human endeavor, such as purchasing decisions, the appreciation of art, and maybe even moral assessment. By studying the neural underpinnings of aesthetic judgments, the emerging area of neurasthenics is expanding our knowledge of their significance. (Chatterjee & Vartanian, 2016)

In our lives, aesthetic judgments, which are widely defined as subjective evaluations of objects—have a significant and enduring impact. (Tsukiura & Cabeza, 2010)

It is debatable that, at their foundation, aesthetic experiences are supported by a small group of similar brain systems: the emotion–valuation, sensory–motor, and meaning–knowledge systems. This is true despite the obvious disparities in characteristics throughout these diverse areas of human activity. (Chatterjee & Vartanian, Neuroaesthetics, 2014)

This opinion is supported by the actual data that is now available in the developing field of neurasthenics, a branch of cognitive neuroscience that aims to comprehend the neural underpinnings of aesthetic experiences. (Pearce, 2016; Nadal & Pearce, 2011; Chatterjee A. , 2011; Skov & Vartainian, 2009)

In particular, assessing the aesthetic quality of cultural artifacts (such as paintings, sculptures, music, and architecture) stimulates the same brain regions that are engaged in assessing primary reinforces (such as food and drink), leading to the idea of a cross-domain "common currency" for judgment. (Montague & Berns, 2002)

A crucial component of AI's use in architectural design is the evaluation of creativity as well as perceptual, cognitive, and emotional processing. (Cropley, Cropley, Kaufman, & Runco, 2010; Mumford, Scott, Gaddis, & Strange, 2002)

Based on the paradigm put out by Chatterjee and Vartanian, four dimensions are employed in connection to AI-generated architectural designs based on this interdisciplinary approach that combines conclusions from the neuroscience of aesthetics, artificial intelligence, and architectural design. (Zhihui Zhang & Mateu, 2023)

Authenticity, beauty, inventiveness, harmony, and overall preference are the four dimensions that may be applied to AI-generated architectural designs. (Zhihui Zhang & Mateu, 2023)

Table 1 shows the summarized main criteria and the sub criteria of the factors that are effecting the acceptance of AI-Assisted designs.

Table 1

Main Criteria and Sub-Criteria for the Factors Effecting the Acceptance of AI Assisted Designs

Criteria	Source	Sub criteria		Source
Authenticity (A)	(Zhihui Zhang & Mateu, 2023)	(AH)	Historical Context	(Silverman, 2015)
		(AM)	Material Integrity	(Matero, 2014), (DİNGİL, 2021)
		(AD)	Design Consistency	(DİNGİL, 2021)
		(AA)	Authentic Expression	(Ouf, 2001), (DİNGİL, 2021)
Beauty (B)	(Zhihui Zhang & Mateu, 2023)	(BV)	Visual Impact	(Lavdas & Salingaros, 2022)
		(BD)	Detailing	(Delbeke, 2017)
		(BI)	Integration with Environment	(Lee D. Y., 2002)
		(BT)	Timelessness	(Erdinç, 2023)
Inventiveness (I)	(Zhihui Zhang & Mateu, 2023)	(IT)	Technological Innovation	(Becerik-Gerber, Gerber, & Ku, 2011)
		(IA)	Adaptive Reuse	(Daneshmand, 2023)
		(IS)	Sustainable Solutions	(Hanie, Ahmad, Aryan, & MohammadReza, 2010)
		(IN)	Spatial Novelty	(Duriseti, 2003)
Harmony (H)	(Zhihui Zhang & Mateu, 2023)	(HS)	Spatial Harmony	(Duriseti, 2003)
		(HP)	Proportional Balance	(Delbeke, 2017)
		(HM)	Material Cohesion	(Didem Ekici, 2023)
		(HE)	Environmental Synchronization	(Delbeke, 2017)

The main criteria elements can be defined as the following:

- Authenticity: The degree to which the design reflects originality, sincerity, and truthfulness in its representation and expression, avoiding imitation or artificiality.
- Beauty: The aesthetic appeal and attractiveness of the design, encompassing elements such as symmetry, proportion, elegance, and visual appeal, which evoke pleasure and admiration.
- Inventiveness: The level of creativity, innovation, and novelty demonstrated in the design, indicating originality, ingenuity, and the ability to break away from conventional approaches or solutions.
- Harmony: The coherence, balance, and unity within the design, where elements complement each other harmoniously, creating a sense of cohesion, order, and integration.

Authenticity: Since authenticity deals with the fundamentals of sincerity and design integrity, it has been selected as the major criterion. The ethical norms and cultural relevance that are expected in contemporary architectural practice are upheld by AI-assisted designs thanks to sub-criteria including Historical Context, Material Integrity, Design Consistency, and Authentic Expression. These factors are crucial in assessing AI's ability to create work that is authentic, sensitive to its surroundings, and true to its source materials.

- Historical Context: to what extent the design honors and captures the local architectural heritage and history.
- Material Integrity: The use of materials in a way that is loyal to their characteristics, sources, and sustainable practices
- Design Consistency: is the capacity of the design to remain faithful to the original conceptual idea throughout the execution, as well as its connection with the intended goal.
- Authentic Expression: The design's capacity to communicate the architect's distinct viewpoint and message without the use of clichés or fads.

Beauty: As a criterion, beauty captures the aesthetic aspect of architecture, which is vital to psychological health and human interaction. In addition to being useful, designs must also be visually and emotionally compelling, as highlighted by the following sub-criteria: Visual Impact, Detailing, Integration with Environment, and Timelessness. The identified elements are most important when evaluating the beauty of the design, and in this case the capability of AI to produce designs that include these elements to add to the beauty of the design which leads to it acceptance.

- Visual Impact: any element and choice that affects the aesthetics of the design wither the shape of it, first impression, and even the chosen color scheme of the design.
- Detailing: the finesses of the finishing and the small details that add to the design such as the fittings, and joinery.
- Integration with Environment: the success of an architectural design not only depends on the design itself but also how the design can contribute to the surrounding urban fabric and it surrounding environment.
- Timelessness: the ability of the design to stay efficient and relevant for long periods without just being considered a trend and loses its value.

Inventiveness: architectural designs needs to solve the stakeholder's problems, and it is vital to always evolve and come up with new and creative solutions to these problems and the more creative and innovative the solution is the more the design is considered innovative and efficient. AI's ability to solve these problems with creative solutions can be measured by adhering and taking into consideration the following defined elements.

- Technological Innovation: utilize and stay up to date with the new and current technologies that helps with increasing the efficiency of the design and improves its performance.
- Adaptive reuse: to use sources that already exist like materials and buildings and adapt it to the current needs.
- Sustainable Solutions: producing new and creative solutions for the design to harvest the resources without harming the surrounding environment, like the conservation of the energy and harvesting the renewable resources.
- Spatial novelty: new and creative methods to arrange the needed spaces in a way that is both efficient and unconventional, along with novel shapes for those spaces.

Harmony: the harmony sub criteria includes and translates to balance and how well the design elements complement each other and work together for a better and more pleasing design aesthetic. The main goal of any architectural design is to solve a problem, in the most functional way, but the aesthetics of the design is also as important where it needs to have a visual that is smooth and coherent, and to be able to measure the AI's capability to satisfy this main criteria, the following sub criteria elements are defined.

- Spatial harmony: how easy and smooth for the occupants to move between the spaces, and their functionality.
- Proportional balance: the balance between the proportions of the chosen design elements that compile the general design aesthetics.
- Material cohesion: how well the materials that the design uses blend together for a pleasing aesthetics.
- Environmental synchronization: a good and efficient architectural design always aims to harvest the environment's elements to it advantage like the wind, sun, and the provided landscape, environmental synchronization, is achieving that in a way that is harmonious with the environment.

The qualitative elements of any architectural design can be easily measured, but the situation is different in this framework that is produced in this research, the aim of this study id create a framework that sets numerical values and weights for each of the mentioned main and sub criteria elements, that translate the aesthetic satisfaction that an AI assisted design receives along with its creative originality. By giving each element a weight and a measurement, the general aesthetic stakeholder satisfaction can measured and quantified. (Zhihui Zhang & Mateu, 2023)

1.10.1 The Selection of Main Criteria and Sub Criteria

Usually when evaluating AI assisted design in the field of architecture stakeholders go for the measurable elements for example, if the AI produced a design that follows the provided specifications wither it's the specified cost to actually build the design, or it the AI produced a design with the right number and areas of the spaces, or if there's a specified type of materials that is required, the qualitative elements that are measured in this research are harmony, beauty, authenticity, and inventiveness, and the justification for choosing these qualitative elements over the mentioned quantitative are as mentioned below:

- First justification: focus on the qualitative elements rather than the normally used quantitative elements

The usual most common process of evaluating any design, that the stakeholders go for is the measurable quantitative metrics, but contrary to this process this research aims to shine a light on the qualitative elements that don’t have numerical metrics to measure, more specifically, authenticity, inventiveness, beauty, and harmony, by providing measurable metrics for these elements AI’s creative capabilities that could be of great benefit in the field of architecture, which is usually overlooked. The thesis aims to explore how AI-assisted designs might improve or change the human experience of space by giving priority to these factors rather than just functional and financial ones. (Zhihui Zhang & Mateu, 2023)

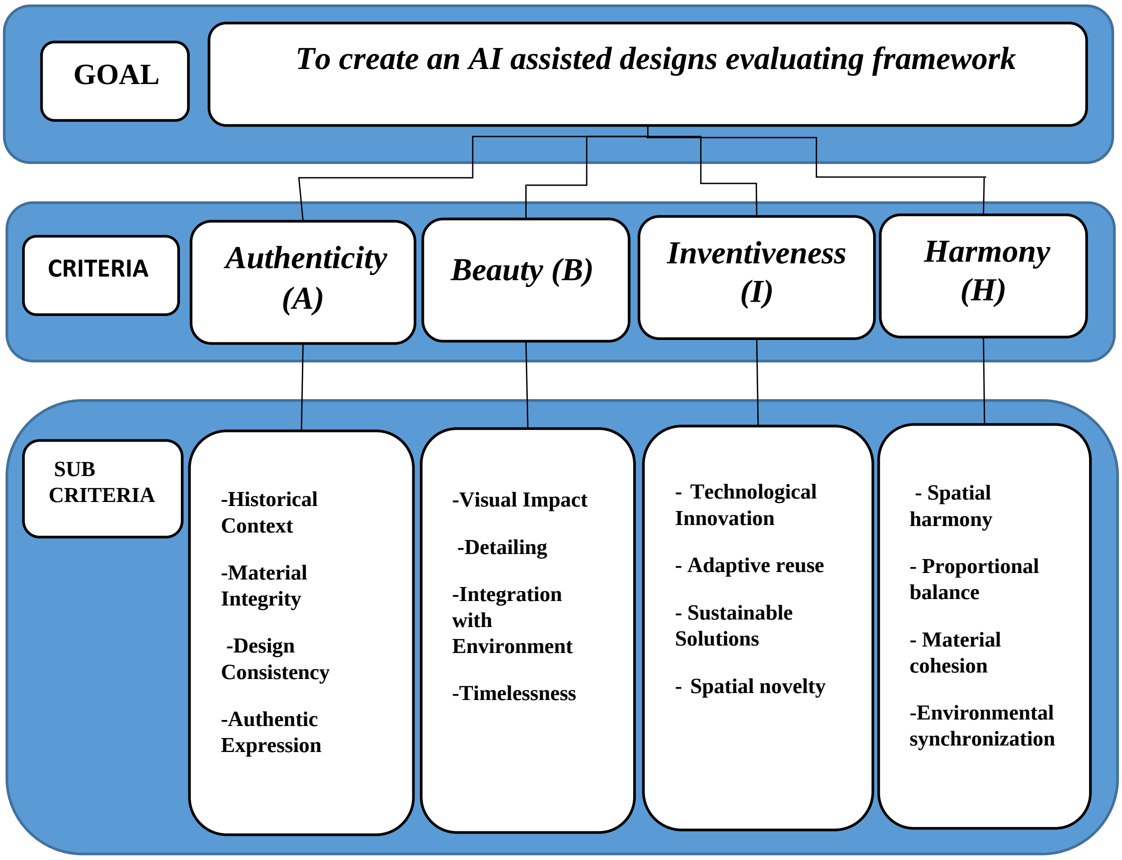
Second justification: Reliability of Measurable Elements

- Must guarantee that certain components stay the same in order to facilitate comparisons. Because of this consistency, the research can distinguish how AI affects design's creative elements. In both AI-generated and human-generated designs, quantifiable aspects are easily stated and controlled. Maintaining these controls will allow the study to present a clear, undistorted picture of how AI affects the more creative and subjective parts of architectural design. (Zhihui Zhang & Mateu, 2023)

These two justifications combined serve as the cornerstone of the thesis' methodological approach, Figure 1 demonstrates the proposed AHP model which aims to critically evaluate AI's contribution to architectural design while highlighting the technology's potential to innovate and enrich the field—particularly in areas that call for creative and nuanced understanding akin to that of humans.

Figure 1

Proposed AHP Model



Chapter Two
Methodology

2.1 Study Design

The aim of the project is to produce a framework for evaluating Artificial Intelligence-assisted designs from the perspective of designers using the Analytic Hierarchy Process. The rationale behind using this quantitative approach is its methodical and structured approach, which facilitates the creation of priority scales and in-depth pairwise comparisons. Experts were given questionnaires to complete, asking them to compare several criteria and sub-criteria that had been found by a thorough literature research in pairs. The fast development of AI technologies in the design business makes a strong framework necessary for assessing AI-produced designs.

The first step of this research which is considered the corner stone of the research is highlighting the main most vital criteria to judge the AI assisted design by, that criteria was identified via the literature review that was conducted which is creativity, harmony, authenticity, and beauty, for such evaluation and for building a hierarchy with more than one level no ordinary method is suitable, the most suitable, accurate method that could really handle the complication of the required framework is the Analytical Hierarchy Process, with it, it was possible to really capture the point of view of the designers when it came to evaluating AI produced designs. The main criteria then were studied more closely and then divided into sub criteria.

The Analytical hierarchy process helped in creating the hierarchy of the main criteria elements which are authenticity, beauty, creativity, and harmony, as well as the sub criteria elements, for the beauty the elements are timelessness, visual impact, integration with the environment, and detailing, as for the authenticity elements, material integrity, historical context, authentic expression, and design consistency, for the creativity criteria it includes, sustainable solutions, innovative technology, spatial novelty, and adaptable reuse, and last but not least, harmony which includes cohesive material, spatial harmony, proportional, and environmental synchrony.

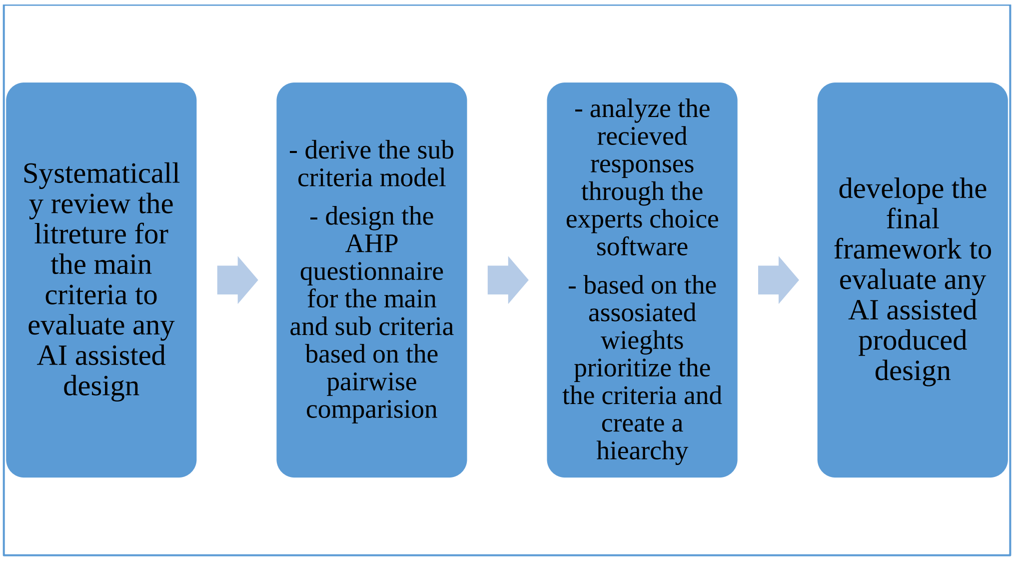
With the existence of this framework, there is a way that is both easy, quantitative, and accurate to evaluate any AI assisted design, all made possible with the use of the AHP method and the participation of the experts in the field.

Figure 2 presents each step in the methodologies that was followed in this research, the methodology that was designed for this research includes the creation of a questionnaire which in turn includes multiple pairwise comparisons that would ask to evaluate multiple pairs of elements within the same criteria, the criteria and sub criteria were defined beforehand, based on the answers the experts gave for the pairwise comparisons, a metric would be presented to indicate the value of each element in its own respective criteria, that would eventually be translated to the elements value in the framework.

To verify the accuracy of the responses, consistency ratios (CR) were computed; a ratio of less than 0.1 was deemed appropriate. Ultimately, the priority vectors were combined to determine the overall criterion and sub-criteria ranking, offering a thorough framework for evaluating AI-assisted designs according to designer opinions. The AHP method captures the complex perspectives of designers and offers a reliable and methodical way to assess AI-assisted designs. By reviewing the literature and expert input, the development of key criteria and sub-criteria, their hierarchical organization, and in-depth pairwise comparisons, this study creates a comprehensive evaluation framework that aids in evaluating the state of AI design tools today and directs future advancements and innovations in AI-assisted design technology.

Figure 2

Methodology Design to Develop a Framework to Evaluate AI Assisted Designs



2.2 Study Population

A wide range of stakeholders with pertinent years of experience and wide knowledge in the domains of design, artificial intelligence, and project management make up the study population for this research. The majority of the population is made up of working designers with a wealth of real-world experience in a variety of design fields, including industrial, graphic, and architectural design. Each of the experts has a purpose and an insight to offer, for example research and professionals in the field of the design have theoretical insights, where designers have practical knowledge on how to asses any design and its usability much AI assisted designs included.

In any design project it needs to approved by more than just one party, there is many stakeholders involved when it comes to any design project, there are customers that need their demands to be achieved, investors, designers and standards that need to meet for the design to be accepted and successful, that’s why it was important to include a variety of experts, different people with different backgrounds contribute to different contributions for example Experts in Human-Computer Interaction (HCI), they contribute by evaluating how different people react to artificial intelligence, other stakeholders like project managers can give tips on the usability of these products, and finally the design students contribute to the scholarly sense when it comes to the artificial intelligence field.

2.3 Instruments of Study

The main method for gathering the needed data when using the AHP method is a detailed questionnaire, the questionnaire consists of two parts the first part is qualitative in nature where it collects data about the experts and their field of work, the second part is quantitative in nature where experts are asked to rank the already identified elements of the main and sub criteria based on what they think is more important in a constructed pairwise comparisons, the scale they were given ranges from 1 to 9 where 9 means the element is most important, that way the questionnaire is wholesome and informative.

To make sure the participants understood the questionnaire and that they answer the questionnaire informatively semi structured interviews were conducted with people from different parts of the architectural design process.

If not for the creation of the Expert choice program it would be a tedious task to calculate each assigned weight for each and every one of the identified elements by analyzing the answers of the pairwise comparisons and even validating them by running a consistency analysis on the given answers which is the best way to validate them and make sure they are accurate, that way researchers can spend more time on concluding insights from the answers rather than spending time on routine complex calculations.

The main goal of this research is to create a hierarchy of the identified elements, the best most suitable method is the Analytical Hierarchy Process which was created by Thomas L. Saaty, this method is made easier with the help of the program Expert Choice that automates all mathematical operations and even conduct further analysis if needed like consistency and sensitivity analysis, another positive factor in the program is that its user friendly and it can run the required math for complex multi criteria (MCDM) situations which is the case for the needed framework to evaluate AI assisted designs. (Saaty R. W., 1987)

A way to validate the answers of the pairwise comparisons that is done by the experts is by the consistency ration (CR) the program conducts mathematical operations to prove that the answers make sense and that the experts really understand what is asked of them, the ratio needs to be less than 0.1, ($CR \leq 0.1$) , the program uses eigenvalue approach to help extract the assigned weights for each element of the main and sub criteria, to give each element a weight relative to their importance and value the primary eigenvalue is used.

When using the AHP method it's important to calculate the data in a program that can handle large data bases and large frameworks, not only that but also a program that can present the calculated data in a way that is easy to read and in different visual presentations, but the most important trait is the consistency ratio that the program provides for each individual answer and total criteria.

The current literature is a vital resource specially the literature that is current and up to date and that is based on the realistic practices that is related to the related field, in this research the current literature is utilized to identify the related criteria that is most important to evaluate AI assisted designs.

2.4 Validation Indicators

The strength of the AHP method is that it uses a strong and reliable validation indicator, which is the consistency ratio (CR). Not only does the Expert Choice program produces an inconsistency ratio for each individual experts' answers, and it indicates if their answer of the pairwise comparison is logical or not but it also produces an inconsistency ratio for the overall main and sub criteria. The acceptable inconsistency ratio is 0.1, anything higher and the answer should be excluded.

Because this validation indicator was utilized the resulting data and framework is consistent and reliable when it comes to evaluating AI assisted designs.

2.5 Questionnaire Design

The purpose of the use of the AHP method in this research is create a hierarchy of the elements that factor in in the acceptance of the AI assisted design, to create this hierarchy a questionnaire was made and distributed not only in the Palestine, due to this fact two versions of the questionnaire was made one in Arabic and one in English they are presented in Appendix A, and B respectively, the reason behind having two versions of the same questionnaire is to not have the language barrier be an issue and cause an inconsistency in the results.

When using the AHP method it’s vital to choose the right people to fill the questionnaire, it’s necessary for the participants to be experts in the field that the AHP method is used in, fulfilling this condition is important to produce reliable and consistent results for a strong hierarchy, when conducting this research, this condition was fulfilled in the first section of the questionnaire, where the experts were asked general but important information about their age, years of experience, and how many years they worked in the field, and their familiarity with AI, which helped understand their viewpoint and the reason for their answers.

The basis of the AHP method is to create a hierarchy of importance based on the given value of each one via the responses of the experts, these values are given by comparing each criteria elements with each other to determine which element is more valued over the others more, so in the second section of the questionnaire experts had to compare between the elements which they were given to them in pairs, that way it was possible to evaluate each element accurately.

The main method to collect data when using the AHP is the pairwise comparison and if the expert is not familiar with it, it can result in data that is not accurate and not consistent that’s why the questionnaire was given and explained in more than one way, and most importantly it was filled while in direct contact with the expert to avoid any of the mentioned issues.

By using this method, it was much easier to help with issue and anything that was unclear which resulted in lesser time to complete the questionnaire.

When using the AHP method there is a specific type of questionnaire that needs to be made, if not familiar with it, it can be a bit confusing to do it. That is why when collecting the required data, it was essential to live communicate with the experts, and that was achieved either by face-to-face sessions or via phone call or zoom meetings, using these methods helped with the confusion of the AHP questionnaire, and produced consistent results.

One of the methods that was used to get the best and more dependable data out of the experts is the consistency ratio analysis, initially, the experts that participated in this questionnaire were more than thirty responses, but as mentioned the inconsistency ratio analysis helped exclude the responses that had a high and unacceptable inconsistency ratio, that way the AHP method would produce a stronger hierarchy of the assessed elements to evaluate AI produced designs.

To conclude, the questionnaire included two section, the first section asked for general information about the age demographic years of experience, and years of experience, all of that adds to the quality of the conclusions and insights deducted, the questionnaire was written in the both Arabic and English to make it easier and smoother to collect accurate the needed data about evaluating the AI produced designs.

2.6 The Analytical Hierarchy Process

Making decisions is not easy especially when it comes to the important things, more importantly professional decisions; one popular and highly useful method is the Analytical Hierarchy Process. The majority of the AHP solutions developed under the Multi-Criteria Decision Making (MCDM) framework are suitable for rating important management challenges. The primary objectives of the strategy consist of ranking the selection criteria and classifying them into increasingly and less important groups. AHP is also a simple technique that emphasizes pairwise comparisons and can be used to evaluate both qualitative and quantitative designs. (Aziz, Sorooshian, & Mahmud, 2016)

Establishing hierarchies, determining priorities, and conducting consistency tests are the three primary activities of the AHP. Subsequently, decision-makers must deconstruct some judgment difficulties using multiple criteria into their component parts with pertinent attributes arranged at multiple hierarchical levels. Next, using their knowledge and experience, the decision-makers compare each cluster in pairs at the same stage. (Elshafei, Katunský, Zeleňáková, & Negm, 2022)

In this study, the experts' completed questionnaire was analyzed using the Analytic Hierarchy Process, Figure 3 shows the proposed AHP to build and evaluation framework for AI assisted designs. The criteria and associated sub-criteria will be given weights by the AHP based on their importance and priority in the created system. The AHP procedure was carried out as follows:

First step: To exactly determine the main objective of the study, and Creating a hierarchical framework comes first. To do this, the goals and components of the specified problem must be divided into a hierarchical model. (Kamaruzzaman, Lou, & Wong, 2018; Seyhan Sipahi, 2010; Handfield, Walton, Sroufe, & Melnyk, 2002)

Second step: Building matrices for pairwise comparisons comes in second. The process of the AHP relies heavily on pairwise comparisons. Each element in a higher level is used to assess the components in the level immediately below it in respect to it, resulting in a pairwise comparison matrix. (Saaty R. , 1987)

Every entry in (Equation 1) the judgmental matrix (A) was constructed by comparing the row element Ai with the column element Aj. (Kamaruzzaman, Lou, & Wong, 2018)

$$\mathrm{A} = (aij)(i, j = 1,2 \ldots \ldots .. (the\ number\ of\ criteria) \quad (1)$$

Utilizing the completed questionnaire results, the necessary matrices were built by translating the linguistic value into a quantitative value. (AbdelAzim, 2017)

Third step: to collect the needed data, to make sure that the data is collected through consistent process, data is gathered as well as opinions, and expert’s experiences to make the necessary comparisons. (Kamaruzzaman, Lou, & Wong, 2018; Seyhan Sipahi, 2010; Handfield, Walton, Sroufe, & Melnyk, 2002)

Fourth step: obtaining the vector of priority. The primary eigenvector of the matrix, which is established by the relative weight of the indicators, is normalized to create the priority vector (Braunschweig, 2001), the scale that is local derived is known as such prior to being weighted by its parent criterion. After weighting, it is referred to as the global derived scale (Saaty R. , 1987) to normalize the matrices, the estimated sum of the values in each column was divided by each element in the pairwise comparison matrix. (Hazem, 2020), and after that, average across rows to ascertain the principle of the matrix vector of eigenvectors. (Braunschweig, 2001)

Fifth step: Calculating the consistency ratio. In order to ensure that the results from different participants are consistent with one another, the AHP technique uses a consistency ratio (CR) and a linear mathematical model for easy understanding. One of the greatest benefits of the AHP is consistency verification. (Said, 2019)

Pairwise analyses are carried out, and their consistency is shown at every stage. Decision-makers should analyze and adjust the pairwise comparisons if the consistency ratio is found to be higher than the acceptable level. (Elshafei G. K., 2022)

If CR rises beyond 0.10, decisions will need to be reconsidered. (Saaty R. W., 1987)

The consistency ratio CR is derived by Equation 2. (Kamaruzzaman, Lou, & Wong, 2018)

$$CR = \frac{CONSISTENCY\ INDEX\ (CI)}{RANDOM\ INDEX\ (RI)} \quad (2)$$

Equation number (3) given the value of (CI):

$$CI = \frac{\lambda_{max} - n}{n - 1} \quad (3)$$

When n is the number of criteria regarded

RI: A dependent factor on n is RI. Tables from several AHP publications are frequently used to compute it. Based on the matrix order n, Table 2 displays a look-up for (RI) values. (AbdelAzim, 2017)

λ_{Max}: Using the methods suggested by Hazem (2020), one can calculate the judgment matrix's average eigenvalue. (Hazem, 2020)

1. The first item priority was multiplied by the values in the matrix's first column; the process is then repeated for the remaining columns.
2. To generate a "Weighted Sum" vector, the values across rows were added together and then split by the relative importance of each criterion, resulting in a vector named "Sum\Weight."
3. The word " λ_{max}" refers to the estimated average of the Sum\Weight values that were obtained.

Sixth step: the judgments of the experts are complied. The geometric mean (GM) was used to aggregate all participant replies and reflect the group's viewpoint. (Hazem, 2020) AHP aggregates group choices using a range of techniques. As per Xu's (2000) findings, the weighted geometric mean is the most favored and extensively employed method. (Xu, 2000) The investigation verified that its intricate judgment matrix demonstrates sufficient consistency. Krejčí and Stoklasa (2018) also examine two of the most popular aggregation techniques: the weighted geometric and weighted arithmetic means. For establishing global priorities of alternatives, the study contends that the weighted geometric mean aggregation is preferable to the weighted arithmetic mean aggregation because the ranking of the former is independent of the normalization conditions of the local priorities, whereas the ranking of the latter is dependent on them. (Krejčí, 2018)

The reciprocal feature is essential for combining the opinions of several people to get a single opinion for the group. Since the synthesized judgments' reciprocals equal the syntheses of their reciprocals, the judgments must be combined. The geometric mean has been shown to be the only way to do this. Experts may choose to exclude their evaluations and simply include their final findings from each hierarchy. In that case, the geometric mean of the outcome is used. (Hussain, 2015)

Equation 4 was used to determine the GM, and the aggregated matrix was subjected to a consistency test. (Hazem, 2020)

$$GM = (a_1 ij \times a_2 j^* \dots \dots * a\mathcal{K}ij)^{\frac{1}{\mathcal{K}}} \quad (4)$$

Where$\mathcal{K}$, is the number of participants.

Seventh step: weighing criteria and sub-criteria, and then synthesizing the outcomes. Synthesizing priorities is one of the main ideas provided by the AHP. The AHP multiplication of local priorities by the priority of the associated criterion in the level above results in an addition for each element in a level that follows the criteria that it affects, which is how priorities are synthesized from the second level down. By utilizing it as a criterion, the elements at the level below are associated to one another and their local priorities are weighed, resulting in the element's composite or global priority being determined. This process continues until the element reaches the lowest level. (Saaty R. , 1987) The results of local weights are shown in the next section, where the responses were analyzed using Expert Choice 11, in accordance with the recommendations of Aziz et al. (2016) and Alyami et al. (2015) for a more straightforward and dependable AHP weighting. (Aziz, Sorooshian, & Mahmud, 2016; Alyami, 2015)

The suggested AHP methodology for ranking the green assessment criteria is summarized in Figure 3.

Table 2

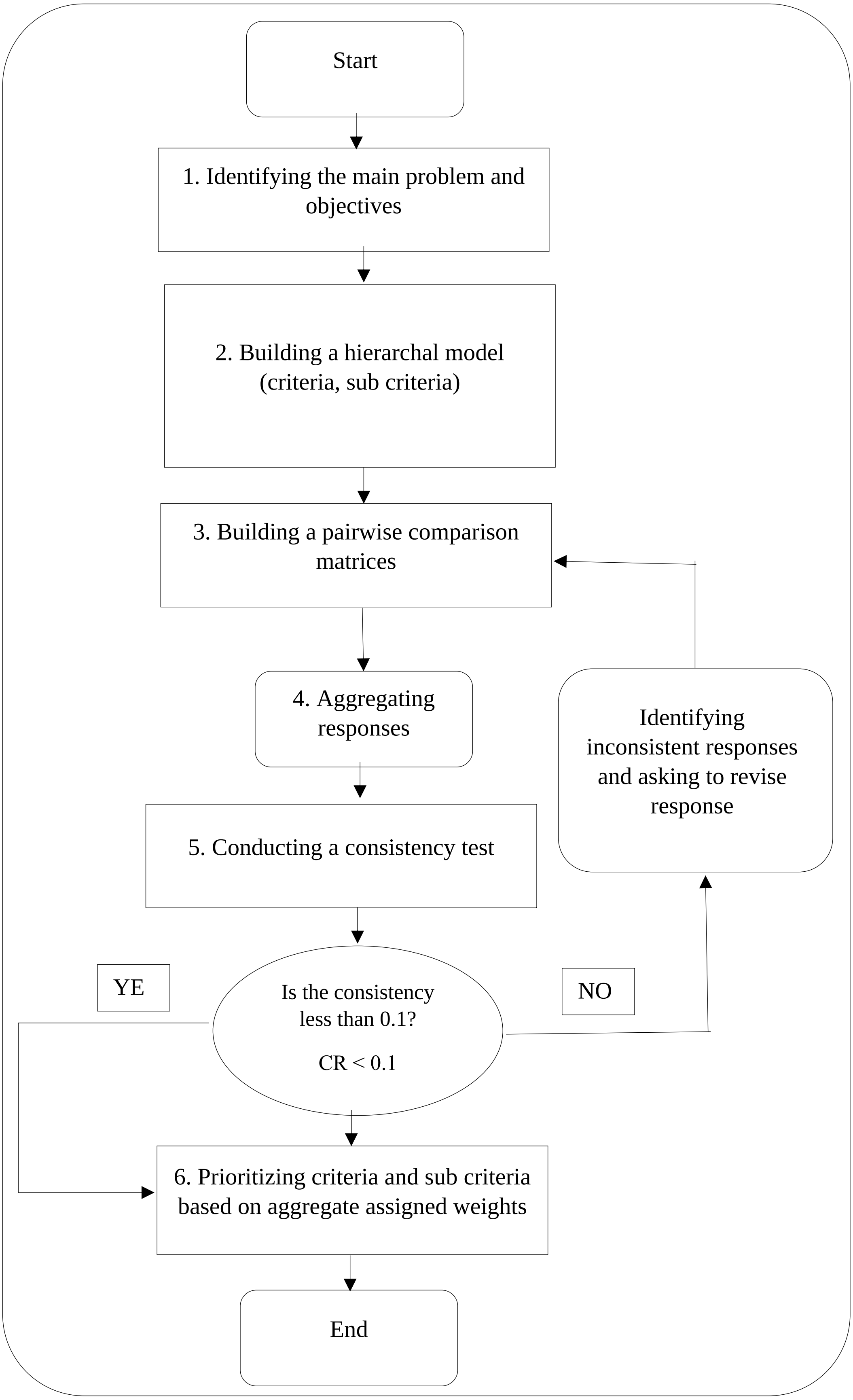
RI Values for Matrix Order (n)

Random index (RI) LOOK-UP from matrix order (n)										
n	3	4	5	6	7	8	9	10	11	12
R1	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48

Note: (AbdelAzim, 2017)

Figure 3

AHP Proposed Model to Build an Evaluation Framework for AI Assisted Designs



Chapter Three
Results and Analysis

3.1 Overview

After collecting the data, the results of the questionnaire is presented in this chapter, not only that but it also presents the conclusions and the learned lessons of form said results that were attained by using the AHP method. The results were all about what the expert's value more when assessing AI produced designs. The results include the weights that were assigned to each element in the main and sub criteria, as well as the results from the consistency analysis that were calculated from the responses of the 30 experts that participated in the mentioned questionnaire via the Expert Choice program. With the wide features of the program it is guaranteed that the results are valid, dependable and coherent.

3.1.1 Data Gathering and Aggregation Procedure

When collecting the data that was needed a specific type of questionnaires is required when using the AHP method, a pairwise comparisons between the main criteria elements as well as pairwise comparisons between the sub criteria elements. Not only the questionnaire contained a section about comparing the mentioned elements but also a section that is about collecting general data about the experts, wither its personal or professional. The conventional AHP scale was used to establish these pairwise comparisons, which allowed for the determination of relative weights that were crucial to the research, as shown in appendix A, and B.

After eliminating replies with inconsistency ratios higher than the permitted threshold of 0.1, as established by the Expert Choice program, a total of 30 acceptable responses were used for the study. A thorough assessment of the criteria was ensured by the participation pool, which represented a varied and highly competent group of specialists. For example, (83%) of the respondents had at least a bachelor's degree, and (60%) of them were men. Only a smaller portion had master's or doctorate degrees. The group's professional experience also differed greatly; (40%) had between one and three years' experience, (33%) had more than ten years, and the remaining members were spread over intermediate degrees of skill. Because both seasoned specialists and early-career workers submitted their ideas, this variety offered a balanced viewpoint.

Additionally, a high degree of familiarity with the topic was shown by the fact that (77%) of the participants claimed having prior experience with AI. Nonetheless, there was a heterogeneous distribution in the self-reported confidence levels when evaluating AI-assisted designs. Of those surveyed, (43%) were uncertain or had no confidence at all, whilst (17%) were highly confident. These results highlight the significance of creating a methodical and approachable evaluation framework by indicating that although the participants were informed, there is a range of self-assurance in assessing this relatively new and difficult subject which is summarized in appendix C, D, E, G, H, and I.

3.1.2 Response Aggregation

When starting this research more than 30 responses were gathered but one of the perks of using the experts choice program is that is aggregates the responses in a way that dependable, not only does it produce weights for each element but it also conducts a consistency analysis that helped go through some the experts answers and eliminate the responses that were not consistent and these responses were identified when the program indicates that the inconsistency ratio was higher than the allowed limit which is 0.1, after that process of elimination only 30 responses remained.

Before entering the responses and evaluations of the experts into the experts choice program, a matrix was produced for the program to have the full vision and goal of the research and as well as for the easy use and better visualization of the goal and matrix. The program conducts consistency analysis to indicate the if the collected are consistent and reliable.

3.1.3 Pairwise Comparison Matrix Construction

When using the Analytical Hierarchy Process there is a certain type of questionnaire that needs to be created to be more specific a pairwise comparison to be able to compare the main criteria elements and also the sub criteria elements, of course these responses were validated through a consistency analysis, after that a dynamic framework was created through an Excel sheet that contains the weights and the normalized weights that is shown in appendix A, and B for an easy use and instant calculations.

In accordance with AHP guidelines, the pairwise comparison matrices were established independently for each sub-criterion and the primary criteria. Normalized weights, The produced framework not only helps with the evaluation of AI assisted to designs but also offer guidance to designers, the strength of the produced framework comes from seeking the opinions of the expert in the field and that are specialists and have previous experience with artificial intelligence, further than that their responses was validated via a consistency analysis.

3.2 Results

In this study 30 experts were asked to fill the Analytical Hierarchy Process questionnaire and evaluate each one of the main criteria and the sub criteria based on what they think is more vital to be in an AI assisted design or any other design for it to be accepted and pleasing to the involved stakeholders, based on these results the following framework in Table 3 summarizes the experts responses and evaluations in a way that is concise and easy to read and use, not only that but it also offer information and conclusions that can be a useful source for guidance when using AI to produce designs, the expert choice program was used to create this framework and priorities.

Table 3

Summary of Criteria and Sub-Criteria Weights

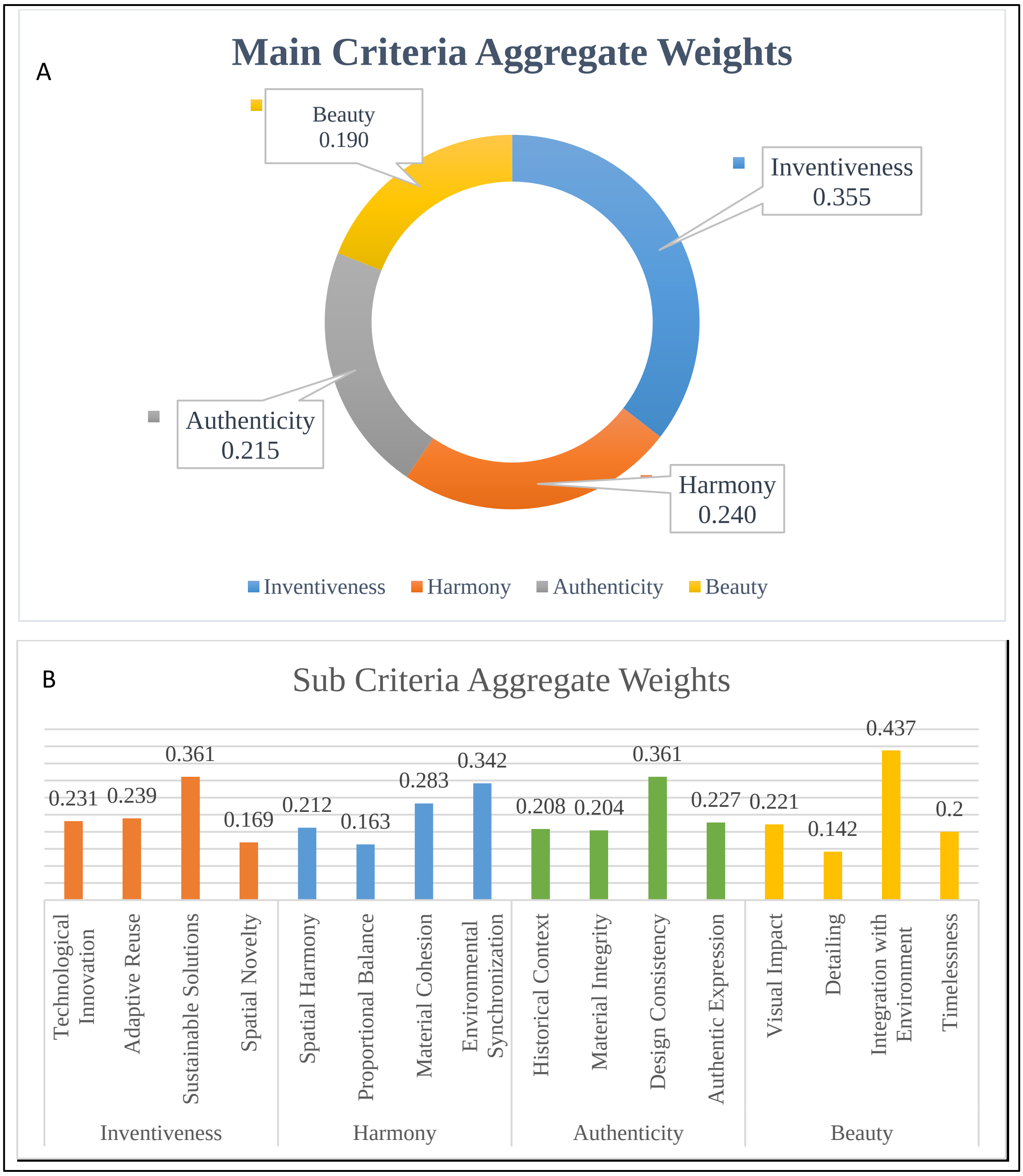
Main Criteria	Weight (%)	Sub-Criteria	Normalized Weight
Inventiveness	(35.5)		
		Technological Innovation	0.231
		Adaptive Reuse	0.239
		Sustainable Solutions	0.361
		Spatial Novelty	0.169
Harmony	(24.0)		
		Spatial Harmony	0.212
		Proportional Balance	0.163
		Material Cohesion	0.283
		Environmental Synchronization	0.342
Authenticity	(21.5)		
		Historical Context	0.208
		Material Integrity	0.204
		Design Consistency	0.361
		Authentic Expression	0.227
Beauty	(19.0)		
		Visual Impact	0.221
		Detailing	0.142
		Integration with Environment	0.437
		Timelessness	0.2

3.2.1 Main Criteria Aggregate Weights Results

Experts in the area were given a questionnaire to complete in order to evaluate the primary criteria used to evaluate AI-assisted designs. The Analytic Hierarchy Process method yielded results that clearly show the relative importance of each criterion in Figure 4 (Section A).

Figure 4

Aggregate Resulting Weights of the Main and Sub-Criteria



Note: Section A: Main Criteria Aggregate Weights, Section B: Sub Criteria Aggregate Weights

With a weight of 0.215, authenticity was found to be very important in assessing AI-assisted designs. With a weight of 0.190, beauty was considered important but had a little smaller impact than the other categories. With the greatest weight of 0.355, inventiveness was shown to be the most important factor, highlighting its crucial importance in the evaluation process. With a weight of 0.240, Harmony was recognized for its significant contribution to the assessment system as a whole, Figure 4 (section A) shows the Aggregate Matrix for the Main Criteria Comparison.

The computed aggregate inconsistency for these comparisons was 0.00095, significantly below the 0.1 acceptable level. The computed weights' credibility is strengthened by the low inconsistency ratio, which indicates a high degree of coherence and reliability in the expert opinions. The robustness of the AHP method application is ensured by the high consistency of the assessments, which lays a strong basis for further analyses and discussions about the evaluation of AI-assisted designs.

3.2.2 Sub Criteria Aggregate Weights Results

From the pairwise comparison matrices, the aggregate weights for the sub-criteria were calculated, representing the experts' relative weights for each primary criterion. These weights give a more thorough knowledge of the contributions made by particular elements, such consistent design or sustainable solutions, to the assessment framework as a whole. An overview of each sub-criteria's normalized weights and their relative importance to the major criteria is provided in the Figure 4 (section B).

3.2.3 The Authenticity Criteria Aggregate Weights Results

The Analytic Hierarchy Process technique was utilized to study the sub-criteria for Authenticity and ascertain their respective significance in assessing designs aided by artificial intelligence. The aggregate weights that are obtained show how important each sub-criterion is, Table 4 (section A) demonstrates the pairwise comparison while Table 4 (section B) shows the final weights of the Authenticity sub criteria. With a weight of 0.21, Historical Context was found to play a significant impact in establishing authenticity. Material Integrity was given a weight of 0.204, indicating that it plays a significant role in preserving the designs' authenticity. With the greatest weight of 0.361, design consistency was found to be the most important sub-criterion, highlighting its crucial role in guaranteeing authentic design aspects. Authentic Expression had a weight of 0.226, indicating that it had a significant influence on the assessment of authenticity as a whole; Figure 6 demonstrates The Aggregate Matrix for the Authenticity Sub Criteria Comparison.

For these comparisons, the consistency ratio was calculated to be 0.001, significantly below the generally recognized threshold of 0.1, this low consistency ratio suggests that the expert opinions were very reliable and that the assessments were consistent and rational. The high consistency provides a strong basis for the ensuing analysis and discussions by confirming the validity of the calculated weights and guaranteeing that the AHP approach was applied correctly.

Table 4

Analysis of the Authenticity Sub-Criteria

	Authenticity sub criteria	Authenticity	Beauty	Inventiveness	Harmony
Section A	Design consistency	1.00	1.20656	1.67882	1.16152
	Authentic expression	0.8293	1.00	1.76801	1.25978
	Historical context	0.5956	0.5658	1.00	1.5304
	Material integrity	0.8607	0.7939	0.6536	1.00

	Main Criteria	Priority Weight	Graphic Representation
Section B	Design consistency	0.361	
	Authentic expression	0.227	
	Historical context	0.208	
	Material integrity	0.204	

Note: Section A: Matrix for the Authenticity Sub-Criteria pairwise Comparison, Section B: Final Weights of the Authenticity Sub Criteria

3.2.4 The Beauty Criteria Aggregate Weights Results

The Analytic Hierarchy Process was used to evaluate the Beauty sub-criteria. Timelessness was weighed at 0.2, Visual Impact at 0.221, Detailing at 0.143, and Integration with the Environment at 0.437, which was the highest weight, as summarized in Figure 7. The expert ratings exhibited a high degree of coherence and reliability, as evidenced by the consistency ratio of 0.001, as shown in Table 5 (section A& section B), this attests to the stability of the AHP technique used in this investigation.

Table 5

Analysis of the Beauty Sub-Criteria

	Beauty sub criteria	Visual impact	Detailing	Integration with environment	Timelessness
Section A	Visual impact	1.00	1.61585	2.10527	1.12613
	Detailing	0.61861	1.00	2.84563	2.2144
	Integration with environment	0.47499	0.35175	1.00	1.4474
	Timelessness	0.88907	0.45166	0.69094	1.00

	Beauty Sub Criteria	Priority Weight	Graphic Representation
Section B	Integration with environment	0.437	
	Visual impact	0.221	
	Timelessness	0.200	
	Detailing	0.142	

Note: Section A: Matrix for the Beauty Sub-Criteria pairwise Comparison, Section B: Final Weights of the Beauty Sub Criteria Graphic Representation

3.2.5 The Inventiveness Criteria Aggregate Weights Results

The Analytic Hierarchy Process was used to evaluate the inventiveness sub-criteria, yielding the following weights. With a weight of 0.231, technological innovation was given special attention in the evaluation, indicating its importance. The weighted value of adaptive reuse was 0.239, indicating its significant impact. With the greatest weight of 0.360, Sustainable Solutions stood up as the most important sub-criterion, highlighting its significant impact on assessing originality. With a weight of 0.169, spatial novelty was found to play a significant but relatively minor influence, as demonstrated in Figure 8. The evaluations' consistency ratio was 0.0065, which is significantly less than the 0.1 acceptable limit. This indicates that the expert judgments exhibited a high degree of coherence and reliability. As shown in Table 6 (section A & section B).

Table 6

Analysis of the Inventiveness Sub-Criteria

Section A

Inventiveness sub criteria	Technological innovation	Adaptive reuse	Sustainable solutions	Spatial novelty
Technological innovation	1.00	0.8809	0.60193	0.80893
Adaptive reuse	1.13529	1.00	0.76885	0.699
Sustainable solutions	1.66122	1.30044	1.00	0.43062
Spatial novelty	1.23652	1.43061	2.32226	1.00

Section B

Inventiveness Sub Criteria	Priority Weight	Graphic Representation
Sustainable solutions	0.361	
Adaptive reuse	0.239	
Technological innovation	0.231	
Spatial novelty	0.169	

Note: Section A: Matrix for the Inventiveness Sub-Criteria pairwise Comparison, Section B: Final Weights of the Inventiveness Sub Criteria

3.2.6 The Harmony Criteria Aggregate Weights Results

The Analytic Hierarchy Process was used to evaluate the Harmony sub-criteria, yielding the following weights. With a weight of 0.212, spatial harmony was found to have a major part in attaining overall design harmony. The weight assigned to proportional balance was 0.163, indicating its significant but minor influence. With a weight of 0.283, Material

Cohesion was highlighted as having a critical role in the cohesiveness of designs. With the greatest weight of 0.342, Environmental Synchronization was determined to be the most important sub-criterion, highlighting its crucial role in making sure that designs are in harmony with their environment, as shown in Figure 9. The evaluations' consistency ratio was determined to be 0.0032, which is significantly less than the 0.1 acceptable limit, as demonstrated in Table 7 (section A & section B); this indicates that the expert judgments exhibited a high degree of coherence and reliability.

Table 7

Analysis of the harmony Sub-Criteria

	Harmony sub criteria	Spatial harmony	Proportional balance	Material cohesion	Environmental synchronization
Section A	Spatial harmony	1.00	0.83059	0.83019	0.5987
	Proportional balance	1.20468	1.00	0.5113	0.49996
	Material cohesion	1.20501	1.95499	1.00	0.80711
	Environmental synchronization	1.67023	2.00015	1.23936	1.00

	harmony Sub Criteria	Priority Weight	Graphic Representation
Section B	Environmental synchronization	0.342	
	Material cohesion	0.283	
	Spatial harmony	0.212	
	Proportional balance	0.163	

Note: Section A: Matrix for the Harmony Sub-Criteria pairwise Comparison, Section B: Final Weights of the harmony Sub Criteria Graphic Representation

Chapter Four
Discussions and Conclusions

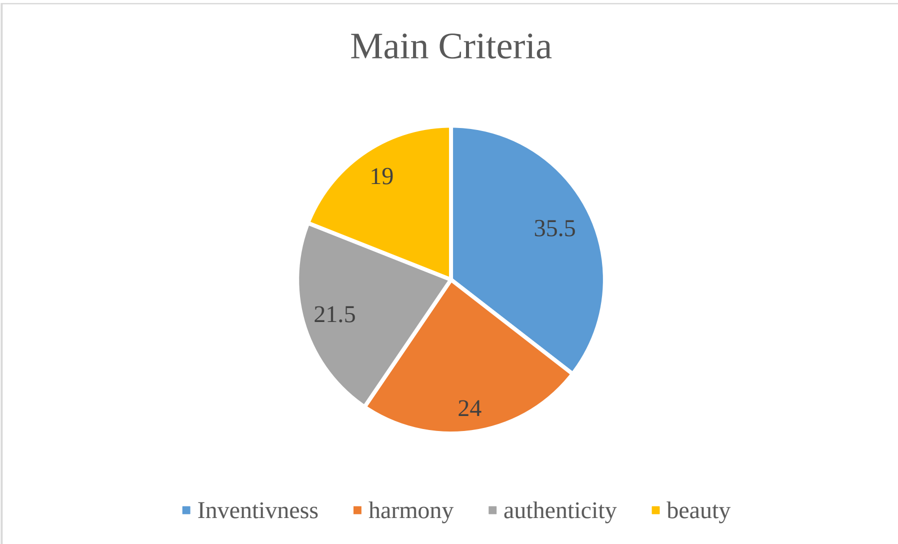
4.1 Discussion of the Results

4.1.1 Main Criteria Result Analysis

The findings of the primary evaluation criteria for AI-assisted designs were analyzed in this section of the discussion chapter. Authenticity, beauty, inventiveness, and harmony were the evaluation criteria, and weights were determined using the Analytic Hierarchy Process in accordance with expert opinions. The research sheds light on the relative weights assigned to each criterion and how those weights relate to the assessment of AI-assisted designs, Figure 5 shows main criteria final aggregate weights.

Figure 5

Main Criteria Final Aggregate Weights



With a weight of 0.215, authenticity was found to be noteworthy in the evaluation framework. This weight suggests that although important, authenticity is not the primary factor. Authenticity in design guarantees that outputs from AI are in line with cultural and historical settings, preserving a true portrayal. The significant weight assigned to this criterion emphasizes how much importance is put on designs that are true to authentic expressions and long-standing traditions. The preference for authenticity implies that experts should give priority to designs that can incorporate AI capabilities while maintaining the design's fundamental characteristics and legacy.

In situations when maintaining cultural and historical integrity is crucial, authenticity is especially significant. For instance, it is crucial to retain an authentic depiction in restoration efforts or culturally significant design endeavors. In order to ensure that technological improvements do not damage the integrity of the design's roots, authenticity is given a weight that indicates the necessity for AI to enhance rather than overpower the authentic parts of design. Which aligns with the findings of Heliane Silverman, which states the notion of authenticity in legacy has been explored, scrutinized, applauded, criticized, and rejected by many sectors such as the visual arts, architecture, landscape, anthropology, and archaeology.

The phrase "authenticity" is contrastive, and individuals aspire to it. In other words, when something is called "authentic," it usually means that it is a good thing. He thinks the idea is still very essential, even though it has evolved from previous interpretations. (Silverman, 2015)

With a weight of 0.190, beauty was identified as a significant but less dominant criterion in comparison to the other criteria. The somewhat smaller weight implies that, although important, visual appeal comes in second to other elements like harmony and originality. Aesthetic impact, attention to detail, and environmental integration are all considered components of beauty. The emphasis on aesthetics ensures that AI-assisted designs are aesthetically pleasing and uphold conventional criteria of beauty, reflecting the continued significance of aesthetics in design.

It is hard to ignore the importance of beauty in design since it affects the user's emotional and perceptual reactions immediately. Designs that are visually appealing have a higher chance of being embraced and valued by users. Within the sub-criteria of beauty, the focus on visual impact and detailing emphasizes how important it is for AI-assisted designs to take fine details and overall visual coherence into account. The assessment of design still heavily relies on the human appreciation of beauty, even in the face of technical breakthroughs. These conclusions are in line with the conclusions of Anjan Chatterjee and Oshin Vartanian where they state in their study that the most significant element influencing someone's desire to dwell in a physical area is its perceived attractiveness, which supports the extensive emphasis on design aesthetics in modern culture. (Chatterjee & Vartanian, 2014)

With the highest weight of 0.355, inventiveness was shown to be the most important factor to consider when assessing AI-assisted designs. This suggests a strong preference for unique and creative ideas that challenge accepted design conventions. The significant weight given to originality emphasizes the significance of technological innovation and creativity in AI-assisted design, implying that professionals appreciate designs that present fresh concepts and adjust to new difficulties. This focus on creativity suggests that artificial intelligence has the power to fundamentally alter the design industry.

The importance of creativity is a representation of how the design industry is dynamically moving and how innovation is essential to being relevant and competitive. Creative AI-assisted designs are going to be at the forefront of industry developments, offering new opportunities and technological breakthroughs. This criterion promotes the investigation of novel concepts and the incorporation of cutting edge technology, which eventually results in ground-breaking designs that raise the bar for the industry.

Which is similar to the study that was done by Becerik-Gerber, Burcin and Gerber, David J., where they stated that the inventiveness is key to the rapidly evolving nature of the AEC sector, where new and innovative approaches are required to keep up with the new and problems and trends. (Becerik-Gerber, Gerber, & Ku, 2011)

With a weight of 0.240, harmony was highlighted as having a major impact on ensuring designs are balanced and harmonious. The significant weight assigned to this criterion suggests that experts place a high value on integrating design aspects that complement one another to form a cohesive whole. Aspects including material cohesiveness, proportionate balance, spatial organization, and environmental synchronization are all components of harmony. The emphasis on harmony indicates that the capacity to produce coherent and well-integrated products is highly appreciated, especially in AI-assisted designs.

A visually and operationally coherent result is produced when all components of a design are harmoniously integrated. The requirement for designs to be contextually relevant and well integrated with their surroundings is indicated by the sub-criteria of harmony's emphasis on environmental synchronization. Harmonious AI-assisted designs are probably going to be easier to use and more aesthetically beautiful, offering a comprehensive experience that appeals to consumers on a number of levels.

These results fall in line with what was stated by Shyama Sundar Duriseti that Architectural space serves as a metaphor for the ways in which human behavior and natural forces interact. It facilitates the construction of structures and building types so that people can coexist harmoniously with the natural world. It proposes small changes to an architectural space's orientation and alignment that, by creating fixities that determine the direction of natural forces, are thought to have a heavy impact on people's wellbeing.

The consistency ratio for the comparisons based on the primary criteria was found to be 0.00095, significantly below the 0.1 acceptable threshold. That only goes to prove that the experts that were consulted and asked to fill out the questionnaire are reliable and that they understand the elements of the criteria and how the AHP method and questionnaire works which can be a real issue that can cause inconsistency and unreliable results that either need to be eliminated or redone. In this case this wasn’t an issue based on the mentioned inconsistency ratio.

When analyzing the results of the experts each main criteria was assigned weight and inventiveness has the highest weight that can only mean that coming up with new, creative ideas is most important. But inventiveness was not the only element that designers considered to be important, they assigned a high weight to the other main criteria elements beauty, harmony and authenticity, these conclusions synthesized from the experts answers which reflect their opinions based on their experience in the field, dealing with all types of stakeholders, and their experience with artificial intelligence.

Originality is important and vital in any design, but using the technology of AI it can open so many new doors to creating designs that are not only original but new and fresh that can lead to new directions and fields, and by using the prioritized framework that was created based on the results of the AHP it can a great tool to help provide each stakeholder with what they need and want in the design that is to be produced by using AI

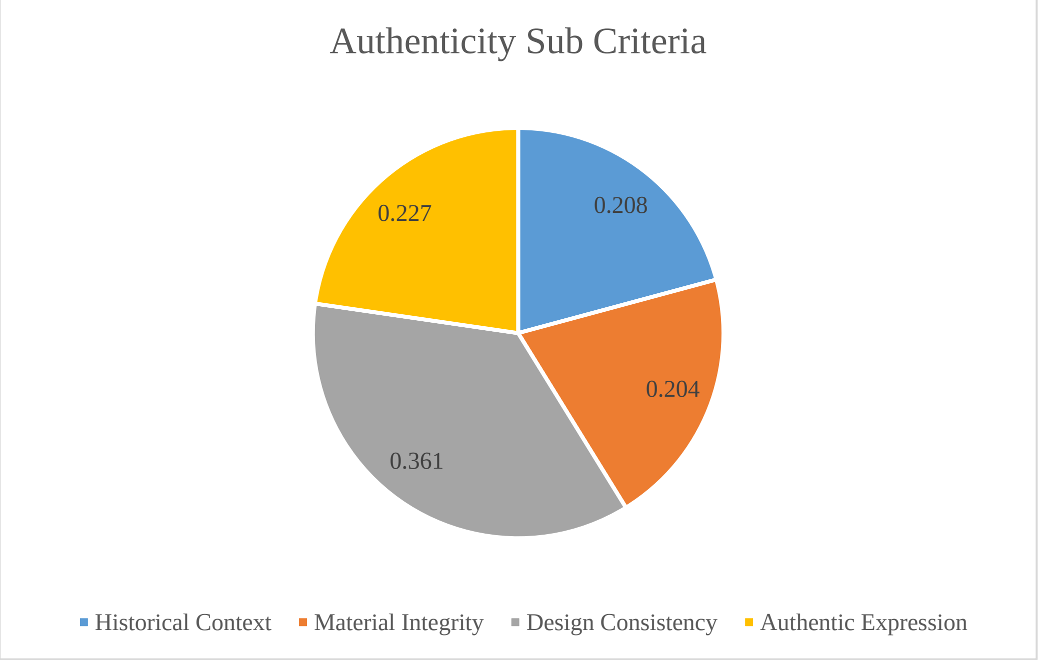
The results of this study not only can be used to evaluate AI assisted designs but also it act as road map for AI programmers to follow to create a better AI and architectural collaboration field, these conclusion can be incredibly helpful to create a better produced designs that would satisfy all stakeholders.

4.1.2 Authenticity Sub Criteria Results Analysis

Historical context, design consistency, authentic expression and material integrity are the elements that are considered and evaluated from the authenticity criteria. The AHP method was used to create the evaluations and the priorities to consider when judging an AI assisted design, the results of the AHP method provided a lot of useful information and how to these elements relate to each other in terms of importance in the evaluation. The results of the AHP method are presented in Figure 6 below.

Figure 6

Authenticity sub Criteria Final Aggregate Weights



One of the sub criteria that stood out in importance is the historical context with a weight of 0.2, manmade designs are naturally a product of human experiences, culture, interactions, and the past that makes it easier for a design that is made by humans to relate to the history and not to deviate from its origins, based on the results it shows that experts put quite a bit of weight on this criteria, because many produced designs that are not related to anything can lead to chaos and dividedness and unpleasant experience.

Culture, ideas, traditions, and nations are preserved through their unique designs and buildings and moving forward in time it’s vital to continue this tradition, the design needs to bring something new to the table with its design, materials, and technology but also honor the culture and surroundings.

Material integrity scored 0.204 which is almost as important as the historical context of the design, the material integrity weight means that experts think that its important to keep in mind that the materials that are used are not only advanced in terms of technology but also take into consideration the design concept.

The most important element that the experts valued in this sub criterion is the design consistency. It was important to them that the produced design to show consistency within its elements or otherwise the design would look chaotic and not aesthetically pleasing, the weight that was given to this sub criterion, which is the highest weight in the authenticity sub criteria, is 0.36. The importance of the design consistency is the perseverance of the concept of the design and main idea or goal.

For any design wither is commercial or residential etc. it needs to solve a problem in a way that is unique to the design and the problem, it also needs to represent uniqueness which is the meaning of authentic expression. Authentic expression scored a weight of 0.226 and that only shows how much the experts value the individuality of the design and for it to represent clearly a message that is not inspired or influenced by another source which would render the AI produced design as an imitation.

The way to validate the expert's responses while using the AHP method and to make sure that the results are coherent and dependable is by the consistency ration which is for this criteria is 0.001, which falls in line under the acceptable limit of 0.1.

Based on the feedback of the experts AI tools that can produce designs need to take into consideration how original and authentic the design is, by adding features to the AI tools that can pay attention to these elements.

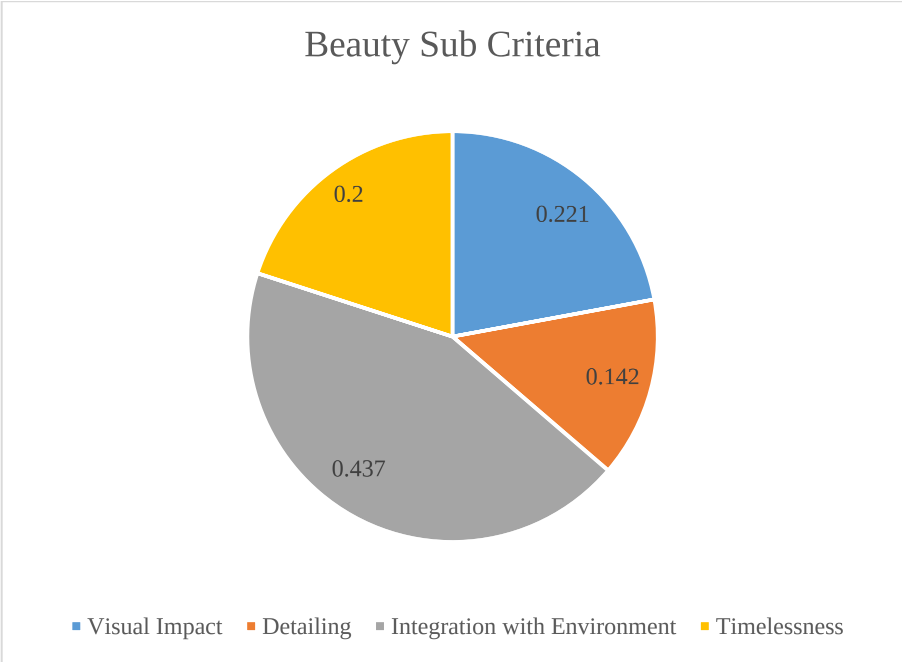
The important conclusion derived from the results that were gathered from the experts is that for any design to be accepted and to be visually and culturally pleasant is that it needs to have a healthy mix of all of the authenticity criteria elements historical context, material integrity, design consistency, and authentic expression.

4.1.3 Beauty Sub Criteria Results Analysis

An extensive understanding of the elements that contribute to the aesthetic appeal of AI-assisted designs has been made possible by the analysis of the Beauty sub-criteria using the Analytic Hierarchy Process. Four sub-criteria were taken into consideration: Timelessness, Visual Impact, Detailing, and Integration with the Environment. Expert assessments were reflected in the weights assigned to each sub-criteria as demonstrated in Figure 7.

Figure 7

Beauty sub Criteria Final Aggregate Weights



With a weight of 0.221, Visual Impact was found to have a significant influence on the general impression of beauty in AI-assisted designs. This sub-criterion highlights the significance of the instantaneous visual attraction a design produces. The comparatively large weight indicates that professionals give great weight to designs that provide a powerful, favorable first impression. Visual impact is an essential part of design evaluation since it plays a major role in drawing and holding consumers' attention. According to this research, AI technologies ought to give preference to aspects that improve a design's visual appeal in order to produce visually arresting and captivating results right away.

With a weight of 0.143, detailing highlights how crucial little, complex details are to enhancing a design's appeal. Even though it is less important than other sub-criteria, detailing is crucial for giving a design more nuance and complexity. The amount of weight given to detailing implies that although professionals appreciate fine work, they view it as an adjunct to more important elements like Visual Impact and Environment Integration. According to this realization, AI-assisted design tools ought to help designers with the fine tuning of elements so as to improve the overall aesthetic without taking away from other important components of the design.

When introducing the concept of integration with the environment to the experts it was explained as the designs ability to blend with the surrounding environment in way that it adds to the beauty of the design, by the high value of the weight that was given to this sub criteria element it shows that experts value above all else for the design to be in harmony with its surroundings.

Experts only validated the importance for any design to last through time and maintain its value not only in aesthetics but also in functionality and usability, timelessness was given a weight of 0.2, thus a design needs to be timeless and also contain qualities that are creative and user friendly.

When using the AHP method it must be validated through using the consistency analysis, the allowed limit for the results to be acceptable is 0.1, for this criteria the inconsistency ratio was 0.001, which way below the limit, this fact only proved the validity of the expert’s responses.

While asking the experts about their evaluation of the beauty sub criteria it was revealed how the experts looked at the aesthetics of any design. Timelessness was given significant weight which shows that designers think it’s important for the design to hold its value over time without being thought of as outdated, along with paying attention to the details of the design that add more depth and meaning plus functionality to the design, all of these are valued along with the integration with the environment where the design need for the design to fit among the surrounding buildings and environment without looking out of place.

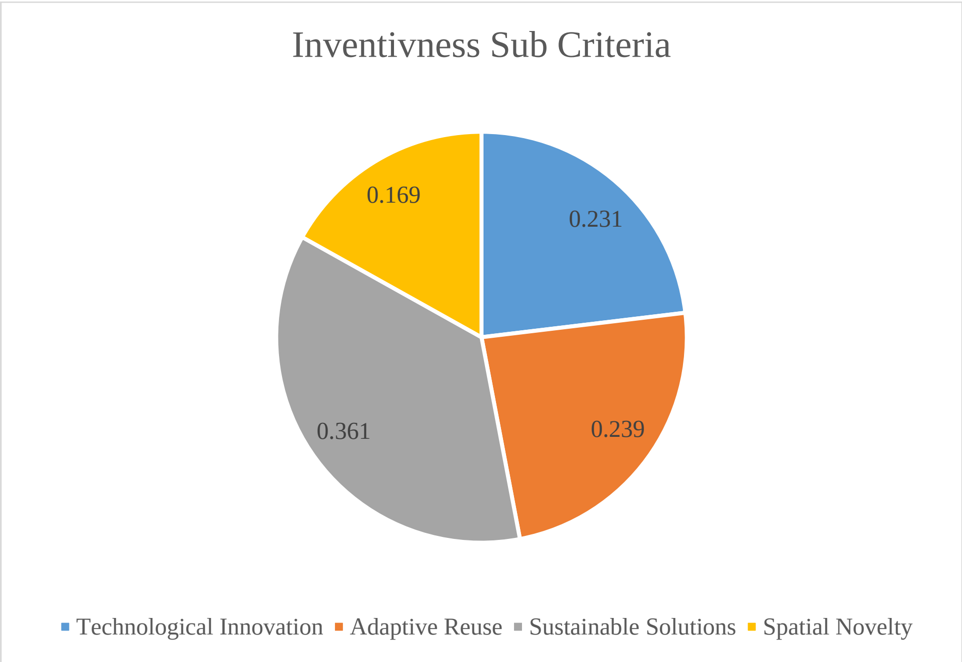
This only shows that a healthy mixture of appealing aesthetics not only for the first look but aesthetics that would last long term, in addition to aesthetics that fit in with the surrounding environment without looking out of place.

4.1.4 Inventiveness Sub Criteria Results Analysis

Analytic Hierarchy Process study of the Inventiveness sub-criteria has produced informative findings about the elements that influence the perceived uniqueness and creativity of AI-assisted designs. The sub-criteria that were taken into consideration were spatial novelty, adaptive reuse, technological innovation, and sustainable solutions. Expert assessments were reflected in the weights assigned to each sub-criteria as shown in Figure 8.

Figure 8

Inventiveness sub Criteria Final Aggregate Weights



With a weight of 0.231, technological innovation is clearly important in characterizing originality in AI-assisted designs. This sub-criterion highlights how crucial it is to incorporate cutting-edge tools and technology into the design process. The significant weight indicates that experts place a high importance on designs that provide new features and functionalities by utilizing cutting-edge technology. This result only shines a light about harvesting the new and most useful technologies.

One of the sub criteria is adaptive reuse which means to recycle and reuse material that already exist or buildings that already exist, experts put a value to this sub criteria, experts think not only designs need to use existing materials and buildings but also they need to find new and creative ideas to recycle these existing resources. The weight that was given to this criterion is 0.239.

According to the experts it was not only to have a creative design ideas and process but it’s also important to have solutions that ensure the designs sustainability this conclusion was reached by the weight that was given to the sub criteria element sustainable solutions 0.360, the point of sustainable solutions is for the design to be friendly to its environment in addition to being sustainable when it comes to the material that have been used in the design as well as to its resources.

Expert opinions that are reflected in the results indicate that spatial novelty with a weight of 0.169 is important but not as important as other sub criteria like sustainability, even though spatial novelty is not on the top of priorities but it’s still vital to create a configuration of the spaces that is aesthetics and functional and inventive, inventiveness is not only important in technological and sustainable solutions but also in the division of the spaces.

The pairwise comparisons and the answers of the experts that were provided are validated via the consistency ratio that was calculated and equals 0.0065, and 0.1 is the acceptable limit for the consistency for the responses to be valid and coherent and most importantly dependable.

While conducting the questionnaire by experts for the sub criteria of inventiveness a light was shed on the most important factors that contribute to the acceptance of AI assisted designs and that should be included in the produces design for it to be accepted by experts and stakeholders. After the analysis it was clear that experts gave great importance to the sub criteria sustainable solutions, which means that the design should include solutions that contribute positively to the environment and ensure the designs longevity. The weight that was given to technological innovation indicates how vital it is for the design to have new technologies that would help with the sustainability and functionality of the design, but not neglecting the importance of the spatial novelty in the design.

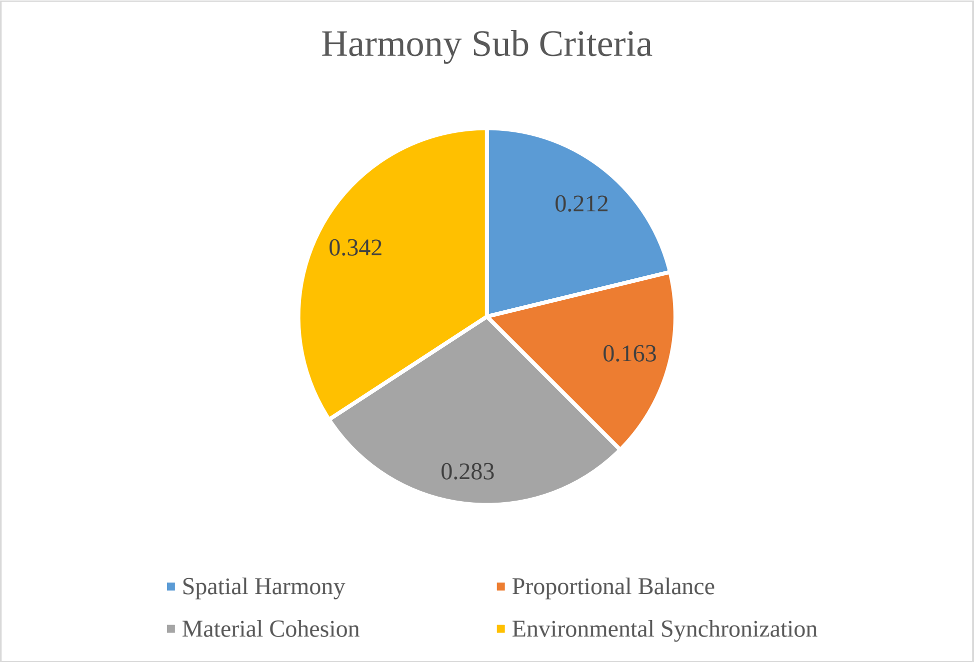
The results give an indication that AI should include features to help produce designs that are creative and have solutions to the spacing assignment while including up to date technologies, which shows how important it is to have a balance between sustainable and spatial solutions and new technological advancements.

4.1.5 Harmony Sub Criteria Results Analysis

After conducting the process of AHP the experts has shown each one of the sub criteria elements of the harmony criteria assigned weights according to their importance in their opinions as experts in the field, the sub criteria includes environmental synchronization, material cohesions, proportional balance and finally spatial harmony, Figure 9 presents the final weights of each sub criteria.

Figure 9

Harmony sub Criteria Final Aggregate Weights



Not only is it important to have harmony and proportionality in the aesthetics of the design, but based on the results of the AHP according to the experts it's also important to have harmony in the assigning of the spaces with a weight of 0.212, that not only helps with the functions of the spaces but also it allows for the smooth transition between the spaces which ultimately contributes to have a harmonic design as a whole.

As it was shown in the results of the AHP process it's very necessary to keep and maintain the right proportions during the design process even if it didn't have the highest weight in harmony criteria 0.163, it sure is still important to the experts to have a visually pleasing deign and also its human nature to crave proportionality.

Another vital sub criteria element that was identified is material cohesion it was given a weight of 0.283, which can be explained by the importance of the choice of materials in any practice, the materials need to complement each other not only in an aesthetic sense but also in a functional sense, it also adds to the general harmony of and coherence of the design in its entirety. This calls for the addition of new features that serves this conclusion in AI design programs.

It was concluded from the results that experts put a lot of value to the design that fits in with the surrounding environment not only aesthetically but also as a function, so it fits with its environment in more than one way, and that is indicated by the high value that is given to the sub criterion environmental synchronization which is 0.342. That conclusion leads to the need to include AI features that help to create designs that are synched to their surroundings but still new and creative.

As a part of the AHP process a consistency analysis is conducted, by comparing the sub criteria elements and the result of the consistency analysis is 0.0032 which is lower than the acceptable limit that is 0.1, the main thing that is concluded from the low value of the consistency analysis is that there is coherence among the responses of the experts which makes their response more dependable and credible.

Environmental synchronization, spatial harmony, material cohesiveness and proportional balance are the sub criteria for the harmony criteria and each weight for these sub criteria is an opportunity for a guideline to follow, for example the high weight of environmental synchronization shows that when creating a design it needs to be in harmony with its surroundings same goes for the material cohesiveness where choosing the right materials that work well together is vital as well as spatial harmony.

For a designer to produce a harmonious and balanced design there needs to be a balance between the materials that were chosen and the context of the surrounding environment plus the spatial arrangement.

4.2 Development of the AI-Assisted Design Evaluation Framework in Excel

An excel sheet framework was produced to evaluate AI assisted designs that includes multiple main criteria and sub criteria the following steps are the process that was followed to create the excel sheet:

- Main criteria evaluation: Authenticity, Beauty, Inventiveness, and Harmony. After determining the main criteria each one was divided into sub criteria.
- The normalization of each assigned weight: each sub criteria were given weights produced by using the AHP process, after that each weight was normalized were that total summation of the normalized weights amount to 1.
- Response Assignment: the assessor scores every sub criteria based on how satisfied with the produced AI assisted design from a scale of 1 to 5, where 5 is the highest score
- Weighted Score Calculation: the importance of each sub criteria is translated into a weighted score that was produced by multiplying the response with the assigned weight produced by the AHP method.
- Main Criteria Scoring: the score of each one main criteria was determined by adding the score of each respective sub criteria which results in producing an overall score for each and every criteria that way it’s possible to evaluate the designs produced by AI.
- A summary table was produced: a summary table was included to dynamically show the updated results based on the input data with separate cells for each major criterion that is linked to the original table.
- Dynamic and Automated Functionality: formulas like SUM, and multiplication allowed for the dynamic nature of the excel sheet which allows it to change and modify in accordance to different inputs which leads to the final results change in relation.

The developed excel sheet that I highly organized and user friendly allowed to evaluate AI assisted designs in depth, with easy and instant summary of the results.

Table 8 shows the dynamic excel sheet for the framework to evaluate AI assisted designs.

While Figure 10 demonstrates Sunburst chart of Global and Local weights of sub-criteria with respect to criterion, which really helps with the visualization of each criteria and sub criteria in relation to the big picture, which contributes to easy hierarchical evaluation of each element within each criteria and among other criteria as well.

Table 8

Global and Local weights of sub-criteria with respect to criterion

Main Criteria	Weight	normalized weights	Points	Weighted Score
		Authenticity (21.5)		
Historical Context	4.5	0.208		0
Material Integrity	4.4	0.204		0
Design Consistency	7.8	0.361		0
Authentic Expression	4.9	0.227		0
	Criteria Total			0
		Beauty (19.0)		
Visual Impact	4.2	0.221		0
Detailing	2.7	0.142		0
Integration with the Environment	8.3	0.437		0
Timelessness	3.8	0.2		0
	Criteria Total			0
		Inventiveness (35.5)		
Technological Innovation	8.2	0.231		0
Adaptive Reuse	8.5	0.239		0
Sustainable Solutions	12.8	0.361		0
Spatial Novelty	6	0.169		0
	Criteria Total			0
		Harmony (24.0)		
Spatial Harmony	5.1	0.212		0
Proportional Balance	3.9	0.163		0
Material Cohesion	6.8	0.283		0
Environmental Synchronization	8.2	0.342		0
	Criteria Total			0

Main Criteria		Total Score
Inventiveness	(35.5)	0
Harmony	(24.0)	0
Authenticity	(21.5)	0
Beauty	(19.0)	0

Figure 10

Sunburst chart of AI-assisted design evaluation elements' Global and Local weights of sub-criteria concerning the criterion

Source: Author's own work

Chapter Five

Conclusions, Implications, and Recommendations

5.1 Conclusions

The AHP was key element in this research, which facilitated a methodology to evaluate AI produced designs, which of course depend it on the expert opinions in the field, every criteria and sub criteria were given a weight of importance that led to the prioritization of each one in terms of importance.

Harmony and inventiveness are some of the most important elements that are considered in the framework among the elements that were given the deserved attention and normalized weights in the reviewing process which aided in the process of evaluating AI produced designs. Which resulted in the validation of the design quality.

Inventiveness came up as most vital with a weight of (35.5) when considering or assessing AI produced designs, which falls in line with the capabilities of AI where it can produce sustainable and adaptable solutions.

Based on the results it shows that the design needs to be in synch with the surrounding environment whilst keeping the idea of the design creative and technologically advanced as well as creating designs with solutions that are traditional and but also relevant, also with scores of 21.5 and 24 authenticity and harmony respectively are vital in the design to make sure that the design follows basic design principles and also be in harmony with the surroundings.

Contrary to common belief the result of the experts in the questionnaire, beauty does not come first when evaluating AI produced designs with a weight of 19.0. On the other hand, integration with the environment was shown to be of high importance, which only indicates the need to contextually appropriate, unlike the sub criteria detailing which was low rated.

The validity of the framework comes from the consistency ratio that is high which only indicates the strengthen the framework and validates the ratings of the experts that participated in the questionnaire, the benefit of the framework lies in guiding the user and stakeholders in balancing the different elements that are necessary to produce a design that is beautiful, technologically advanced, and coherent with the culture and surrounding environment.

The framework can be further validated and proved effective by using the framework in different sections and parts of the design process, and also its adaptability to fast based dynamic nature of the technology of AI, of course the framework could be developed overtime by revising the criteria and sub criteria in relation to what’s important at any current time, which will keep the process of incorporating the technology of AI into the design process smooth and produce designs that are time appropriate and coherent with the surroundings and culture.

5.2 Implications

5.2.1 Practical Implications

- The framework can be applied in the architectural practices: the use of AI in the architectural sector is ever growing, and there needs to be an evaluation tool to ease the transition AI into a tool that can produce designs that combines the previously mentioned elements, and which are prioritized from the viewpoint of experts.

- To better improve the evaluation process of designs: using this framework will make the decision making process more efficient specially if there was more than one stakeholder involved, this framework will achieve this consistent evaluation process of the designs because it incorporated the AHP process that quantifies elements that are subjective.

- To develop AI in the field of architecture: after the use of AHP each criteria and sub criteria were given a weight, which results in prioritization of these elements, and that could be of major help to AI designers because they can create algorithms based on the prioritization that was established by AHP which leads to better quality designs being produced.

- Impacts on Sustainable Design and Environmental Integration: when using AI to produce A design that takes into consideration the sustainability of the eco-environment and the harmony of the design with the surrounding environment it can aspire better material selection and spatial planning by the designers which contributes to the sustainability of the environment.

- Educational Use: one of the main contributions is offering a quantitative tool to measure qualitative aspects, which can be introduced to architectural student after introducing the new field of AI assisted designs.

- Policy Implications: it can be used to evaluate projects in the public sector and agencies, in addition to projects involving larger urban planning projects. When used in these situations the AI can produce designs that satisfy the needed requirements are put in mind for example sustainability and inventiveness.

- Future Research and Development: The outcomes of this study can create an opening for new opportunities to develop multiple areas in AI which can ultimately create creative, coherent and more aesthetically pleasing designs that are better tailored to human use, which can open more doors for AI to be used in the architectural domain.

5.2.2 Theoretical Implications

Based on the evaluation framework that was presented in this study which is an important contribution to the previous theoretical models that only evaluate quantitative element, which is considered an important research gap, this study allows the evaluation of elements that are qualitative, that way the gap between subjective atheistic and objectives analysis by including the main criteria and their subjective sub criteria for example authenticity, beauty, and harmony. By the use of the AHP and the evaluation framework it can provoke further development and research areas.

5.3 Recommendations

After using the AHP method and creating the assessment framework, here are a few recommendations to use the framework in the best possible manner:

- Innovation and sustainability should be greatly used by AI: Because of the new environmental issues that are occurring designers are now moving in the direction of sustainability and innovative sustainability solutions and with AI's ability to come up with spaces and arrangements that can contribute positively to these criteria and bring new solutions and friendly environment.
- The authenticity and coherence sub criteria should be put on top of the list of importance to develop: by developing these elements it will help accept AI assisted

designs more, and that can insure that AI not only brings new and creative ideas but also ideas that can adhere to cultural norms.

- AI should be developed more specifically in the aesthetic and details aspect: to be able to create architectural designs that are highly detailed and complicated. Usually these skills and expertise can acquired through experience, thus AI needs to combine its resources with human skills.
- To improve the blending with the environment: AI should include more details that are specific to certain sites to be able to create designs that blend in with the urban surroundings and environment, this is due to the sub criteria integration with environment scoring high assessment score.
- Including the AI in projects that are large in scale: because AI has proven its ability as a good source of creative, sustainable ideas it should be used in large projects and urban planning, because it can help largely in creating good sustainable foundations.
- To equalize between new age innovation and traditional designs: after conducting this research it was found that it’s important to produce a design that combines between the traditional and conventional methods and element as well as new and recent elements. Which can create a huge difference in the acceptance of AI designs.
- The AI design tools needs to be developed and researched more: the design tools that are offered as a part of AI need to be further analyzed, to make sure that AI produces not only ideas that are creative but also aesthetically pleasing and coherent.
- The main and sub criteria can be evaluated in high accuracy that will insure the framework will be used as whole. Thus allowing the deign to be analyzed fairly and as a whole.
- The framework can be used repeatedly. The design can always be improved even after it was evaluated in the beginning, which can lead to reach high design standards.
- Using the framework, keep thorough records of the evaluation procedure. In order to guide upcoming design projects and enhance evaluation procedures, consider the conclusions and realizations derived from each criterion.
- Keep informed of the most recent developments in AI and design principles. Take part in professional groups, workshops, and courses to keep learning and improving your abilities so that you can apply the framework to AI-assisted design evaluation in an efficient manner.

- Designers can use the framework to create AI-assisted designs that are unique, genuine, lovely, and harmonious, adhering to strict criteria of relevance and quality, by implementing these suggestions.

5.4 Limitations and Future Research Directions

The limitations of the study are the following:

- The intricacy of the AHP method can present difficulties for practitioners who are not acquainted with this methodology, which could restrict the study's findings' applicability and accessibility to a wider audience in the design community.
- The experts' cultural backgrounds may affect their opinions despite the worldwide panel, maybe resulting in a bias that reflects their cultural norms and practices.

List of Abbreviations

Abbreviation	Meaning
AA	Authentic Expression
AH	Historical Context
AM	Material Integrity
A	Authenticity
AD	algorithmic design
AHP	Analytical hierarchal process
AI	Artificial intelligence
AIGC	Building information modeling
B	Beauty
BD	Detailing
BI	Integration with Environment
BIM	Building information modeling
BT	Timelessness
BV	Visual Impact
CAD	computer-aided design
CR	Consistency Ratio
DL	Deep Learning
GAI	Generative Artificial intelligence
GAs	Genetic algorithms
GMM	Gaussian Mixture Models
H	Harmony
HCI	Human-computer interaction
HE	Environmental synchronization
HM	Material cohesion
HMM	Hidden Markov Models
HP	Proportional balance
HS	Spatial harmony
I	Inventiveness
IA	Adaptive reuse
IN	spatial novelty

IoT	Internet of Things
IS	Sustainable Solutions
IT	Technological Innovation
ML	Machine learning

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Appendices

Appendix A

The pairwise comparison-designed questionnaire used by this study (English Version)

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Engineering Management Masters

- **Study Title: Developing a Hierarchical Framework for Evaluating AI-Produced Designs: Insights from Design Experts**

- **Study Description:**

This research aims to devise a method for evaluating AI-generated designs with input from design experts. It will use the Analytic Hierarchy Process (AHP) to create a framework tailored to designers' perspectives. Experts are invited to contribute insights on traditional design principles applied to AI designs, crucial for developing an effective evaluation system. This endeavor is significant for advancing design methodologies in the realm of artificial intelligence.

Done by: Eng. Aseel Kayed

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- **Part 1: General information**

1. Name	-------------------------------
2. Gender	a) Male b) Female
3. Educational Background	a) Bachelor's Degree b) Master's Degree c) PhD/Doctorate d) Other (please specify)
4. Years of experience in design field	a) Less than 1 year b) 1-3 years c) 4-6 years d) 7-10 years e) More than 10 years
5. Current employment status	a) Employed full-time b) Employed part-time c) Self-employed d) Student e) Other (please specify)
6. Previous experience with AI-Assisted designs	a) Yes b) No
7. Rate your level of confidence in assessing AI-assisted designs	a) Very confident b) Confident c) Neutral d) Not very confident e) Not confident at all

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Part 2: analytical hierarchy process

How will this process work?

The AHP is a vital process to prioritize the factors that help evaluate AI produced designs.

Compare between criteria A and criteria B by circling a number based on the importance.

	Scale	
1 = equal importance	3= moderate importance	5= strong importance
7= very strong important	9= extreme importance	

Prioritize the main criteria factors:

- **Authenticity: The degree to which the design reflects originality, sincerity, and truthfulness in its representation and expression, avoiding imitation or artificiality.**
- **Beauty: The aesthetic appeal and attractiveness of the design, encompassing elements such as symmetry, proportion, elegance, and visual appeal, which evoke pleasure and admiration.**
- **Inventiveness: The level of creativity, innovation, and novelty demonstrated in the design, indicating originality, ingenuity, and the ability to break away from conventional approaches or solutions.**
- **Harmony: The coherence, balance, and unity within the design, where elements complement each other harmoniously, creating a sense of cohesion, order, and integration.**

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Criteria A	AI-Assisted Designs Evaluating Factors									Criteria B
	Factors weighting score									
	More important than				Equal	Less important than				
Authenticity (A)	9	7	5	3	1	3	5	7	9	Beauty (U)
Authenticity (A)	9	7	5	3	1	3	5	7	9	Inventiveness (B)
Authenticity (A)	9	7	5	3	1	3	5	7	9	Harmony (H)
Beauty (U)	9	7	5	3	1	3	5	7	9	Inventiveness (B)
Beauty (U)	9	7	5	3	1	3	5	7	9	Harmony (H)
Inventiveness (B)	9	7	5	3	1	3	5	7	9	Harmony (H)

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- Historical Context: to what extent the design honors and captures the local architectural heritage and history.
- Material Integrity: The use of materials in a way that is loyal to their characteristics, sources, and sustainable practices
- Design Consistency: is the capacity of the design to remain faithful to the original conceptual idea throughout the execution, as well as its connection with the intended goal.
- Authentic Expression: The design's capacity to communicate the architect's distinct viewpoint and message without the use of clichés or fads.

Criteria A	Authenticity Sub Criteria Factors									Criteria B
	Factors weighting score									
	More important than				Equal	Less important than				
Historical Context (AH)	9	7	5	3	1	3	5	7	9	Material Integrity (AM)
Historical Context (AH)	9	7	5	3	1	3	5	7	9	Design Consistency (AD)
Historical Context (AH)	9	7	5	3	1	3	5	7	9	Authentic Expression (AA)
Material Integrity (AM)	9	7	5	3	1	3	5	7	9	Design Consistency (AD)
Material Integrity (AM)	9	7	5	3	1	3	5	7	9	Authentic Expression (AA)
Design Consistency(AD)	9	7	5	3	1	3	5	7	9	Authentic Expression (AA)

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- Visual Impact: The shape, color palette, and general form of the design as well as how visually arresting it is at first glance.
- Detailing: The dexterity and grace of the design's minor components, such the joinery, fittings, and finishing.
- Integration with Environment: The degree to which a design enriches and complements the urban or landscape it is placed in.
- Timelessness: The capacity of a design to withstand volatile design trends and hold up across time in terms of aesthetic appeal and relevance.

	Beauty Sub Criteria Factors									
Criteria A	Factors weighting score									Criteria B
	More important than				Equal	Less important than				
Visual Impact (BV)	9	7	5	3	1	3	5	7	9	Detailing (BD)
Visual Impact (BV)	9	7	5	3	1	3	5	7	9	Integration with Environment (BI)
Visual Impact (BV)	9	7	5	3	1	3	5	7	9	Timelessness (BT)
Detailing (BD)	9	7	5	3	1	3	5	7	9	Integration with Environment (BI)
Detailing (BD)	9	7	5	3	1	3	5	7	9	Timelessness (BT)
Integration with Environment (BI)	9	7	5	3	1	3	5	7	9	Timelessness (BT)

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- Spatial harmony: The smooth transition and sensible relationship between various places that encourage usability and mobility.
- Proportional balance: is the process of creating a balanced visual composition in design by paying attention to scales and proportions.
- Material cohesion: is the result of carefully choosing and combining visually pleasing materials.
- Environmental synchronization: Design that attains a harmonious interaction with the natural environment, encompassing elements like light, wind, and landscape integration.

	Harmony Sub Criteria Factors									
Criteria A	Factors weighting score									Criteria B
	More important than				Equal	Less important than				
Spatial harmony (HS)	9	7	5	3	1	3	5	7	9	Proportional balance (HP)
Spatial harmony (HS)	9	7	5	3	1	3	5	7	9	Material cohesion (HM)
Spatial harmony (HS)	9	7	5	3	1	3	5	7	9	Environmental synchronization (HE)
Proportional balance (HP)	9	7	5	3	1	3	5	7	9	Material cohesion (HM)
Proportional balance (HP)	9	7	5	3	1	3	5	7	9	Environmental synchronization (HE)
Material cohesion (HM)	9	7	5	3	1	3	5	7	9	Environmental synchronization (HE)

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- Technological Innovation: Using the newest construction techniques and technology to improve efficiency and performance.
- Adaptive reuse: the creative process of finding new and inventive uses for pre-existing materials or buildings.
- Sustainable Solutions: Creative methods of achieving sustainability with an emphasis on energy conservation, renewable resources, and a low environmental effect.
- spatial novelty: The investigation of novel shapes and arrangements of space that go against established architectural conventions

	Inventiveness Sub Criteria Factors									
Criteria A	Factors weighting score									Criteria B
	More important than				Equal	Less important than				
Technological Innovation (IT)	9	7	5	3	1	3	5	7	9	Adaptive reuse (IA)
Technological Innovation (IT)	9	7	5	3	1	3	5	7	9	Sustainable Solutions (IS)
Technological Innovation (IT)	9	7	5	3	1	3	5	7	9	spatial novelty (IN)
Adaptive reuse (IA)	9	7	5	3	1	3	5	7	9	Sustainable Solutions (IS)
Adaptive reuse (IA)	9	7	5	3	1	3	5	7	9	spatial novelty (IN)
Sustainable Solutions (IS)	9	7	5	3	1	3	5	7	9	spatial novelty (IN)

Appendix B

The pairwise comparison-designed questionnaire used by this study (Arabic Version)

جامعة النجاح
كلية الدراسات العليا
ماجستير الإدارة الهندسية

- **عنوان الدراسة:**

تطوير إطار هرمي لتقييم التصاميم المنتجة بالذكاء الاصطناعي: رؤى من خبراء التصميم

- **وصف الدراسة:**

يهدف هذا البحث إلى ابتكار طريقة لتقييم التصاميم المولدة بالذكاء الاصطناعي مع مدخلات من خبراء التصميم. وسوف يستخدم عملية التسلسل الهرمي التحليلي (AHP) لإنشاء إطار مصمم خصيصًا لوجهات نظر المصممين. الخبراء مدعوون للمساهمة برؤى حول مبادئ التصميم التقليدية المطبقة على تصاميم الذكاء الاصطناعي، والتي تعتبر ضرورية لتطوير نظام تقييم فعال. يعد هذا المسعى مهمًا لتطوير منهجيات التصميم في مجال الذكاء الاصطناعي.

عمل المهندسة: أسيل كايد

جامعة النجاح
كلية الدراسات العليا
ماجستير الإداره الهندسية

- **الجزء الأول: معلومات عامة**

1. الإسم:	-------------------------------
2. الجنس:	أ. أنثى ب. ذكر
3. الخلفية التعليمية:	أ. درجة البكالوريس ب. درجة الماجستير ت. دكتوراة ث. اخرى (------------)
4. سنوات من الخبرة في مجال التصميم:	أ. أقل من سنة ب. من 1 إلى 3 سنوات ت. من 4 إلى 6 سنوات ث. من 7 إلى 10 سنوات ج. أكثر من 10 سنوات
5. حالة التوظيف الحالية:	أ. موظف بدوام كامل ب. عمل بدوام جزئي ت. توظيف ذاتي ث. طالب/ة ج. أخرى (------------)
6. الخبرة السابقة في التصميمات المدعومة بالذكاء الاصطناعي	أ. نعم ب. لا
7. قم بتقييم مستوى ثقتك في تقييم التصميمات المدعومة بالذكاء الاصطناعي	أ. واثق/ة جدا ب. واثق/ة ت. محايد/ة ث. غير واثق/ة ج. غير واثق/ة بشدة

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- **الجزء الثاني: عملية التسلسل الهرمي التحليلي**

كيف ستعمل هذه العملية؟

تعد AHP عملية حيوية لتحديد أولويات العوامل التي تساعد في تقييم التصميمات المنتجة بواسطة الذكاء الاصطناعي.

قارن بين المعايير (أ) والمعايير (ب) بوضع دائرة حول رقم بناءً على الأهمية.

	المقياس	
1 = أهمية متساوية	3 = أهمية معتدلة	5 = أهمية قوية
7 = أهمية قوية جدا	9 = أهمية قصوى	

إعطاء الأولوية لهذه العوامل:

- **الأصالة: الدرجة التي يعكس فيها التصميم الأصالة والإخلاص والصدق في تمثيله وتعبيره، وتجنب التقليد أو التصنع.**

- **الجمال: المظهر الجمالي وجاذبية التصميم، الذي يشمل عناصر مثل التماثل والتناسب والأناقة والجاذبية البصرية، التي تثير المتعة والإعجاب.**

- **الابتكار: مستوى الإبداع والابتكار والحداثة الذي يظهر في التصميم، مما يدل على الأصالة والبراعة والقدرة على الابتعاد عن الأساليب أو الحلول التقليدية.**

- **التناغم: التماسك والتوازن والوحدة داخل التصميم، حيث تكمل العناصر بعضها البعض بشكل متناغم، مما يخلق شعوراً بالتماسك والنظام والتكامل.**

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عوامل تقييم التصميمات المدعومة بالذكاء الإصطناعي

قائمة (أ)	عوامل درجة الترجيح									قائمة (ب)
	أكثر أهمية من				متساوي	أقل أهمية من				
الأصالة (A)	9	7	5	3	1	3	5	7	9	الجمال (U)
الأصالة (A)	9	7	5	3	1	3	5	7	9	الإبتكار (B)
الأصالة (A)	9	7	5	3	1	3	5	7	9	التناغم (H)
الجمال (U)	9	7	5	3	1	3	5	7	9	الإبتكار (B)
الجمال (U)	9	7	5	3	1	3	5	7	9	التناغم (H)
التناغم (H)	9	7	5	3	1	3	5	7	9	الإبتكار (B)

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- السياق التاريخي: إلى أي مدى يكرم التصميم ويجسد التراث المعماري المحلي والتاريخ.
- سلامة المواد: استخدام المواد بطريقة تتفق مع خصائصها ومصادرها وممارساتها المستدامة
- اتساق التصميم: قدرة التصميم على البقاء مخلصًا للفكرة المفاهيمية الأصلية طوال فترة التنفيذ، بالإضافة إلى ارتباطه بالهدف المقصود.
- التعبير الأصيل: قدرة التصميم على إيصال وجهة نظر المهندس المعماري المتميزة ورسالته دون استخدام الكليشيهات أو البدع.

عوامل المعايير الفرعية للأصالة

قائمة (أ)	عوامل درجة الترجيح									قائمة (ب)
	أكثر أهمية من				متساوي	أقل أهمية من				
السياق التاريخي (AH)	9	7	5	3	1	3	5	7	9	سلامة المواد (AM)
السياق التاريخي (AH)	9	7	5	3	1	3	5	7	9	اتساق التصميم (AD)
السياق التاريخي (AH)	9	7	5	3	1	3	5	7	9	التعبير الاصيل (AA)
سلامة المواد (AM)	9	7	5	3	1	3	5	7	9	اتساق التصميم (AD)
سلامة المواد (AM)	9	7	5	3	1	3	5	7	9	التعبير الاصيل (AA)
اتساق التصميم (AD)	9	7	5	3	1	3	5	7	9	التعبير الاصيل (AA)

جامعة النجاح
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ماجستير الإدارة الهندسية

- التأثير البصري: الشكل ولوحة الألوان والشكل العام للتصميم بالإضافة إلى مدى جاذبيته للوهلة الأولى.
- التفاصيل: براعة ونعمة المكونات الثانوية للتصميم، مثل النجارة والتجهيزات والتشطيب.
- التكامل مع البيئة: الدرجة التي يثري بها التصميم ويكمل المنطقة الحضرية أو المناظر الطبيعية التي يقع فيها.
- الخلود: قدرة التصميم على تحمل اتجاهات التصميم المتقلبة والصمود عبر الزمن من حيث الجاذبية الجمالية وأهميتها.

	عوامل المعايير الفرعية للجمال									
قائمة (أ)	عوامل درجة الترجيح									قائمة (ب)
	أكثر أهمية من				متساوي	أقل أهمية من				
التأثير البصري (BV)	9	7	5	3	1	3	5	7	9	التفاصيل (BD)
التأثير البصري (BV)	9	7	5	3	1	3	5	7	9	التكامل مع البيئة (BI)
التأثير البصري (BV)	9	7	5	3	1	3	5	7	9	الخلود (BT)
التفاصيل (BD)	9	7	5	3	1	3	5	7	9	التكامل مع البيئة (BI)
التفاصيل (BD)	9	7	5	3	1	3	5	7	9	الخلود (BT)
التكامل مع البيئة (BI)	9	7	5	3	1	3	5	7	9	الخلود (BT)

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ماجستير الإدارة الهندسية

- الابتكار التكنولوجي: استخدام أحدث تقنيات وتقنيات البناء لتحسين الكفاءة والأداء.
- إعادة الاستخدام التكيفي: العملية الإبداعية لإيجاد استخدامات جديدة ومبتكرة للمواد أو المباني الموجودة مسبقاً.
- الحلول المستدامة: أساليب مبتكرة لتحقيق الاستدامة مع التركيز على الحفاظ على الطاقة والموارد المتجددة والتأثير البيئي المنخفض.
- الجدة المكانية: التحقيق في الأشكال والترتيبات الجديدة للمساحة التي تتعارض مع الأعراف المعمارية المعمول بها

	عوامل المعايير الفرعية للابتكار									
قائمة (أ)	عوامل درجة الترجيح									قائمة (ب)
	أكثر أهمية من				متساوي	أقل أهمية من				
الابتكار التكنولوجي (IT)	9	7	5	3	1	3	5	7	9	إعادة الاستخدام التكيفي (IA)
الابتكار التكنولوجي (IT)	9	7	5	3	1	3	5	7	9	الحلول المستدامة (IS)
الابتكار التكنولوجي (IT)	9	7	5	3	1	3	5	7	9	الجدة المكانية (IN)
إعادة الاستخدام التكيفي (IA)	9	7	5	3	1	3	5	7	9	الحلول المستدامة (IS)
إعادة الاستخدام التكيفي (IA)	9	7	5	3	1	3	5	7	9	الجدة المكانية (IN)
الحلول المستدامة (IS)	9	7	5	3	1	3	5	7	9	الجدة المكانية (IN)

جامعة النجاح
كلية الدراسات العليا
ماجستير الإدارة الهندسية

- الانسجام المكاني: الانتقال السلس والعلاقة المعقولة بين الأماكن المختلفة التي تشجع على سهولة الاستخدام والتنقل.
- التوازن النسبي: هو عملية إنشاء تركيبة بصرية متوازنة في التصميم من خلال الاهتمام بالمقاييس والنسب.
- تماسك المواد: هو نتيجة الاختيار الدقيق للمواد المبهجة والجمع بينها.
- التزامن البيئي: التصميم الذي يحقق تفاعلًا متناغمًا مع البيئة الطبيعية، ويشمل عناصر مثل الضوء والرياح وتكامل المناظر الطبيعية.

	عوامل المعايير الفرعية للتناغم									
قائمة (أ)	عوامل درجة الترجيح									قائمة (ب)
	أكثر أهمية من				متساوي	أقل أهمية من				
الإنسجام المكاني (HS)	9	7	5	3	1	3	5	7	9	التوازن النسبي (HP)
الإنسجام المكاني (HS)	9	7	5	3	1	3	5	7	9	تماسك المواد (HM)
الإنسجام المكاني (HS)	9	7	5	3	1	3	5	7	9	التزامن البيئي (HE)
التوازن النسبي (HP)	9	7	5	3	1	3	5	7	9	تماسك المواد (HM)
التوازن النسبي (HP)	9	7	5	3	1	3	5	7	9	التزامن البيئي (HE)
تماسك المواد (HM)	9	7	5	3	1	3	5	7	9	التزامن البيئي (HE)

Appendix C

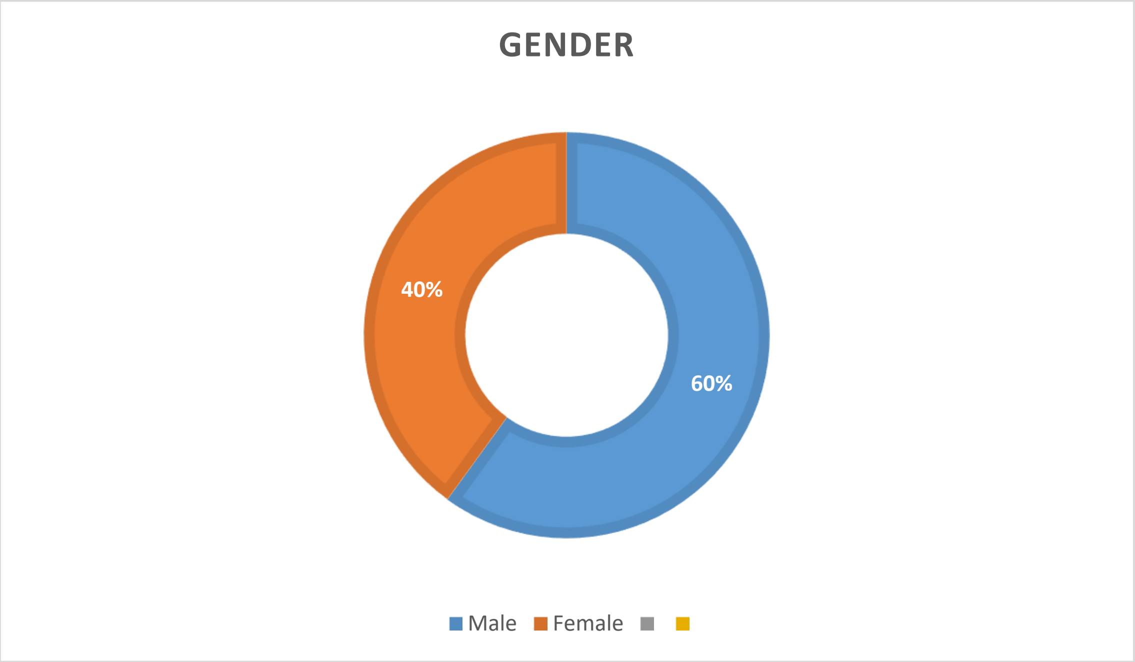
Data of the experts who participated in the study

The professional field data of the 30 experts who participated in the study

Expert	Professional field
1	- Architectural Engineer
2	- Architectural Engineer - Masters in architectural design theories
3	- Architectural Engineer - Contemporary issues in design
4	- Architectural Engineer
5	- Architectural Engineer
6	- Architectural Engineer
7	- Architectural Engineer
8	- Architectural Engineer - Building security and safety measures
9	- Architectural Engineer
10	- Architectural Engineer
11	- Architectural Engineer - Specialized in green buildings
12	- Architectural Engineer
13	- Architectural Engineer
14	- Architectural Engineer
15	- Architectural Engineer
16	- Architectural Engineer
17	- Architectural Engineer - Masters in urban planning
18	- Architectural Engineer
19	- Architectural Engineer
20	- Architectural Engineer
21	- Architectural Engineer
22	- Architectural Engineer - Masters in urban planning
23	- Architectural Engineer
24	- Architectural Engineer
25	- Architectural Engineer
26	- Architectural Engineer - Green architecture
27	- Architectural Engineer
28	- Architectural Engineer
29	- Architectural Engineer
30	- Architectural Engineer - Masters in architectural design theories

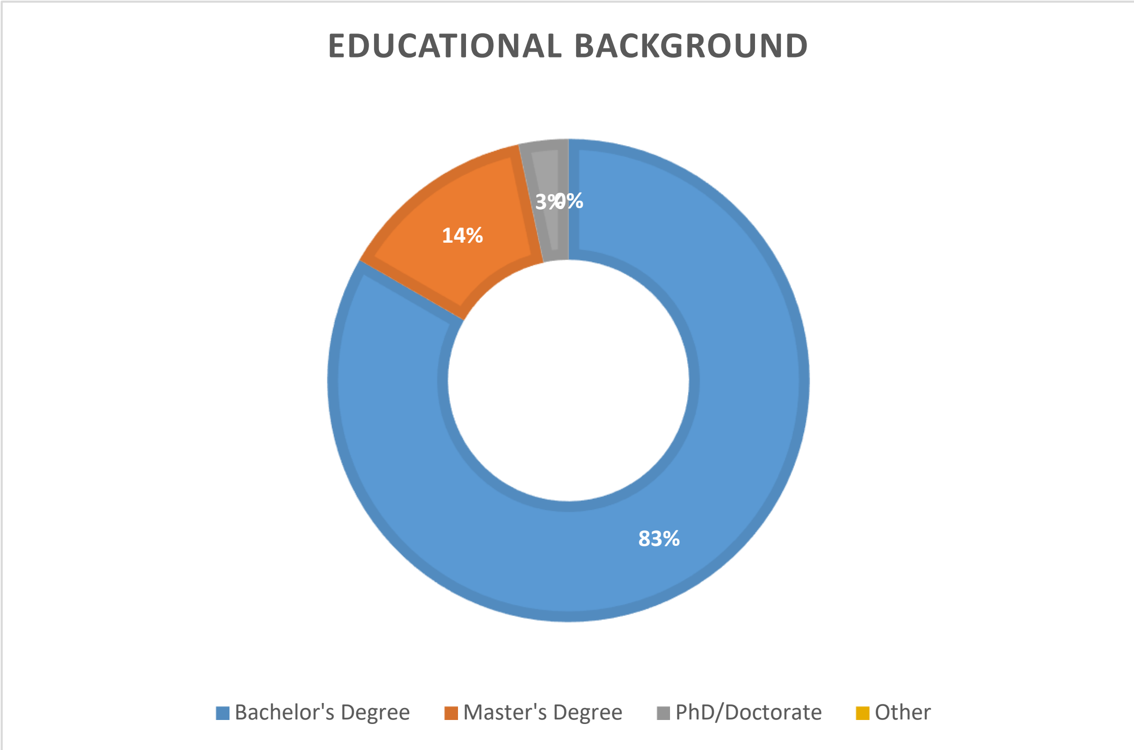
Appendix D

The gender data of the 30 experts who participated in the study



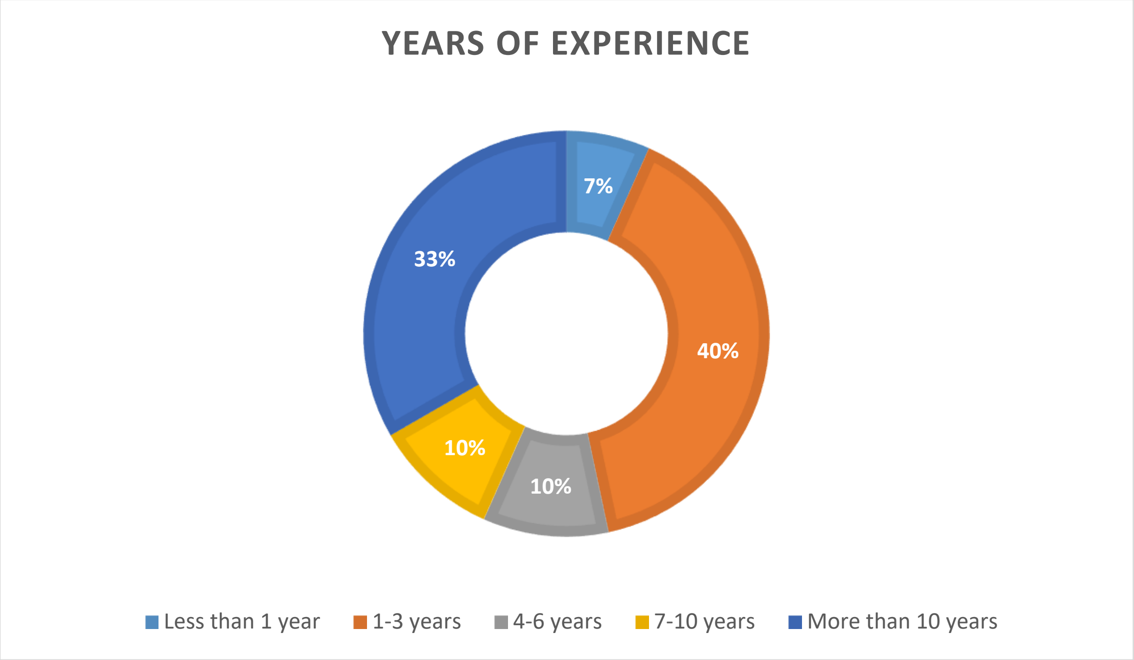
Appendix E

The educational background data of the 30 experts who participated in the study



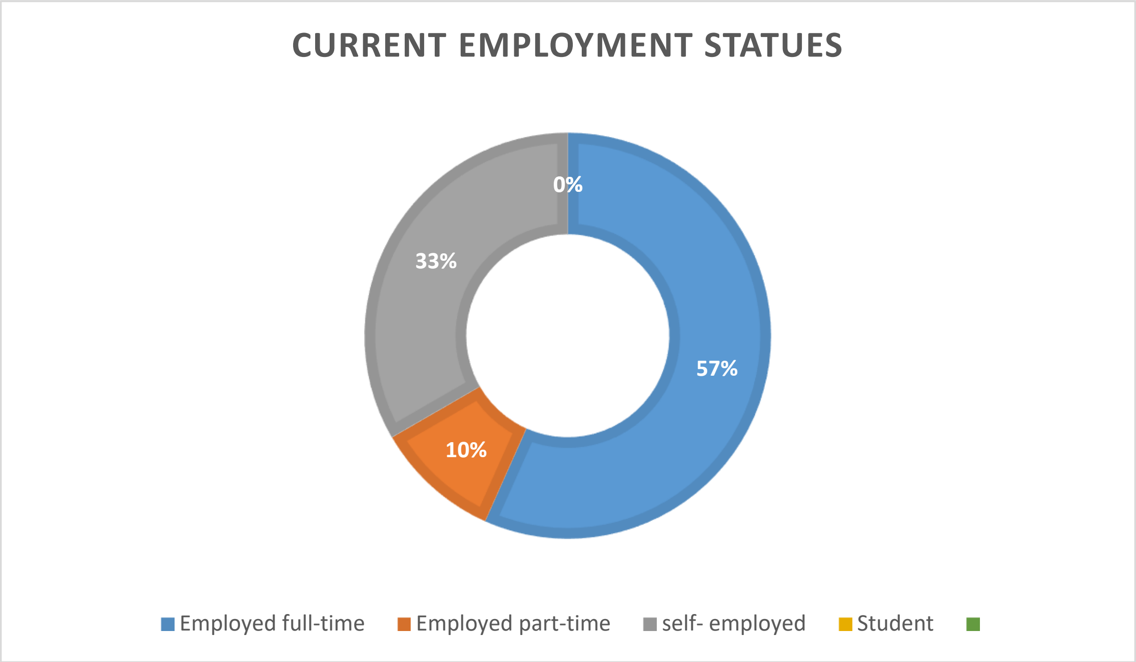
Appendix F

The years of experience of the 30 experts who participated in the study



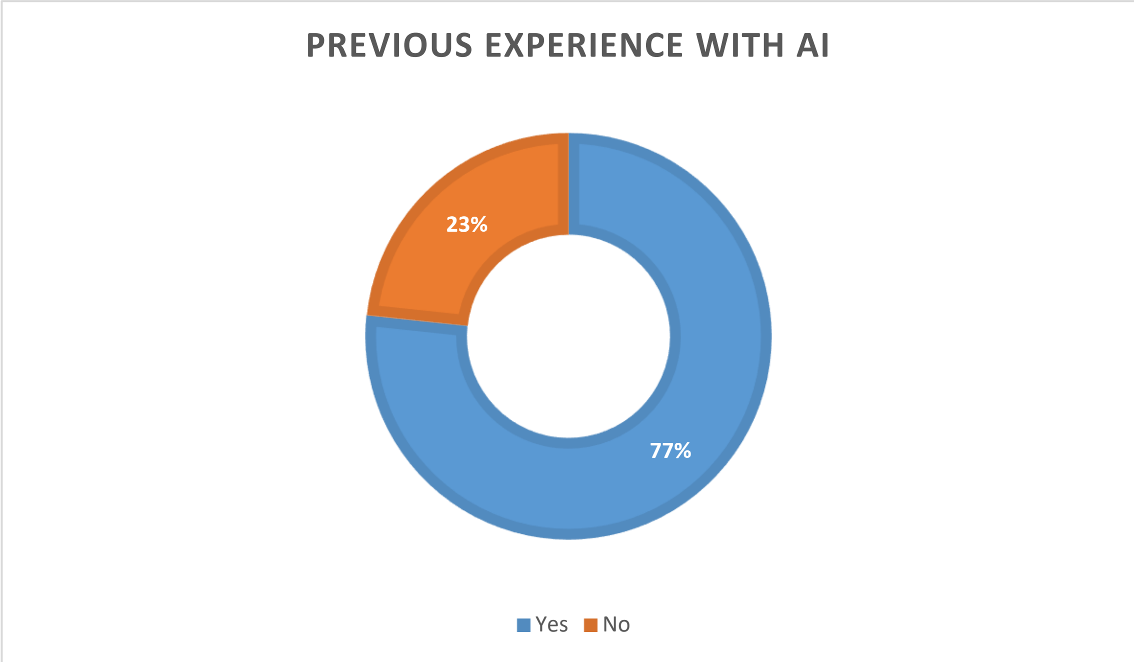
Appendix G

The current employment statues of the 30 experts who participated in the study



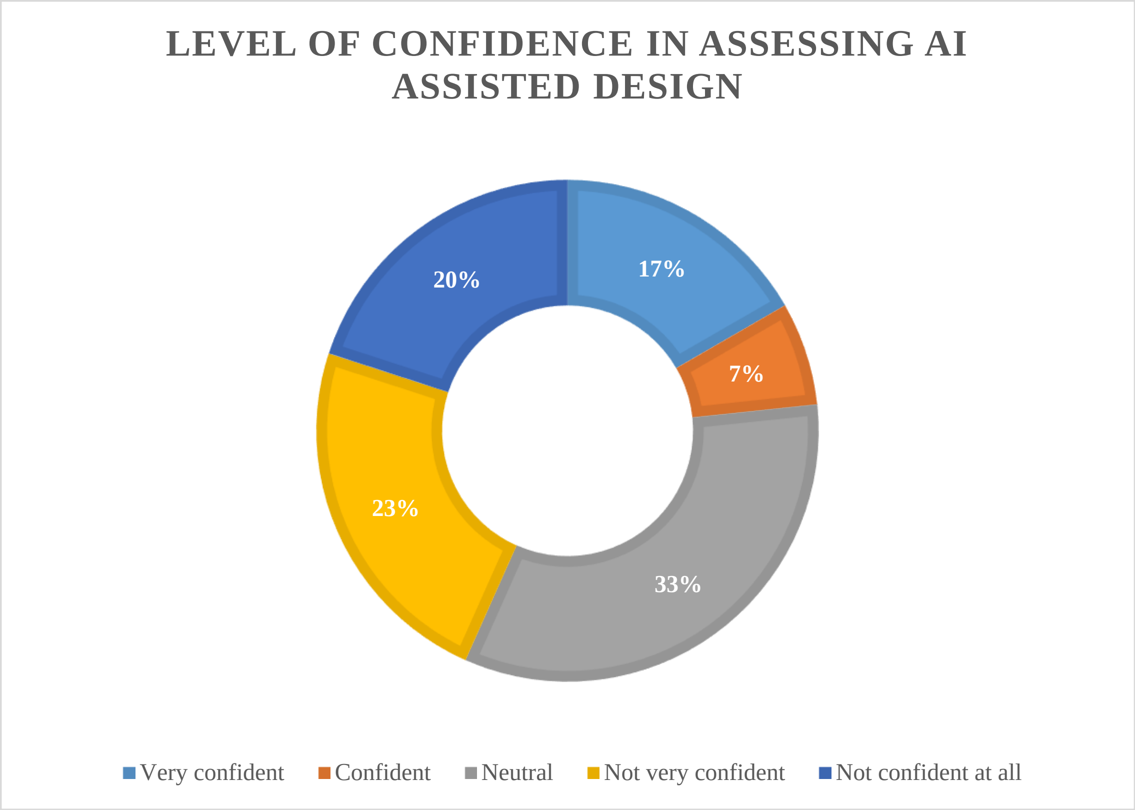
Appendix H

The previous experience with AI of the 30 experts who participated in the study



Appendix I

The level of confidence in assessing AI assisted design of the 30 experts who participated in the study



جـامعـــة النجاح الوطنية

كليـــة الدراســـات العليـــا

معايير قائمة على عملية التسلسل الهرمي التحليلي لتقييم التصميمات المدعومة بالذكاء الاصطناعي كما يراها المصممون

إعداد

أسيل عارف وجيه كايد

إشراف

د. معاوية رمضان

د. يحيى صلاحات

قدمت هذه الرسالة استكمالا لمتطلبات الحصول على درجة الماجستير في الإدارة الهندسية، من كلية الدراسات العليا، في جامعة النجاح الوطنية، نابلس– فلسطين.

2025

معايير قائمة على عملية التسلسل الهرمي التحليلي لتقييم التصميمات المدعومة بالذكاء الاصطناعي كما يراها المصممون

اعداد

أسيل عارف كايد

إشراف

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الملخص

تقدم هذه الأطروحة تطوير إطار عمل لعملية التسلسل الهرمي التحليلي (AHP) لتقييم التصاميم المعمارية بمساعدة الذكاء الاصطناعي. الهدف الرئيسي هو بناء مقياس أولوية يعكس تقييم الخبراء للأهمية النسبية لعناصر التصميم المختلفة. ولتحقيق هذه الغاية، وبعد دراسة منهجية مستفيضة، وُجد أن أربعة معايير رئيسية – الأصالة، والجمال، والإبداع، والتناغم – حاسمة في تقييم التصاميم المعمارية. وقد استُخلصت معايير فرعية من كل معيار من هذه المعايير الرئيسية لتقديم تقييم أكثر تفصيلاً.

وُجه استبيان من جزأين إلى لجنة من المتخصصين في مجالات الهندسة المعمارية والذكاء الاصطناعي بهدف إثراء الإطار المقترح. وفي القسم الثاني، تم تقييم المعايير والمعايير الفرعية المحددة.

تُظهر نتائج AHP أن الإبداع بنسبة (35.5%) هو العامل الأكثر تأثيرًا في تقييم التصاميم بمساعدة الذكاء الاصطناعي. الأصالة بنسبة (21.5%) والتناغم بنسبة (24%) هما المعياران التاليان الأكثر أهمية على التوالي. وجد أن الجمال له وزن (19%). تم العثور على أهم معيار فرعي للأصالة بأوزانها على أنه اتساق التصميم (36.1%)، مع سلامة المواد (20.4%)، والتعبير الأصيل (22.7%)، والسياق التاريخي (20.8%). أهم عوامل الترتيب للجمال هي التكامل مع البيئة (43.7%)، والتأثير البصري (22.1%)، والخلود (20%)، والتفاصيل (14.2%). برزت الحلول المستدامة (36.1%) كأعلى عنصر تصنيفًا للإبداع، مع الابتكار التقني (23.1%) وإعادة الاستخدام التكيفي (23.9%) التي لها أيضًا تأثيرات كبيرة. يُحدث

التجديد المكاني تأثيرًا أقل، ولكنه لا يزال ذا أهمية (16.9%). ويُعدّ تماسك المواد (28.3%)، والتناغم المكاني (21.2%)، والتوازن النسبي (16.3%)، والتزامن البيئي (34.2%)، المكونات الرئيسية للتناغم.

يُسهم هذا البحث بشكل رئيسي في تمكين الباحثين والمهندسين المعماريين وأصحاب المصلحة من تقييم التصاميم المعمارية المُنتجة باستخدام الذكاء الاصطناعي كميًا، وذلك من خلال منهجية تقييم مبتكرة قائمة على تحليل الأداء المعماري (AHP). يُسهم هذا الإطار في الحوار الدائر حول دمج الذكاء الاصطناعي في مجال الهندسة المعمارية، من خلال إعطاء الأولوية لعناصر التصميم المهمة وتوفير منهجية منهجية للتقييمات القادمة. ويُتيح النهج المنهجي للإطار إجراء تقييم شامل لجودة التصميم.

الكلمات المفتاحية: عملية التسلسل الهرمي التحليلي، الذكاء الاصطناعي، التصميمات بمساعدة الذكاء الاصطناعي.