“Greening” Architecture Design Education:

A Proposed Framework for Saudi Arabia

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ABSTRACT

Today, concerns for environmental quality affect nearly all walks of life. In response to demands for resource conservation, architecture has become more complicated because the design process now depends on a large number of different disciplines. Now more than ever, building owners and users have many requirements—informed by developments in knowledge, technology, and science. These stakeholders are asking architects to design for lower operational cost, good daylighting and views, and higher indoor environmental quality (IEQ). Integrating all of these issues in building design is a dynamic process, which looks holistically at all of the dimensions of architectural. Present barriers of integrating green and sustainable strategies in the design process are mostly associated with architect's education and the understanding of the fundamental knowledge of the dynamics between the building and the local environmental conditions. For example, Saudi Arabia faces many challenges related to creating more environmentally responsive buildings, and peoples' behavior may not be easily changed with regard to resource conservation. To achieve such changes, a new educational framework for architecture is needed.

This study captures and structures knowledge that informed the examination and development of the new knowledge-based educational framework for green building design in Saudi Arabia. Through literature review, a series of case studies, and interviews with professors from United States architecture schools and interviews with graduates from Saudi Arabian architecture schools, the study revealed how knowledge related to green building can be structured and strategically implemented into architectural design education in Saudi Arabia. This framework presents green knowledge in a logical, sequential structure representing a learning path/knowledge map. The knowledge map was not intended to present a sequential structure over the course of several years, but is more general so that it can be applied across all architecture schools in Saudi Arabia. In other words, the knowledge map may be applied as-is within the current architectural educational knowledge in Saudi Arabia schools, or it can be used as a guideline and assistance tool for educators and school administrators. Overall, this framework presents a workable model for green design education in the context of the existing Saudi Arabia educational practices. Thus, the goal of the final knowledge framework is to transform the architectural educational system in Saudi Arabia.

Dedication

To my Mother, her praying, encouragement, and constant love have sustained me throughout my life…

To my wife, Ebteesam Aljadai, for her understanding, patience, and care…

To my sons, Riyadh and Turki, to my daughters, Teaf, Ruba, Jana, and Mays…

You all are the best supporting team ever…

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1. INTRODUCTION

Today, concerns for environmental quality affect nearly all walks of life. As a result, environmentally responsive architectural design has become commonplace in many countries. Saudi Arabia faces many challenges related to creating a more environmentally responsive infrastructure and architecture, as peoples' behavior may not easily change with regard to resource conservation as it has been said that for oil-rich countries oil is "cheaper than water". To achieve changes it is necessary to increase awareness for the contribution of buildings to national resource consumption.

1.1 Evolving Role of Architecture

Architecture creates the framework around our lives, it protects us from the external environment and it gives us a place to relax, to live and to work. However, architecture today can be very complicated, because of the still growing complexity that characterizes our time and our society. At present, the design process depends more than ever on a large number of different disciplines. Also, developments in knowledge, technology, and science are incorporated with art and materials to make architecture more complex. Today, owners and users have different requirements than before. They are asking architects to design for lower operational cost, good daylighting and views, and higher indoor air quality (IAQ).

For more recent concerns, buildings are a significant part of resource conservation efforts and have an impact on resource consumption. Buildings are responsible for approximately 40% of the total world annual energy consumption (Yeang and Spector 2011, Gascoigne 2001). In United States, buildings are responsible for 76 percent of the electricity and 48 percent of energy consumption (AIA 2013). At the same time, the building and construction sectors take the largest share of natural resources, both for land use and for materials extraction. Buildings use 50 percent of the world's raw materials-many of which are nonrenewable resources-and they are responsible for 36 percent of all waste generated worldwide (Graham 2002).

As a result of this growing concern for resource conservation architects are being asked to design for performance mandates such as Building Research Establishment's Environmental Assessment Method (BREEAM), and the U.S. Green Building Council

(USGBC) Leadership in Energy and Environmental Design (LEED). These mandates address energy consumption, water conservation, daylighting, and high indoor air quality.

As a result, new knowledge-bases are needed for architects that merge quality of place with environmentally responsive strategies including ‘green’ architecture. It could be argued that if buildings are being designed differently, then the education of the architect should evolve.

For this, the education of architects must involve new knowledge-bases related to resource conservation. Thus, the role of higher education would be to develop and share of these new knowledge-bases.

This is particularly important in countries such as Saudi Arabia (SA) where resource conservation has not been an issue to architects. As a result, there is a need to redefine the architectural education model in this country. From a more general position of design, education to more specific concerns about how we educate architects in response to these evolving issues a new education model is needed.

1.2 Roles for Architecture

Architecture has influenced our lives for thousands of years and continues to do so today. Until about the last hundred years, due to the use of mechanical heating and cooling systems, architecture was often well adapted to the local climate and the land. Today, architecture is a complex discipline that incorporates a variety of knowledge domains, including design, building construction, mechanical systems, and social sciences. Architecture cannot be a mere form, or perhaps something which is made “to impress the populace” as Rapoport said (Norberg-Schulz 1980a). Architecture today requires different solutions in order to satisfy man’s physical and psychological needs. Architecture should be about designing a good place as a primary objective and resource reservation can contribute to this objective.

One of the basic questions concerning architecture is how to live in a certain place and feel that it is a good place to be. Today this question is seldom asked because we use mechanical systems for comfort control. As stated by Christian Norberq-Schulz this “cuts us away from a natural, elemental feeling of belonging to a place. We just close ourselves within walls, put on a machine, and have the right temperature” (1979b). Designing the place as “a bunker, is aesthetically and physiologically a disaster” (Yeang and Spector

2011) (p.69). Therefore, losing all contact with the outside, making us very dependent on energy supply, and ignoring the natural light and view will lead to a loss of psychological comfort, health, and well-being.

The trend of modern architecture leads to loss of the place rather than maintaining it or developing it. According to Norberg-Schulz (1980a), this has two causes, and both imply a misunderstanding of the concept of place. They relate to the dimensions of "space" and "character". Modern architecture should give buildings and place individuality, with regard to space and character. This can be achieved by taking "the circumstantial conditions of locality and building task into consideration, rather than basing the design upon general types and principles". (Norberg-Schulz 1980a) (p. 195)

Louis Kahn, through his work during the 1950s and 60s, was something of a revelation at a moment of unrest when many architects were losing their faith in architecture as a positive framework for living. Through his projects he proposes solutions in terms of space and character where he poses the question: "what does the building want to be?": "Suddenly everything is there again: open and close space, clusters and groups, symmetry and asymmetry, node and path; and above all: the wall as a "threshold" between interior and exterior." (Norberg-Schulz 1980a), (p. 197) In the walls of Kahn's works, past and present are united, and thus he said: "I thought of wrapping ruins around buildings". His walls are designed to receive light, "the giver of all presences."(p. 197) or as Frank Lloyd Wright said "The reality of the building does not consist in the four walls and the roof but in the space within to be lived in." (Kaufmann 1955) (p. 80). Wright considered space as the core of life and form of architecture; it is a useful volume for building. He views interior space as flowing into exterior space.

The 'spirit' of buildings has influence on people's comfort as well. Architects design buildings primarily with regard to the images and emotions of the people who live in them, more than the satisfaction of mere physical need.

Pallasmaa et al. (2005) indicated the following types of experience that could well be among primary feeling or emotions produced by architecture:

- The house as a sign of culture in the landscape; the house as a projection of man and a point of reference in the landscape;

- Approaching the building, recognizing a human habitation or a given institution in the form of a house;
- Entrance into the building's sphere of influence, stepping into its territory, being near the building;
- Having a roof over your head, being sheltered and shaded;
- Stepping into the house, entering through the door, crossing the boundary between exterior and interior;
- Coming home or stepping inside the house for a specific purpose, expectation and fulfillment, sense of strangeness and familiarity;
- Being in the room, a sense of security, a sense of togetherness or isolation;
- Being in the sphere of influence of the foci that bring the building together, such as the table, bed or fireplace;
- Encountering the light or darkness that dominates the space, the space of light;
- Looking out the window, the link with the landscape. (p. 94)

Furthermore, a building should produce a sense of loneliness and silence regardless of the actual number of people present or the surrounding noise (Pallasmaa et al. 2005). Consequently, people can experience the sense of being in a unique place.

On the other hand, architecture has a direct role to the immediate city and ecosystem. Graham (2002) says that every architectural artifact connects to the earth, depends on nature for resources, causes environmental change, and affects both human and nonhuman life (Attmann 2009). Here, architecture becomes a part of the problem and should contribute to a solution. By designing buildings based on green principles, this will reduce consumption of natural resources.

Whether designing in Saudi Arabia or in any of the world's developed countries, the main responsibility of the architect is to design good places that are environmentally responsive. As a result, there is a need for new knowledge domains and ways of designing. In order to fully achieve this, architectural design should avoid approaches that concentrated only on energy efficiency in buildings, while pushing for a new green approach. This approach should include a certain level of improvement in energy efficiency and resource conservation, incorporate renewable energy systems, site design, provide rules for indoor environmental quality and indicate levels of resource conservation and recycling that support sense of place.

Architects can help toward resource conservation if they consider the interrelationships between building site, design elements, building systems and function, while following green principles.

Some architects suggest that Europian buildings are more expressive of an attitude for resources conservation than in the United State, partly driven by Europe's higher energy cost. However, recently there has been a shift in the United States toward a more responsive attitude for resource conservation.

When compared to that of Europe and the United States, in Saudi Arabia in 2010 electrical energy consumption in the residential sector was 51% percent of the total energy consumption (Saudi Electricity Company 2010), approximately equal to the sum of all the other sectors. In the United States, on the other hand, the residential sector accounted for about 22.5% of primary energy consumption in 2010 (Energy 2012).

Currently, resource conservation is typically not a concern for architectural design in Saudi Arabia. This is mainly due to several factors such as the availability of oil, governmental subsidies for oil production and electricity generation, the relative low cost of oil, and absence of similar subsidies for renewable energy programs (Said, El-Amin, and Al-Shehri 2004, Alawaji 2001). This is reflected in comparative energy cost where Saudi Arabia is at $0.032/kwh, California at $0.1/kwh and $0.078/kwh for Texas (Aljarboua 2009). Adopting green design principles might help Saudi Arabia prepare for a post-oil era.

Recently, Saudi Arabia seeks to reduce dependence on fossil fuels by developing a roadmap for a renewable energy program. In this roadmap, there is a goal to install 23.9 gig-watts (GW) of renewable power capacity by 2020 and 54.1 GW by 2032, which would make Saudi Arabia one of the world's leading producers of renewable electricity (McDowall 2013). Currently, green building policies that encourage energy conservation are still fairly new to the region; however, the Saudi Green Building Council (SGBC), formed in 2009, is working on its own version of LEED (SGBC 2012). This is intended to limit the level of environmental impact, and use green building guidelines for major developments that will eventually be used in the private buildings sector. The architectural educational system should support this initiative.

1.3 Architecture as a Catalyst for Change

Architecture can be a catalyst for change in at least two ways, direct impacts and indirect impacts. With direct impacts, architects can reduce resource consumption, and environmental impact, by designing buildings for low energy use, water conservation, and fewer or reduced materials. The indirect impacts can be achieved by promoting heightened awareness for resource consumption by the building demonstrating a response to environment factors.

1.3.1 Direct impact

Rising global energy demands, increasing fuel costs and scarcity for natural resources have elevated concerns for resource conservation in buildings. Buildings have a major impact on resource consumption. 40% of the total annual energy consumption is building related (Abdeen Mustafa 2008, Attmann 2009), 17% of the total water consumption (Roodman and Lenssen 1995), 50% of the world's materials, and buildings are responsible for 36% of all waste generated worldwide (Graham 2002).

Typically half of the energy in buildings is for heating, cooling, ventilation, and lighting where often, natural systems can be used to meet these needs. This can reduce the environmental impact of new buildings while lowering costs. Therefore, it become important to design and construct buildings responsibly, for the benefit of both the occupants and the greater good of society. The reduction of natural resource consumption should be a goal from the start, specifically at the early design stages.

Roodman and Lenssen (1995) note three ways to make good buildings: exploit natural forces like the sun and wind for heating and cooling, select efficient appliances and climate-control systems, and use good construction materials. They suggest, positioning windows to capture the sun’s energy in winter, along with insulation and airtight construction can cut heating needs by more than 97%. Similar techniques can eliminate air conditioners in hot climates. Simply planting trees near buildings can cut cooling needs up to 30%.

Buildings should provide protective environments where the occupants feel safe and secure against the various natural elements. Buildings should provide health and habitable environments for people, and be designed to maximize productivity by minimizing operator fatigue and discomfort, and should be free from physical and psychological effects of buildings such as sick building syndrome (Attmann 2009). The architect's role is not only to promote resources conservation, lower operating cost, and improve indoor environmental quality but to do this while making good places.

Buildings have a major impact on the global environment. The most significant impact is CO2 emissions due to their use of electricity. One-third of worldwide greenhouse gas emissions (GHG) are buildings related, which will likely continue to increase as construction increases. In the United States, electricity consumption in the commercial building sector doubled between 1980 and 2000, and is expected to increase another 50% by 2025 (Torcellini et al. 2006). Also, the Organization for Economic Co-operation and Development (OECD 2003) indicates that energy consumption associated with the building sector in OECD countries has continually increased since the 1960s and is expected to continue to do so in the coming years, which is primarily due to the construction booms in Asia, the Middle East, and Latin America (Attmann 2009). Roodman and Lenssen (1995) said "It is important that innovations like these spread rapidly, because the environmental problems generated by buildings are getting worse worldwide".

It is argued that as a consequence of increasing greenhouse gas emissions (GHG), global warming is increasing and has become one of the biggest challenges of our time.

The concern for environmental impact suggests the need for improvements in building performance. Hawkes suggests that a conventional building of the 1990s, built to satisfy building regulations at that time, will consume only 50% of the energy when compared to a similar building from the 1970s. Hawkes goes on to suggest that a further 50% reduction in building energy use is possible through environmentally responsive strategies (Hawkes 2001).

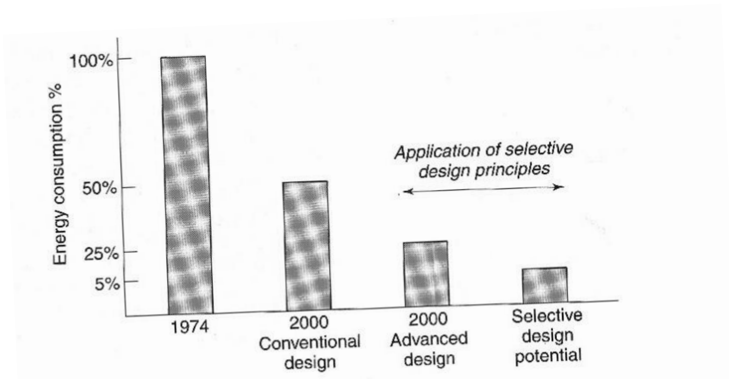

Figure 1-1 Energy consumption trends in non-domestic architecture (Hawkes 2001).

1.3.2 Indirect impact

Architecture can contribute to an increased awareness of resource waste and the need for conservation. Buildings can express the client's and architect's attitude toward resource conservation. Ken Yeang states that, "Architects have a tendency to over value the appearance of buildings, but as you walk through a public space your sphere of awareness is actually limited to a few meters in height. Anything further up you see only as a blur" (Yeang and Spector 2011) (p.51). However, some recently constructed buildings demonstrate green design principles and became iconic, from both exterior and interior.

Ken Yeang's building can be seen as an approach to heighten awareness and teach people about resource consumption. His buildings speak to us about resource conservation. For example, the Solaris building in Singapore is considered one of Yeang's greenest buildings. In this project, he demonstrated his approach to ecological design by highlighting ecological features using a 0.93 mile-long linear park as a design idea that started from the basement-level and wrapped itself vertically around the building. The vertical park achieves energy load reduced through a number of features such as shading, and insulating the building while providing a social amenity. Energy load further decreased through the employment of an innovative "light shaft" within the building, that brings daylight deep into the building through an angled shaft (Hart 2011). Anyone who walks through the building feels the natural light filtered through the shade: showing how design such as this can utilize natural resources and while providing a social amenity. Through architecture such Ken Yeang's, we become more aware of our role as energy consumers. Therefore, as a framework around our lives, architecture becomes a means for buildings to show a desirable response to the environment.

Thom Mayne, the designer of San Francisco Federal Building says:

"When architecture engages social, cultural, political and ethical currents, it has the potential to transform the way we see the world and our place in it. It is from this intersection of broad societal currents that we approached the design for the new Federal Building in San Francisco. Our primary interest was to produce a performance-driven building that would fundamentally transform its urban surroundings, the nature of the workplace and the experience of the people who use it while making intelligent use of natural resources. For me this project represents the epitome of an optimistic architecture; an architecture that synthesizes its complex forces and realities into a coherent whole" (Morqhosis 2007)

The San Francisco Federal Building was designed as a LEED building that minimizes energy use, responds to the climatic conditions of its site, and meets the operational needs of its owner. However, more importantly it physically democratizes the workplace as it enhances health and comfort, and empowers its users with a sense of control over their surroundings (Morphopedia 2009). Most office spaces don't give you the choice to dim your lights or control your ventilation as this building. Mayne placed staff along the perimeter of the building and managers to the interior. He says this will increase interaction between management and staff and promotes engagement between colleagues (Ziger/Snead 2008).

Architecture has the power to inspire us; to make us feel good about our life, and more importantly, well-designed buildings can reflect on our social values. The education of the architect should support this view.

1.4 Architecture is evolving in response to these catalytic opportunities

Some buildings over the last 30 years have demonstrated the catalyst for change previously mentioned. The practice of architecture is evolving in response to these catalytic opportunities. For example, now energy modeling, life cycle cost assessment and other types of analysis are often included in the design process.

As part of these changes and integrated design practice, other professionals such as HVAC systems consultants, lighting designers, daylighting and acoustic experts are now involved in the design process.

Moreover, we see the consideration of environmental factors; climate analysis, site analysis, sun and solar analysis, and daylighting analysis are often part of the design process. With these new design procedures the architects can reduce the building's energy consumption with passive strategies using the available climatic data (Yeang and Spector 2011). In office buildings for example, strategies such as these will allow for natural airflow for cooling and ventilation and include natural daylight.

Today, new technologies and advanced building systems such as: Heating, Ventilation, and Air-Conditioning (HVAC) systems, double skin facades, and new materials have all had an impact on building performance and should be involved in the design process. These new technologies should support better living and working conditions for building occupants. As said by Robert Tango (2009), "we don't feel like we are walking into a machine, but into a well-designed space appealing to all of our human senses".

On the other hand, HVAC systems are responsible for maintaining comfort conditions in most buildings. These systems along with lighting consume a large percentage of energy in buildings, which makes them significant when reducing environmental impact is a goal. Also, good indoor air quality often depends on the ventilation these systems provide. Paul Scheckel (2005) says in his article in *'BuildingGreen.com'* "the first place to look to minimize the impact of a mechanical system isn't the equipment, however; it's the building's design and construction". So, in the design process we should use appropriate levels of insulation to minimize the need for supplemental air conditioning.

Finally, many building energy simulation programs are reaching maturity since their origination in the 1960s (Crawley et al. 1998). Simulation tools will continue to evolve for two major objectives: "firstly to make simulation tools more accessible to the architectural profession to support the open-ended nature of design inquiry and secondly, to enable effective 'real-time' sharing of design information between the entire team through a web-based infrastructure" (Yeang and Spector 2011) (p.88). Decisions made in the early stages of design often have a significant impact on energy efficiency and the quality of the internal environment of the building. New tools such as these will support the integration of green design principles including health, comfort and productive habitats for human activities while minimizing resource utilization and waste generation (Yeang and Spector 2011).

1.5 Green Architecture

During the last 30-40 years, the practice of architecture has undergone many changes, including performance, integrated design practice, inclusion of environmental factors, new buildings systems and new simulation tools. This suggests the need for new knowledge bases that allow the architect to better respond to these changes.

"Green architecture" was founded and established after the World Commission on Environment and Development's report (1987), which defined the term "sustainability", and injected concerns for environment into architectural discourse.

Spector (2011):

> *"In an analogy of architectural design process, we have now completed the "conceptual stage" in designing for our sustainable future, and next we have to delve deeply and quickly into the "design development stage" of green design and clean green technologies." (p. 6)*

Green design is an approach that produces buildings that are environmentally responsible and resource-efficient throughout its life-cycle. The objectives of this approach are to provide a good place for the occupants and resource conservation.

For architects, maybe the most difficult question is: how do we design buildings for a green future?

In regard to answering this question, Ken Yeang says:

> *"Many designers wrongly believe that if they stuff a building with enough ecogadgets such as solar collections, wind generators, photovoltaic and biodigestors then they will instantly have an ecological design. Of course, nothing could be further from the truth. While we should not deny the experimental usefulness of these technological systems and devices, which may eventually lead us to the ideal technological produce or infrastructure or plan, they are certainly not the be-all and end-all in ecodesign. Many of these are just empty attempts at an ecological architecture. There is a sanctimonious mythology around what is basically a collection of admirable engineering innovation."(Hart 2011)(p. 15)*

Therefore, Green design is much more than low-energy or reduced carbon emissions and water use. Green designs address a range of interrelated issues, including social, cultural, psychological and economic dimensions (Buchanan 2005), which are as important as the energy efficiency and low carbon emission. In the green design process, the architect should not be limited to certain aspects of knowledge such as implementing enough ecogadgets; they should have comprehensive knowledge to cover all aspects of architectural practice.

Somewhat unfortunately, many architects think that green design is about achieving the highest level of rating on a performance scale. Few deny the importance of rating systems such as BREEAM or LEED as useful references for buildings, but these rating systems are not comprehensive. They work as a partial checklist of the consideration in green design and as one of the proselytizing tools to a wider audience (Yeang and Spector 2011). None of these rating systems in themselves assures a good building.

New architecture practices can have a positive impact on the way buildings are designed, nonetheless, we should not let the environmental agenda become one that is limited to political, populist fads as Ken Yeang says (Hart 2011). Yeang says that “the objective of Eco-design is a benign and seamless bio-integration with the environment,” (Hart p. 15). Buildings should be well integrated with the biosphere not just minimize their impact on the biosphere. Buildings should lead to positive outcomes. This actually requires a discipline which includes matters such as microclimate, biodiversity, diet and social organization- in addition to topography, density, proximity, aesthetics and culture/political/ economic parameters (Hart 2011).

Buchanan (2005) in his book *‘Ten Shades Of Green’* refers to ten key issues that need to be considered when creating a fully green architecture: low energy/high performance, replenishable sources, recycling, embodied, long life, loose fit, total life cycle costing, place; access, health and happiness, and community and connection. This book refers to the built schemes, and to their various degrees of 'greenness'.

While Yeang suggests that architects don’t fully understand green design and most think that is about the use of photovoltaics, wind generations, compliance, etc. Yeang suggests that it is more than that; it is complex and not as easy as had been imagined. He suggests five strategies that can be adapted to get as close as possible to the goal of stasis with the natural environment (Yeang and Spector 2011):

1. To view green design in terms of the weaving of four strands of infrastructure: (green, gray, blue, and red), these color-coded systems, covering natural habitats, engineering, water management and human culture;
2. To regard green design as a seamless and benign environmental bio-integration of the artificial with the natural environment;
3. To regard green design as 'ecomimesis', imitating eco-systems' processes, structure, features and function;
4. Eco-design can be regarded as not only creating new artificial 'living' urban eco-systems or rehabilitating existing built environments and cities, but also restoring existent devastated eco-systems within the wider landscape of our designed system;
5. Eco-design is to regard our designed system in the context of the biosphere globally as a series of interdependent interactions environmental stasis and the repair of the environmental devastation by humans, natural disaster and the impact of our human built environment, activities, and industries (Yeang and Spector 2011).

Finally, in '*Ten Shades of Green'* by Buchanan and through Yeang's work, we find the criteria for design and the roots of green architecture. Therefore, architectural education must support these changes and new criteria for design. Thus, there is a need for an evolving architectural education model in support of these new knowledge-bases.

1.6 Evolution of Architectural Education

When proposing a new architectural education model one must first look back about a hundred years. At that time, the architect was seen as the master builder where he was both a designer and a builder. He often directed a work force numbering into the hundreds. A master builder was responsible for educating, guiding, and mentoring his fellow craftsmen. The education of architects was through an apprentice relationship while working toward a Master Builder status.

1.6.1 Bauhaus Model

During an international exhibition held in Weimar in 1923, the Bauhaus coined the slogan "Art and Technology: A New Unity" (Emanuel et al. 1980). This was a turning point in educational strategy through recognition of the role and importance of technology as a new area that should be considered to be in architecture design curriculum. Also, this was the theoretical model in which the Bauhaus movement was grounded. The distinction between ‘artistic instruction’ (*Formlehre)* and ‘practical instruction’ (*Werklehre)* in the curriculum is the most visible embodiment of this model (Findeli 2001).

The Bauhaus exemplified a significant clearinghouse for constructivist[1] ideas in the western world. Also, the Bauhaus joined art, architecture, and design as part of an integrated program, a try to produce a *gesamtkunstwerk* or total-work-of-art involving the school‘s woodcarving, mural painting, furniture, and stained glass workshops. At the same time the Bauhaus grounded its teaching practices on a renewal guild system, in which students enrolled in the workshop of a master.

Today, as result of Bauhaus influence, we see an educational model, where art and craft are still rooted in design practice. The dynamics of this school produced a new philosophy and approach to design education, which has since influenced many programs in the United States and Europe.

1.6.2 Current Models

Some organizations began improving and organizing the profession of architecture practice and architecture education. In May 1919, during an American Institute of Architects (AIA) convention in Nashville, TN, 15 architects from 13 states came together to form an organization that would become the National Council of Architectural Registration Boards (NCARB). NCARB is a nonprofit corporation comprising the legally constituted architectural registration boards of the 50 states in the United States. Today, NCARB’s mission “is to work together as a council of member boards to safeguard the health, safety, and welfare of the public, and to assist member boards in carrying out their duties” (NCARB 2004a). One of its goals is to strive to improve the general educational standards of the architectural profession in its mission to promote excellence in architectural education, training, and practice in the United States, and provides funding for new curriculum initiatives that integrate practice and education. (NCARB 2004a).

[1] Constructivism an avant-garde movement initiated in the USSR in 1913, it lasted into the 1920s. The term, Constructivism, emerged in 1921(just before the movement‘s decline) from fervent debates on the purpose of art. The Constructivists rejected the idea of "art for art‘s sake" and were in favor of utilitarian designs intended for mass production. (Christina 1985)

In supporting of the environmental responsive design, in 1980s, Ecological Literacy in Architecture Education (ELAE) project was created by the Committee on the Environment (COTE) in the American Institute of Architects (AIA). The goal of this project was:(Gould 2006)

> *"To assess the state of ecological literacy and the teaching of sustainable design in architecture education as part of a proposal for a large-scale, long-term effort, led by the AIA COTE, to inject ecological literacy and sustainability principles into architecture education in the United States." (P.1)*

This project concerned largely with schools of architecture, as well as other places where students and practicing architects might learn about ecology and design.

In addition, new criteria of environmental responsive design are starting to emerge in European architectural schools. EDUCATE is a program funded by the European Commission, started in June 2009 and finished in May 2012. The mission of this program has been to "foster knowledge and skills in sustainable environmental design at all stages of architectural education, aiming to achieve comfort, delight, well-being and energy efficiency in new and existing buildings within a culturally, economically and socially viable design process" (EDUCATE 2009). The promotion of green principles in the design is a key-factor for addressing the challenges mankind faces in response to finite resource availability, environmental deterioration and climate change. Therefore, new criteria of environmental responsive design are needed to be implemented in Saudi Arabia architectural education systems today.

1.6.3 Saudi Arabia

Saudi Arabia's economy is petroleum-based; about 75% of incomes and 80-90% of export earnings come from the oil industry (Energy Information Administration 2001). This suggests an economic over dependence on oil. Therefore, there is a need for new strategies that can help overcome the post-oil economic challenges.

Today in S.A., most buildings use air conditioning, artificial lighting, and desalinated water. Electrical power and water supply are subject to subsidies and are therefore provided to householders at a low price. There is a growing concern that Saudi Arabia will not be able to continue to support these subsidies in the future, especially during the post-oil period.

1.7 Problem Statement

The purpose of this research is to develop a new knowledge-based educational framework for green building design in Saudi Arabia. The research will examine knowledge domains, knowledge structuring and sequencing, and learning theory. Saudi Arabian architectural education is in need of a new educational framework for environmental responsive design. This study seeks to reveal how knowledge related to green building can be structured and strategically implemented into architectural design education.

1.7.1 Research goals

- Reduce negative environmental impacts associated with buildings.
- Increase the awareness and perception of the importance of green architectural design among the public, architects, designers, and decision makers.
- Enhance the role of architecture in society as a proponent of resource conservation.
- Reduce the energy consumption associated with buildings.

1.7.2 Research objectives

- Identify the meaning of green architecture principles and the Saudi Arabia context through a review of the literature, and of case studies of western universities.
- Determine the AS-IS educational framework in western universities and identify the barriers to and constraints of incorporating green architecture principles into architectural education and practice.
- Determine the Saudi Arabia framework, including the historical, environmental, economic, social, and cultural dimensions.
- Interpret and adapt the Western knowledge to inform the Saudi Arabia educational framework.
- Develop a new framework for Saudi Arabian architectural education to give architects the required knowledge domains, knowledge structuring and sequencing, and learning path for environmentally friendly architecture.

- Develop a narrative study that describe how Western green knowledge can be systematically applied and understood in the architecture education in Saudi Arabia.

1.8 Research Method

Qualitative research has five approaches to inquiry: phenomenology, grounded theory, biography, case study, and ethnography (Creswell 2009). This research will use a grounded theory approach, which generates theory from the observation of data (Glaser and Strauss 1967). Three sources of data will be used to enable triangulation or cross-examination (Cheng 2005): literature review and its interpretation, case studies, and documents review. The case study approach will be a major source of knowledge for this research. Case studies can provide a basis for identifying, coding and categorizing knowledge domains for implementation of green architecture knowledge in the TO-BE model. This knowledge will influence the development of the proposed framework.

1.8.1 Data Collection Methods

The process of developing the proposed framework will occur in four main phases. Figure 1-2 maps the research method: knowledge input, interpretation and organization, knowledge shearing, adapting the knowledge to the Saudi Arabian context and developing the new TO-BE framework, and narrative the merger of the AS-IS model into the TO-BE model in practice.

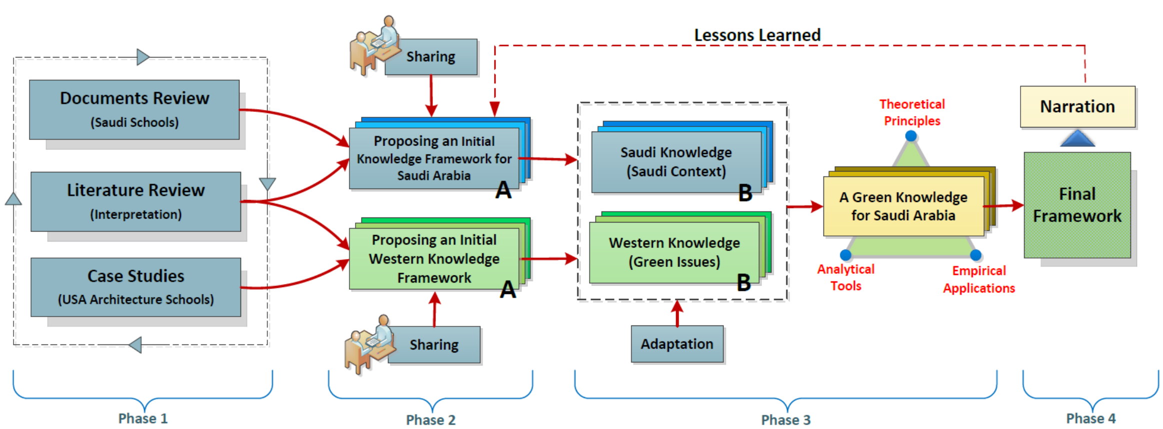

Figure 1-2 Research Methods Map

1.8.1.1 *Literature Review and Interpretation*

The review of literature can serve one or both of the following roles in the research. First, a literature review can establish the current state of knowledge in the research area, which can lead to the development of the research question. Second, the literature review can be integrative, where collection and interpretation of selected key pieces of literature become sources of data to be applied to the research question. For this research, the literature will serve both roles. For the integrative literature review, publications related to green building design will help identify and categorize relevant knowledge domains that will be applied to the Saudi Arabia model. This document dedicates Chapter 2 to a review of the more general related literature, chapter 4, and chapter 5 to an interpretation of the literature that is more related to the objectives of the research. It is hoped that the interpretation will inform the final Saudi Arabia framework.

1.8.1.2 *Case Studies—Current Models / Criteria for Green Building Design*

The current models for green architecture education and the knowledge-bases for green building design will be introduced by performing case studies of the existing architectural programs in the United States, such as in the University of Oregon and the University of Arizona. These programs will be studied to understand the knowledge components that focus on green architecture issues.

1.8.1.3 *Documents Review: Saudi Arabian Context (TO-BE Framework)*

The main purpose of the document review conducted in the present study was to determine the current context—the historical, environmental, economic, social, and cultural perspectives—of the six schools of architecture in Saudi Arabia. Investigating these perspectives is vital to understanding the nature, needs, and priorities of the country.

Documents from the six schools in Saudi Arabia are available online as PDF files on each university's website. These documents were assumed to be reliable, updated, and stable. An initial review of the curricula of the six Saudi architecture schools was conducted to understand their similarities and differences regarding the five context dimensions. Significant similarities were found (see chapter 5 for more detail).

1.8.2 Building the Saudi Arabia Framework

This phase of the research will examine what does and does not make sense for a new Saudi Arabian green architecture educational model. In other words, this phase will filter potential knowledge of a model, retaining elements that are adaptable to Saudi Arabia and rejecting elements that are not. Ultimately, the Saudi Arabian model, other existing models (e.g., the University of Oregon's), and the literature review will be interpreted and analyzed to come-out with new knowledge that can be adapted to the Saudi Arabia context and then developing the TO-BE framework for Saudi Arabia.

1.8.3 Interviews—Community Review of the Western and Saudi Arabia Framework

This phase of the research will introduce interviews and coding procedures as research tactics. The purpose will be to propose an education framework that can serve the profession, and improve or change the current Western educational framework. The interviews will be with academics and practitioners from the two mentioned case studies. Professors who are trying to either teach green architecture or have an understanding of green architecture will be interviewed. Interview topics will include what works and what difficulties they are having with implementing green architecture issues in education. Their answers will help identify and define the problem of why academic experts cannot fully implement an educational model related to green architecture.

In additional, the Saudi Arabia framework is introduced to Saudi doctoral students at Virginia Tech. The interviewees were graduated from Saudi universities and mainly architects and designers in the field—they had an understanding of the Saudi Arabian context and educated in Saudi Arabia. Most of these students are Ph.D. candidates, and they will be future professors in Saudi architectural schools. Their expertise helped achieve and improve the accuracy of the framework of Saudi Arabia context.

1.9 Research Contributions

Expected outcomes and contributions to the body of knowledge can be summarized as the following discussions. First, this study will better enable educators to prepare future generations of architects, who can make successful contributions to the world they inhabit as professionals. Second, this study provides insight into how green building can be productively and strategically integrated into formal architectural curricula. Third, buildings have a major impact on resource consumption and a large hand in environmental degradation. Therefore, it is of great importance that future practitioners understand and appreciate the many of issues surrounding green building as well as larger scale holistic sustainability, and how the field affects all scales. Fourth, presently, there is a difficult to learn or a steep learning curve as senior professionals struggle to remain current regarding relevant issues and implement green design strategies. This learning can be repeated if students are not introduced to this information until after they have graduated and are practicing. In addition, Instilling the meaning, value, and tools of green architecture in future architects as students might expedite the implementation of green building practice in the country.

1.10 Research Assumptions

This study makes certain critical assumptions about the availability of documents for review, the qualification of the researcher to perform the research, and the degree to which the interviewees represent the larger population of green architecture experts.

First assumption: documents and materials of the current educational model for the schools of architecture in Saudi Arabia are available online and will be used to determine the Saudi Arabia context framework. Further, these documents are assumed reliable. The researcher will, by contacting the administration of the proposed schools, double check that the documents are updated. The theoretical foundation and the interpretation of this part of the research will largely rest on these documents.

Second assumption: The researcher is a good instrument of data gathering and interpretation. The researcher worked for ten years as a lecturer in Saudi Arabia architectural colleges. During this time, I contributed many committees developing and preparing the curricula of the technical department of Civil and Architectural courses in Riyadh College of Technology and the curricula of the Department of Architectural Engineering in Imam University. Some of this work included a structural model, course content materials, and a syllabus description. In addition, the researcher worked as a practicing architect to design and construct many private residential buildings. These experiences in education and in practice should help the researcher interpret the literature and facilitate communications with the research participants.

The third assumption is that the interviewees will be a good, selective sample. They should be numerous enough and representative to give the researcher good reactions, and information. Eventually this may positively affect the new Saudi Arabia framework.

1.11 Research Limitations

This research will focus on the higher educational systems of architecture in Saudi Arabia. In addition, the development of the educational system is mainly concerned with the green buildings knowledge, and pedagogical approaches to the higher educational program for architectural design. The knowledge was transferred into a logical, sequential structure representing the learning path/knowledge map. The knowledge map was not be structured around a sequential structure of years, and courses; it is structured to be more general so that it can apply across all of the architecture schools in Saudi Arabia.

1.12 Researcher's Role and Background

1.12.1 Researcher Background

A brief biography of the researcher would identify the professional and academic background of the researcher and define his ability and bias in analyzing the subject he intends to study. It also helps to establish the credibility of the researcher in the subject area. The researcher's brief biography is as follows:

He started to become interested in environmental issues during his undergraduate study. As a graduation project, he designed an office building in Dammam city in Saudi Arabia, consisting of 12 floors. The project focused on energy efficiency (in terms of cooling). However, the project assumed different construction materials, glassing types, lighting, equipment, and building orientation to minimize the cooling needs. The researcher used the PowerDOE program to simulate the building in different cases to get the desirable result. This project increased his interest in seeking green architecture knowledge as a point of interest in his master's degree.

During the period of 2003-2006, the researcher finished his master's degree at Sydney University; his specialty was building science and design. His graduate courses were intensive research (76 units) that improved his knowledge of building design and science, especially in green architecture aspects including energy efficiency, passive and active solar engineering, daylighting, and acoustics subjects. While studying at Sydney

University, he was nominated for a "Certificate of Excellence" and satisfied the requirements for the Chartered Institute of Building (CIOB) Australasia award of Excellent Building Postgraduate Student of the Year 2007 for two research projects of his master's program: 'Design proposal for Mixed Usage Development and What Is a Good Building'.

From 2006 to 2009, the researcher worked as a lecturer in the Riyadh College of Technology. He had been involved in the twinning project between Riyadh College of technology (SA) and Derby College (UK) as coordinator of the Saudi team for the Competition to Design an Eco-Friendly House. The purpose of the project was to design an eco-friendly house appropriate for Saudi family culture and for Riyadh's environment and surroundings. This project gave the researcher a chance to combine his knowledge of green architecture with western knowledge within this domain.

In addition, the researcher worked as a lecturer in Saudi Arabia architectural colleges. He had taught architecture design at the higher education level for 10 years in Saudi Arabia before he came to the United States and started to construct an educational framework for green architecture design in Saudi Arabia. He uses a constructivist pedagogical approach in his teaching and strives to provide a student-centered learning environment. In addition, he contributed to several committees developing and preparing curricula structure, course content materials, and syllabus descriptions for the technical department of Civil and Architectural courses in Riyadh College of Technology and to the Department of Architectural Engineering in Imam University.

Based on the above professional and academic background, it is assumed that the researcher is a good instrument of data gathering and interpretation. This might help the researcher interpret the literature and facilitate communications with the research participants.

1.12.2 The Researcher's Role

It is important to mention that when analyzing qualitative research, the researcher is the primary instrument of analysis. In interviews, the researcher performs the function of the instrument, identifying issues and concepts and measuring their relative value. In addition, he or she should build relationships with the interviewees to get honest and open responses. The benefit of the researcher as an instrument of analysis is that the researcher has the flexibility to modify his or her approach as needed and can detect and elicit latent content inherent in the subjects. The drawback of using the researcher as the instrument of analysis is that the researcher often lacks the same precision and objectivity that a physical instrument or test might afford. As an instrument of analysis, the researcher must recognize his or her biases and attempt to mitigate them in order to improve the reliability and validity of the study findings.

1.13 Structure of the Dissertation

The dissertation will be presented in seven chapters:

Chapter One (Introduction): Lays out background information, reviews the motivation for the study and for changes in architectural education, and addresses problem statements, research goals, and objectives. The Introduction also discusses the research method, the scope and limitations, the assumptions of the dissertation, and researcher’s role and background.

Chapter Two (Literature Review): This overview of the general literature will set out the problems, the relevant literature, and backgrounds of the four domains of green architectural education (architecture design, green building issues, Saudi Arabia context, and education).

Chapter Three (Methodology): The Methodology chapter will restate the research problem and objectives and give an overview of the qualitative method. Then more in depth discussion of the research methods will be presented.

Chapter Four (The Western Knowledge Framework): This chapter presents two main steps of the Western framework. The first step is to combine and synthesize the Western knowledge framework. The second is to present the questions, results, and analysis of the interviews by performing case studies of the existing curriculum programs, such as the University of Oregon, the Arizona State University, and University of Southern California in the United States. Eventually, this chapter proposed a final Western knowledge to establish an adaptation for the Saudi Arabia knowledge framework proposed in Chapter 5.

Chapter Five (The Saudi Arabia Knowledge Framework): This chapter will be introduced the Saudi Arabian context framework that focuses on the country’s historical, environmental, economic, and social and cultural perspectives. This chapter will present the questions, results, and analysis of the collected data, and conducting interviews with Saudi Ph.D. students.

Chapter Six (Adapting and Transferring the Knowledge to the Final Proposed Framework): This chapter presents two main steps. The first step is to merge and adapt the results of the Western model in chapter 4 and the results of the Saudi model in chapter 5 and come up with lists of green architecture criteria that are suitable for Saudi Arabia case. Secondly, after being adapted with knowledge from western universities, the Saudi Arabia green knowledge needs to be triangulated and combined with its empirical applications (e.g., workplace, education, residential) and its analytic domain (e.g., simulation tools) to be comprehensive. Ultimately, the final Saudi Arabia knowledge educational framework will be presented in this chapter.

Chapter Seven: (Narrative): This chapter presents two main steps. The first step will discuss the narrative about translating the Western model into the Saudi Arabia model in practice. Also, gives examples of how the Western framework would be applied in Saudi Arabia.

Chapter Eight (Conclusion): The final results will be discussed and summarized, and the final research recommendations will also be summarized.

2. LITERATURE REVIEW

2.1 Architecture from the Researcher's Viewpoint

Over the past half century, architecture and design have been about how people should work, learn, and play—in other words, how they should live. Today, owners and users of building ask more of environmental responsive design than ever: lower building operation cost, access to good daylight and view, and interior air quality. They are asking architects for less building operational cost, good daylighting and a view, and interior air quality. As our times and society grow ever more complex, so too does architecture. The design process now depends more than ever on many different disciplines. Developments in knowledge, technology, and science are incorporated with art and a variety of materials, making architecture even more complex. The architecture of today must respond to its environment, rather than manipulate the environment for our needs.

Architecture today has a deep influence on our lives, environment, and awareness. It must have multiple solutions to meet humans' various physical and psychological needs, rather than being mere form, or something made "to impress the populace," as Rapoport said (Norberg-Schulz 1980). Architecture should be about designing good places to live with less operational cost.

According to Pallasmaa et al., a strong architectural experience should produce a sense of loneliness and silence regardless of the number of people present or the surrounding noise. Good architecture gives people an impression of something sacred and the sense of being in a unique place fit for higher beings (Pallasmaa et al. 2005). According to Pallasmaa, "A house may seem built for a practical purpose, but in fact it is a metaphysical instrument, a mythical tool with which we try to introduce a reflection of eternity into our momentary existence" (1965).

Natural light is another feature of architecture today that can provide comfort and reduce energy use. Louis Kahn (2011) said, "No space, architecturally, is a space unless it has natural light" (p. 15). Today, delighting is important for improving the quality of a place, maximizing visual comfort, and providing the comforting feeling of knowing the time of day. Kahn also says that "natural light has all the moods of the time of the day, the season of the year, [which] year for year and day for day are different from the day preceding" (P. 18). Designing a building as "a bunker" is "aesthetically and physiologically a disaster" (Yeang and Spector 2011) (P. 69). Architecture that cuts us off from the outside makes us totally dependent on artificial energy supplies and worsens users' psychological comfort and health. Reversing these outcomes is what the "green movement" of the past 10-15 years has really been about.

2.2 Architecture's Role in Society

2.2.1 Brief History

It is critical to understand the basic history of the built environment to understand the history of human civilization and the nature of contemporary culture. The story of architecture began once human beings settled down to the business of agriculture, instead of hunting and gathering, and permanent settlements became a fact of life (Gascoigne 2001). Over different eras, architecture's roles in society underwent several movements.

Prehistoric architectural structures (between 10,000 BCE and 300 BCE) that remain today, even if only partially, were typically religious in nature and were made of long-lasting materials such as brick and stone. The style and appearance of these structures vary dramatically, but each tells much about the technology and culture of its people (Borden et al. 2008, Gascoigne 2001).

From the 7th to 5th centuries BCE, Greeks and Romans made a great architectural shift into what is called "Classical[2] Architecture." The Greeks were perhaps most well-known for the subtle and highly calculated visual effects produced by their incredibly crafted buildings. Rigid geometries defined their temples and the ornaments applied to them, such as the narrowing of a column to change its apparent size, depth, or proportion of the surrounding structure. While the Romans borrowed much from Greek style, they tended to focus less on religious structures and more on public or civic ones (Spielvogel 2009).

The arts and crafts movement was an international design movement between 1860 and 1910 (Triggs 1902). It began and developed first and most fully in England (Campbell

[2] "The word 'classic'…is often used…to indicate qualities which are the special praise of Greek and Roman work – stateliness, elegance, and the careful coordination of all the parts of the composition…. [It implies] standard excellence" (Sturgis 1836-1909).

2006) but spread to the United States and to the rest of Europe and influenced various regional styles (Kaplan 2004). It was largely a reaction against the impoverished state of the decorative arts at the time and the conditions in which they were produced (King 2005). The movement was short-lived because of the relative expense of handicraft.

Modern architecture began in the early 1900s. The distinction of modern architecture is usually in an absence of applied decoration and in simplification of form. Worldwide in scope, it reconciled the values underlying architectural design with quick technological development and the modernization of society (Curtis and Curtis 1996). The development of new building and transportation technologies, particularly steel and the automobile, called for new architecture that met the needs of society and the environment. The 1950s through 1970s were decades immersed in the second wave of modernism, and designers explored the aesthetics and advances in building technology with optimism (Robinson and Foell 2003). The modern movement celebrated these new technologies, emphasizing their simplicity, efficiency, and speed. The most famous, influential, and studied first-generation modernist architects include Ludwig Mies van der Rohe, Le Corbusier, Walter Gropius, and Frank Lloyd Wright, while the work of Louis Kahn was influential in the second generation and remains so today.

During the 1960s and 1970s, postmodern or late-modern architecture started in the United States (Habermas 1988) as a rejection of the overly functional and undecorated buildings of the modern movement. The movement replaced the functional and formalized shapes and spaces of the modernist style with diverse aesthetics: styles collide, form is adopted for its own sake, and new ways of viewing familiar styles and space abound (Habermas 1988). The original 1984 AT&T Building in New York City, by Philip Johnson, is considered an example of this movement, which the building borrows elements and references from the past and reintroduces color and symbolism to architecture.

2.2.2 Current Architecture

Today, there are multi-dimensional and complex relations between architecture and society. It is difficult to describe these complex relations in a manner simple enough to enable a discussion of the relationship's basic determinants.

Architecture is art that is physically rooted in the geographic location of its society. A society may not be an integrated entity, but its architecture can still reflect its artistic sensibility, aspirations, and economic wealth, as well as its technological advancement, elements of climate, topography, and social structure. Architecture is not merely the net embodiment of all of a society's contradictions; it also helps the society conceptualize itself. In brief, architecture reflects society's activities and also shapes its identity (Serageldin 1986).

There is a large volume of published studies describing the role of architecture in society. This relationship has been widely investigated by several scholars and practitioners, including Ludwig Mies van der Rohe, Christian Norberg-Schulz, Le Corbusier, Louis Kahn, Robert Venturi, Juhani Pallasmaa, and others.

Christian Norberg-Schulz (1968) stated in his book *INTENTIONS IN ARCHITECTURE* that "the modern movement is the only true tradition of the present because it understands that historical continuity does not mean borrowed motives and ideals, but human values which have to be conquered in always new ways" (p. 206). However, modern architecture failed to account for some of the factors that give importance to the built environment, especially the role of perception and the importance of history as a source of meaning. Norberg-Schulz says that architecture can be a sensitive medium again, if it keeps a certain visual order and has "a formal differentiation of the buildings corresponding to the functional differences of the building tasks" (p. 18).

In the same context, Frank Lloyd Wright indicated the importance of "a respect for the harmonious relationship between the form/design and the function of the building" (Elman 2013). In his works, each building clearly reflects its own purpose and its own aims. For instance, Wright did not accept building a bank like a Greek temple. A house must function as a house. A bank must function as a bank. In this respect, each building's basic needs should be in harmony with the building plan, its site, its form, and its aim (Elman 2013).

The modern movement took as its point of departure the creation of new dwellings. In 1929, Sigfried Giedion wrote (Norberg-Schulz 1985)

> *The present development in building is undoubtedly focused on the dwelling and in particular on the dwelling for the common man…Neither the public building nor the factory is today of equal importance. That means: we are again concerned about the human being (p. 108).*

In 1925 Le Corbusier showed a sample apartment at the Exposition International des Arts Decoratifs in Paris, called the Pavilion de I'esprit nouveau. This sample was a dwelling for the common person and ignored the "spirit" of the modern age by means of a monumental symbol. He says, "Human beings are badly housed, that is the profound and real reason for the present upheavals" (p. 108). The problem of the new dwelling has been solved through the work of Frank Lloyd Wright. In 1910, after their publication in Germany, his works became a major source of inspiration to European architects. During the 1920s and 1930s, the modern house was developed, and came to represent an important contribution to the enhancement of humanity's living conditions (Norberg-Schulz 1985).

Jessica Weigley, co-founder of architecture and interior design studio Síol, said, "Space is so affecting to people that creating the best space possible will have a positive effect on people and therefore hopefully have a positive impact on society" (Catherine Yang 2013).

By understanding humanity's needs and goals, architects can use both subjective and objective design elements to create the optimal space. As Aldo Van Eyck said, "Man is the subject as well as the objective of architecture" (p. 27) (Jencks and Kropf 2006). For example, for a family, Hackett says, "Anytime you open up a simple environment and connect living to dining to kitchen and open plans, you see a whole family that can … [be] connected." He added, "They're living a happier connected existence, because now there's not that division between spaces, and in some ways the walls have come down, and that connective environment is sort of key." It is obvious that our lifestyles have changed; for example, Old Victorian houses in San Francisco have a separate dining room and a separate living room, a division that has disappeared in today's homes (Catherine Yang 2013). Because of social and cultural customs, religious spaces designed in Saudi Arabia are similar to Old Victorian houses where all the spaces are separated from each other.

Within the last few years, globalization has become a catch phrase in architecture associated with a loss of place identity. Because identity plays an important role in the continuity of a people's culture, people living in globalized architecture will be isolated from their past. Place influences the meaning occupants give to it through personal, social, and cultural processes (Altman and Low 1992, Burd 2008) and can be described in terms of many multidimensional physical and psychological environmental attributes (Eldemery 2009).

According to Norberg-Schulz (1985)in his book *The Concept of Dwelling: On the Way to Figurative Architecture*, contemporary housing did not fully satisfy what we need from private dwellings, lacking what he called "figural quality." He stated that the modern house was certainly practical and healthy, but it did not look like a house, or "it favored 'life in space' rather than 'life with images.'" For example, elements such as gables and arches give houses the identity of a "tower," a "garden pavilion," or a "balcony on the world" (Van Nes 2012). Also, every part of these elements should display its own identity while at the same time merging with the whole, as in the design principles and characteristics of Frank Lloyd Wright's architecture.

One of Norberg-Schulz's significant works is *Between Heaven and Earth*, which presents the core of his work on place and architectural phenomenology. In this study, he explains place identity based on the concept of *Jord*, *himmel*, and *synsrand*—the Earth, sky, and optical array. He gives an example that the Earth rises toward heaven. This expresses the qualitative difference between "up" and "down." To describe the "character" of a place is to consider how Earth, sky, and the optical array uniquely interact. In regard to dwellings, he emphasizes horizontal and vertical relations as they express a particular mode of connection between heaven and earth. For example, a roof form can contribute to a silhouette related more toward the sky or more toward the horizon and surrounding landscape. Also, he debates how contrasting roof shapes can play an important role in distinguishing one place from another (Van Nes 2012, Norberg-Schulz 1968).

Norberg-Schulz's work explained how physical and spatial elements shape and strengthen place character. Qualities of light and the composition and colors of terrestrial surfaces can have a positive impact on place character. Similarly, urban character depends on environmental borders and surfaces. For example, qualities of urban walls, like materials, color, and number and manner of openings, all speak to lived qualities, like the architectural degree of openness or closure or a building's sense of movement or rest (Norberg-Schulz 1968, Van Nes 2012).

The character of a place is also defined by its space, the reality of building and primary element in architectural design. Frank Lloyd Wright said, "Space is the central reason for building; it is the useful volume within that is the generating element in architectural creation. Space is not just a void, not the absence of the facades" (p.14) (James 1968). Wright was influenced by the conception of space in Lao Tzu, who claimed, "The reality of the building does not consist in the four walls and the roof but in the space within to be lived in" (p. 80) (Wright 1955). Wright considered space as the core of life and form of architecture. It is a useful volume for building function. He viewed interior space as flowing into exterior space (James 1968):

> *My sense of "wall" was no longer the side of a box. It was enclosure of space affording protection against storm or heat only when needed. But it was also to bring the outside world into the house and let the inside of the house go outside. In this sense I was working away at the wall as a wall and bringing it towards the function of a screen, a means of opening up space which, as control of building-materials improved, would finally permit the free use of the whole space without affecting the soundness of the structure. (pp. 141-142) (Wright 2005)*

The shape of a house's space is the reflection of life of the occupants and helps to determine the form of the building.

A room's atmosphere and its inside-outside relationship play a significant part of the users' comfort. The inside should be expressed on outside (Venturi 1977). An interior's environment relates to open and closed rooms, which have much to do with how the interior connects to the outside. For example, the amount of light that windows offer the interior is one of the most significant features of the interior's atmosphere. So, the study of window size, shape, and placement is important in the early stages of a design.

Louis Kahn's works contains many examples of rooms' inside-outside relationships that are conducive to meditation, such as the Salk Institute in La Jolla, California (1965). Juhani Pallasmaa (2010), in his book *THE THINKING HAND: EXISTENTIAL AND EMBODIED WISDOM IN ARCHITECTURE*, says the Salk Institute is "delineated by two rows of buildings, with the sky as its sublime ceiling and the horizon of the Pacific Ocean as its hypnotizing back wall…" (103). Kahn designed an open space to talk to the horizon line of the Pacific, and he employed a channel of water and light to suggest a metaphysical dimension in the research into the hidden laws of nature (Figure 2-1).

Figure 2-1 The Salk Institute in La Jolla, California (1965) (Yusheng 2010), Used with permission of Liao Yusheng

The Kimbell Museum in Fort Worth, Texas (1972) is a good example of how interior atmosphere can influence people's comfort and bring spirit to the space. Kahn designed cycloid vaults split open at their crest to admit a crack of daylight to the interiors, where it is diffused over polished concrete surfaces (Curtis 2012).

Due to the growth of human societies, changes in people's lifestyles, and development of technological advances, places no longer convey meaning, and people suffer from a sense of "placelessness." Relph (1976) stated that "placelessness" refers to places that do not have any distinctive personality and cannot be culturally recognized; they suffer from lacking a sense of place, or, to put it another way, embody the physical characteristics of nonplace (Sime 1986). Najafi (2011), in his paper *The Concept of Place and Sense of Place in Architecture Studies*, indicates that this problem needs to be countered by understanding users. Learning more about the full variety of people's experiences of places, including our emotional relationships to them, can help solve placelessness.

Designers, architects, and planners should pay more consideration to the quality of places and built environments. Relph claimed that designers and architects who disregard the places' meanings try to destroy reliable places and make fake ones. Consequently, the more significant role of design as a tool today is to answer human needs and expectations (Gustafson 2001, Najafi 2011).

In 1965, Juhani Pallasmaa pointed out that the "spirit" of buildings has influence on people's comfort as well. Architects design buildings primarily with regard to the images and emotions of the people who live in them, more than the satisfaction of mere physical need (Pallasmaa 1965):

If a building does not fulfill the basic conditions formulated for it phenomenologically as a symbol of human existence it is unable to influence the emotional feelings linked in our souls with the images a building creates. Architectural effect is based on a number of what we could call primary feelings. (451)

These feelings can change and form the case architecture and make a building something other than a large-scale sculpture, for example. In this regard, Pallasmaa (2005) indicated ten types of experience that could be among the primary feeling or emotions produced by architecture (Chapter One).

In the same context, a building's design should produce a sense of loneliness and silence regardless of the actual number of people present or the surrounding noise, similar to the experiences of silence and light commonly found in Louis Kahn's works. (Pallasmaa et al. 2005)

Architecture design has power. It can impact a building's users and can shape society. Thomas Markus (1993) wrote a descriptive history of buildings around the Enlightenment that demonstrates how buildings can form people. He discusses in detail how the architecture of schools, hospitals, prisons, and hotels are designed to discipline people. Markus observes that teachers recognized that the architecture of a school has a power on students. They discovered that the design of the building was as powerful as the content of their teachings. Furthermore, the design of schoolrooms frequently favored different philosophies of pedagogy by shaping how students connect with each other and can be observed by other students and teachers. For instance, some schools were designed to allow an observer to sit at a desk or in each of a few corridors. Other changes included desks laid out in a U-shape to prevent students from making eye contact with students from other classes that shared the room (Markus 1993, Shah and Kesan 2007).

In the same context, Markus (2007) tries to deliver important evidence that our freedom can be affected by building design. For instance, the spatial ability of actors can be controlled by buildings through a set of rules that govern their interaction, such as defining their locations, visual paths, paths of movement, planned meetings, and odds of chance meetings. Markus also investigated how architecture disciplines can be extended to other buildings such as shopping malls, hospitals, and theme parks.

Architecture also has a direct role in the ecosystem. Graham (2002) says that every architectural artifact connects to the earth, depends on nature for resources, causes environmental change, and affects both human and nonhuman life (Attmann 2009). In this regard, Itsuko Hasegawa says, in her book *ARCHITECTURE AS ANOTHER NATURE*: "Architecture must be responsive to the ecosystem as all of human existence is ultimately encompassed" (p. 113) (Jencks and Kropf 2006). Indeed, architecture today has become a part of the problem, but it should contribute to a solution. Architecture faces a challenge to propose new designs connected with new science and technology.

Whether designing in developing countries such as Saudi Arabia or in developed countries such as the United States, architecture's main responsibility is to design good buildings that are responsive to the environment. Architecture today seeks to provide a good living space for people and minimize buildings' negative environmental impact by enhancing efficiency and moderation in the use of materials, water, and energy by focusing on resources conservation.

These goals suggest an ecological system that integrates architecture and ecology. In his book *DESIGN WITH NATURE*, Ian McHarg says that the benefit of the ecological view is economic, industrial, and commercial, but the greatest benefits lie in education: "This ecology offers the science of the relations of organisms and the environment, integrative of sciences, humanities and the arts – a context for studies of man and environment" (p. 135) (Jencks and Kropf 2006).

Some called this emerging integration of architecture and ecology "bioarchitecture" or "ecotechture" (Jencks and Kropf 2006). Sim Van Der Ryn and Sterling Bunnell stated that

> *Human beings cannot hope to improve on the efficiency of natural negentropic processes. However, a goal can be [to] design habitat and culture in such a way that natural systems and the information contained in them are not degraded and destroyed....* (pp. 16-17) (Farallones Institute 1979).

Architecture design can be integrated with ecological principles to help improve and retain our natural resources and keep our natural environment clean. People must be made aware of the need for environmentally responsive approaches to the design and operation of buildings.

2.3 Architecture as a Catalyst for change

Architecture can be a catalyst for change in at least two ways, direct impacts and indirect impacts.

2.3.1 Direct Impacts

Direct impacts include the reduction of resource consumption and environmental impact. This can be done through designing buildings to use less energy, water, and materials.

In 1872, natural conservation efforts were promoted and publicized by John Muir, who relentlessly petitioned Congress to create national parks. After World War II, environmental awareness started to increase, and people's attention turned more toward modern environmentalism than just nature conservation. Issues such as new materials, advancements in technology, increasing ecological stress and global pollution, growing population, limited resources, and economic disparities among the nations became the new agenda of the environmental movement (Attmann 2009, Leopold 1949).

The ecological movement was the first branch of modern environmentalism to appear, with the 1949 publication of Aldo Leopold's *A Sand County Almanac*. The major contribution of this book was a presentation of ecology as a science that was focused on respect for the environment and the ecological importance of conservation. In 1962 Rachel Carson published *Silent Spring*, which drew significant attention to the impact of chemicals on the natural environment (Carson 2002, Attmann 2009).

In the United States, the 1960s saw two important turning points for the ecological movement. The first was the Sierra Club's 1966 campaign against the Bridge Canyon Dam, which resulted in the cancellation of the dam's construction plans in 1968; the second was the Santa Barbara oil spill in 1969. These events increased the public's awareness of ecological issues and helped turn it into a social movement (Attmann 2009).

By 1973, the oil embargo and resulting energy crisis led to greater interest in renewable energy and encouraged research in other energy sources, including solar, wind, and nuclear power (Furr, American Bar Association. Section of Real Property, and Law 2009). In 1977, President Carter, with pressure and support from the public, convinced Congress to create the United States Department of Energy (DoE), with the goal of conserving energy (DoE 2013, Attmann 2009).

Despite these developments, in the first half of the twentieth century most scientists did not believe that increased levels of carbon dioxide (CO_2) would result in global warming. Yet global warming has produced the biggest challenge of our time: to shift the world from a path of increasing greenhouse gas (GHG) emissions to a path of more advanced technologies that remove these emissions.

In fact, buildings have a major impact on energy use and the environment. According to the International Energy Agency (IEA), in 2005 40% of the world's total annual energy consumption was building related (Attmann 2009). In the United States, commercial and residential buildings use 47.6% of the nation's energy and approximately 74.9% of its electricity, as shown in Figure 2-2 (EIA 2011, Architecture2030 2011). This usage is the result of more and faster construction of new buildings and the growing population. Energy usage has become a global problem. Architecture design should respond to these challenges by shifting building design to new, green design strategies.

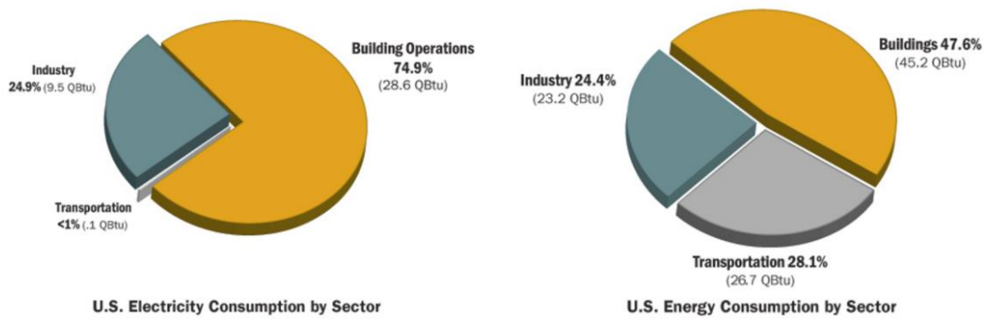

Figure 2-2: US Electricity Consumption and Energy Consumption by Sector source: (Architecture2030 2011)

The U.S. Energy Information Administration (EIA) now reports that, in coming years, the energy consumption of the building sector will grow faster than that of industry and transportation: the total energy consumption of the building sector will increase by 4.74 quadrillion Btu between 2012 and 2030, while industry will grow by 3.33 QBtu and transportation is expected to decrease by 0.37 QBtu. To put these projections into perspective, 1 QBtu is equal to the delivered energy of thirty-seven 1,000-megawatt nuclear power plants or 235 coal-fired power plants at 200 megawatts each (Architecture2030 2011).

At the same time, the use of electricity produces CO2 emissions that have a major, negative impact on the environment. Buildings contribute to one-third of worldwide GHG emissions, a figure that will likely continue to increase as construction increases. According to the U.S. EIA, nearly half (44.6%) of all CO2 emissions in 2012 came from the building sector. By comparison, transportation accounted for 34.3% of CO2 emissions, and industry accounted for just 21.1%, as shown in Figure 2-3 (Architecture2030 2011). It is argued that as a consequence of increasing GHG emissions, global warming has increased and has become one of the biggest challenges of our time. These concerns suggest the need for improved building performance.

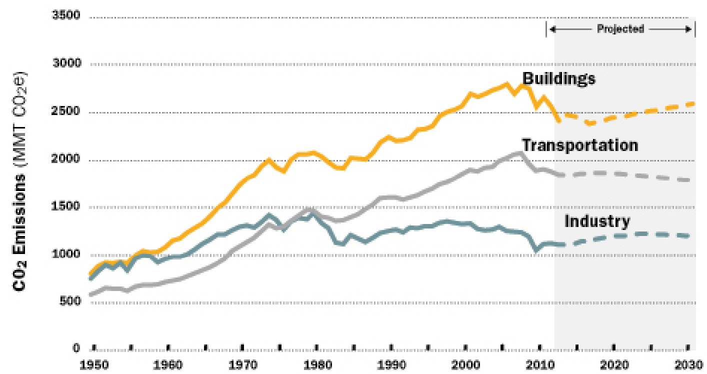

Figure 2-3: U.S. CO_2 Emissions by Sector (Historic / Projected) (Architecture2030 2011)

The materials and technological elements of a building should be made efficiently by using recycled elements with minimal waste, made effective by producing the desired results, and made productive by changing and storing energy and water. For example, during the construction of the San Francisco Federal Building, only 10% of materials ended up in landfills, and 87% of the materials used were recyclable (Attmann 2009). Hawkes (2001) suggests that a 50% reduction in building energy use is possible by implanting environmentally responsive strategies in design.

In addition, buildings and construction have a major impact on the global environment. They take the major share of natural resources, both for land use and for materials extraction. Buildings use 50% of the world’s raw materials, most of them nonrenewable resources (Graham 2002), and are responsible for 36% of all waste generated worldwide (Attmann 2009).

Architecture should be a catalyst of change and should respond to these challenges. To fully address its responsibilities, architecture should concentrate on new green design strategies. These strategies should improve energy efficiency and resource conservation, incorporate renewable energy systems into site design, provide rules for indoor environmental quality, and indicate levels of resource conservation and recycling.

2.3.2 Indirect Impact

Architecture can indirectly influence change by promoting heightened awareness of resource consumption, by means of buildings that demonstrate a response to environmental factors.

According to Reese Rowland,[3] there has been an important change among his clients in the past 10 or 15 years. In 1990, customers were mostly concerned with a project's first cost, but now they are looking at long-term energy costs, and looking more for environmentally responsive design strategies. Customers became more willing than in the past to invest more on the front end, in such things as insulation, energy efficient heating and cooling systems, and lighting technology, to save money on the back end (Brawner 2013).

In this regard, Kevin R. Hackett[4] says (Catherine Yang 2013):

> *The more people that can bring awareness to themselves, and in space, then they can bring themselves to be aware in society, and to look at it—it's a sustainable revolution that's going to actually move forward and to shift our very sort of global-centric system.*

People have to be aware of the importance of long-term reductions in energy use and design buildings to be environmentally responsive. They should also increase their awareness not just of space but also of their lifestyles—how they connect and how they act. This might be the bigger issue. When awareness of the environment is created in a person, the person brings this understanding back into society. Therefore, the community has a role and responsibility to educate, encourage collaborative thinking, and change in dealing with environment.

Buildings can express the client's and architect's attitude toward resource conservation and increase awareness of this issue. Some recently constructed buildings

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[3] Principal and project designer at Polk Stanley Wilcox Architects

[4] Recruitment Consultant at TCG

demonstrate green design principles, and both their exterior and interior have become iconic.

Recently, design has shifted heavily toward smart urban planning and incorporating the character of the city. Also, more “green” systems are being used, like vertical gardens and gray-water systems. As Reese Rowland stated, “a building that doesn’t have a story to it, that doesn’t have a message, in my mind, is not really architecture…It’s just a building” (Brawner 2013).

Ken Yeang’s works heighten awareness about resource consumption and environmental issues. His projects demonstrate his approach to ecological design by highlighting ecological features. He used vertical gardens in a number of his buildings, such as the Solaris building, EDITT Tower, Compilation of Ken Yeang Skyscrapers, Spire Edge, and Jianshe HQ Tower. The vertical gardens reduce energy consumption through a number of features, such as shading and insulating, while providing a social amenity for the buildings’ users.

To reduce energy consumption from lighting in the Solaris Building, Yeang employed a solar light shaft that cuts diagonally through the South Tower, bringing daylight deep into the internal areas of the building. The artificial internal lighting operates on a sensor system, which decreases energy use by automatically turning off the lights when there is acceptable daylight. Balconies within the solar light shaft add visual interest and create dramatic views (Hart 2011).

Daylighting design has a strong influence on both the energy use of a building and the general comfort and well-being of its occupants. Schittich (2003) says, “Human beings need daylight because it satisfies two basic needs: illumination of the room and the biological stimulation of the psychological and physical sense of well-being” (p. 60). Also, “Lighting is not an exact science, but also an art that affects objects and humans” (p.59) (Schittich 2003). Hence, the absence of daylight can have indirect impacts on occupants’ health, such as depression, bone disease (due to vitamin D deficiency) and disturbances of sleep and concentration. A study conducted by SunWorld (1996) at a school in Alberta, Canada, indicates that the absence of daylight can affect children’s health: “Students in classrooms with full-spectrum light were healthier, attended school 3.2-3.5 days more per year, had nine times less dental decay and grew an average 2.1 cm more over two years than students in rooms with average lighting” (p. 37) (Cofaigh et al. 1999). Another study in the IAEEL Newsletter (1996) in Johnston County, North Carolina (United States), indicates that “school attendance was higher in ‘daylit’ schools, and after three years in these schools students scored 14% higher in final exams than students in conventional schools” (p. 37) (Cofaigh et al. 1999). Therefore, windows and daylight are beneficial to health and, at the same time, can save energy. Ken Yeang and TR Hamzah’s EDITT Tower follows many green approaches: place making, vertical gardens, water management, solar energy, storm water collection, green materials and technologies, and concern for environmental health. Besides the reduction of energy consumption, the building also features photovoltaic technologies for greater energy self-sufficiency (see Figure 2-4) (Alexandra 2008).

The design has a built-in waste floor for recycling. The materials drop down to the basement waste separators, where they are kept for collection. Also, the tower achieved 55.1% water self-sufficiency by collecting rainwater and gray water for reuse in the tower. The rainwater collection system is composed of a roof-catchment-pan and layers of scallops located at the building’s facade to catch rainwater running off its sides (see Figure 2-5) (Attmann 2009).

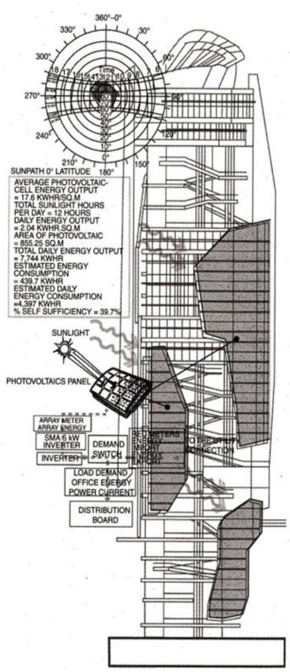

Figure 2-4 Use of ambient energy (Attmann 2009)

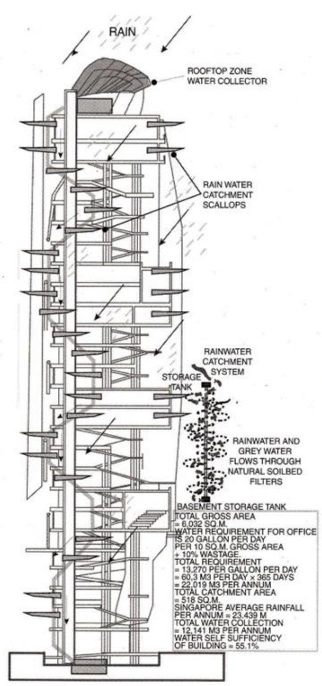

Figure 2-5 Rainwater collection and recycling system (Attmann 2009)

The San Francisco Federal Building in California was completed in 2007. Thom Mayne, founder of Morphosis Architects, designed this building to be a high-performance and green building for the General Services Administration (GSA). The building include green features, such as sunscreens, sensor-controlled natural daylighting, natural ventilation, individually controlled shading devices, a flexible floor, energy-efficient elevators, low-toxicity or nontoxic building materials, wood ceilings, and waste management systems. According to the GSA, these features account for a 33% reduction in energy use, 50% blockage of solar radiation, and 7% savings in project cost. According to Mayne, (Morphosis 2013)

> *Our primary interest was to produce a performance-driven building that would fundamentally transform its urban surroundings, the nature of the workplace, and the experiences of the people who use it while making intelligent use of natural resources. For me, this project represents … an architecture that synthesizes its complex forces and realities into a coherent whole.*

Efficiency from Mayne's viewpoint is primary driver of sustainability, and it is the design team's mission to produce a high-performance building. Overall ceiling heights of 13 feet in the office floors allow daylight to penetrate deep into the work area for occupants to use. Also, a series of sensors are embedded in the building to automate temperature and light adjustments. The temperature sensors on the façade open the ventilation windows at night and the outside air gets into the building. The building is the first office tower in the United States to forego air-conditioning in favor of natural ventilation, which serves up to 70% of the work area and affords natural light and operable windows to 90% of the workstations (Ziger/Snead 2008). These create high-quality workspaces and maximize energy efficiency in the building.

The building has another significant feature: it physically democratizes the workplace and enhances occupants' health, comfort, and sense of control over their environment (Morphopedia 2009). Most office spaces do not give occupants the choice to dim the lights or control the ventilation, but the Federal Building does (as mentioned in Chapter-1). The layout locates open work areas at the building's perimeter and private offices and conference spaces at the central cores. According to Mayne, this design might increase interaction between management and staff and promote engagement between colleagues. Another significant point is that the building elevators are designed to have stops on every third floor for purpose of cultural change and savings energy. According to the building occupants, using stairs up or down to get to the desired floor has a positive impact so far. This increased social interaction in the elevator lobbies (Ziger/Snead 2008).

A well-designed workplace can elevate morale (Estates 1994) among workers, which can lead to a healthier staff with less absenteeism, which, in turn, can increase productivity and creativity. For instance, the Reebok International headquarters building in the United States was designed to bring 1,000 workers together in one building to support and improve their creativity and productivity (Heritage 2005). Reebok's goal is to provide workers with a sense of identity with their products.

Architecture has the power to inspire us, to make us feel good about our life, and more importantly, reflect our social values. Through architecture such as Ken Yeang's and high-performance buildings such as San Francisco Federal Building, we become more aware of our role as energy consumers. As a framework around our lives, architecture becomes a means to express a desired response to the environment.

Finally, today's architecture has shifted its focus to designing good places, primarily, and to conserving resources, secondarily. In fact, architecture can educate and be the catalyst of change by employing tangible and intangible elements in buildings design, such as interactive implementation of new technologies and alternative energy sources, energy efficiency, materials reuse, and recycling. Also, designs for occupants' health, including daylit and comfortable spaces, increase indoor environmental quality.

2.4 Architecture as an Evolving Practice

2.4.1 New Performance-Based Design

The practice of architecture, as demonstrated by some buildings over the last 30 years, is evolving in response to the opportunity to be a catalyst for change. The American Institute of Architects (AIA), in their paper *Fact Sheet on Architects and Climate Change*, indicated that architects and designers know "that most buildings can be designed to operate with far less energy consumption than the average U.S. building does, at little or no additional upfront cost" (Tango 2009). This can be done through good "site planning, building geometry, glazing properties and location, material selection, and by incorporating natural heating, cooling, ventilation, and daylighting strategies" (Tango 2009).

Over the last 100 years, the traditional design process has begun with the architect and the client agreeing on a design concept, including general project information, orientation, and fenestration, and then designing the general exterior appearance by using basic materials. The appropriate mechanical systems are implemented into the design based on the client's request. "The traditional design process has a mainly linear structure due to the successive contributions of the members of the design team" (Nils Larsson 2002). Optimization during the later stages the traditional process is difficult or even impossible. Moreover, the design and performance implications of such a process often entail the following practical consequences, as stated by Nils Larsson (2002):

- *The building takes little advantage of the potential benefits offered by solar gain during the heating season, resulting in greater heating demand.*
- *The building may be exposed to high cooling loads during the summer, due to excessive glazing exposed to summer sun.*
- *The building may not be designed to take advantage of its daylighting potential, due to a lack of appropriately located or dimensioned glazing, or inappropriate glazing types, or a lack of features to bring the daylight further into the interior of the building.*
- *Occupants may be exposed to severe discomfort, due to excessive local overheating in west-facing spaces or glare in areas without adequate shading. (p. 7)*

The need for high-performance buildings with green design has become imperative today. The global drive toward more environmentally responsive design has increased the pressure on building designers and developers to create new buildings with a higher level of environmental performance. Some scholars and experts support the achievement of measurably high performance over the full life cycle of buildings, in the following areas (Nils Larsson 2002):

- *Minimal consumption of non-renewable resources, including land, water, materials and fossil fuels.*
- *Minimal atmospheric emissions related to global warming and acidification.*
- *Minimal liquid effluents and solid waste.*
- *Minimal negative impacts on site ecosystems.*

- *Maximum quality of indoor environment, in the areas of air quality, thermal regime, illumination, and acoustics/noise.*
- *Adaptability, flexibility, and operating cost as well as life-cycle cost. (p. 7)*

2.4.2 Integrated Design Practice

Professionals such as HVAC systems consultants and daylighting experts have become involved in the design process much earlier. Today, architecture design teams are facing increasing complexity of projects, which leads to increasing numbers of team members, high-quality requirements, and other complicating factors. The architect must work with specialist consultants, whether professional engineers or contractors, and include project managers, building owners and/or tenants, energy consultants, inspectors, and facility managers with design responsibility in the design process (Figure 2-6).

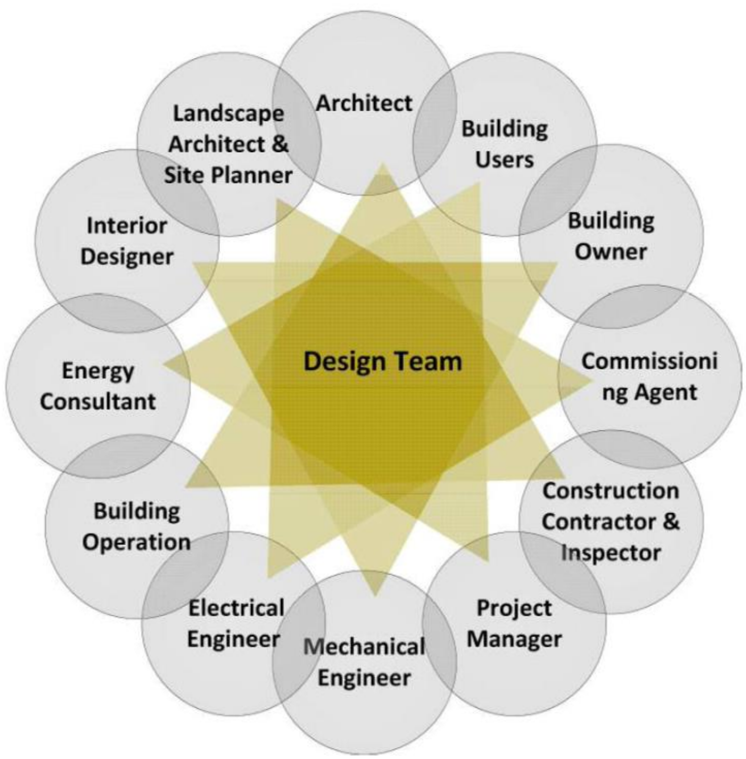

Figure 2-6 Project team for green design adapted from LANL (2002)

Successfully designing and constructing a green building requires that the project team be gathered very early in the design process. All members must have experience with systematic, integrated designs and the desire to employ them. “It is important to take a team-oriented, multi-disciplinary approach in which all members of the project team recognize and commit to the steps and actions necessary to achieve the project vision” (LANL 2002).

The integrated design process includes a different approach from the very early stages of design, and it can produce very different results. A high level of skills and communication within the team are required in integrated design process, includes a cooperation of skills and knowledge through all the project stages, uses modern simulation tools, and works to a high level of integration of systems. This can help to achieve a high level of performance and reduced operating costs. (Nils Larsson 2002)

The key elements of the integrated design process are simple and straightforward. In his book *GREEN BUILDING THROUGH INTEGRATED DESIGN*, Yudelson (2008) described five steps that should be followed in the design process of a high-performance building:

1. *Make a commitment to integrated design and hire design team members who want to participate in a new way of doing things.*
2. *Set “stretch” goals for the entire team, such as LEED Platinum, Living Building certification or Zero Net Energy, and judge the final result from that standpoint.*
3. *Get the team to commit to zero cost increase over a standard budget, so that cost management is a consideration from the beginning and the need to find “cost transfers” or “cost tradeoffs” is built into everyone’s thinking.*
4. *“Front load” the design process with environmental charrettes, studies, and similar “thinking” time* (Figure 2-7). *This gets more difficult if the schedule is compressed, but is essential for the process to work.*
5. *Allow enough time for feedback and revisions before committing to a final design concept.*
6. *Everyone has to buy in and participate. No building team member should be allowed to consider just their own special interest.* (p.45-46)

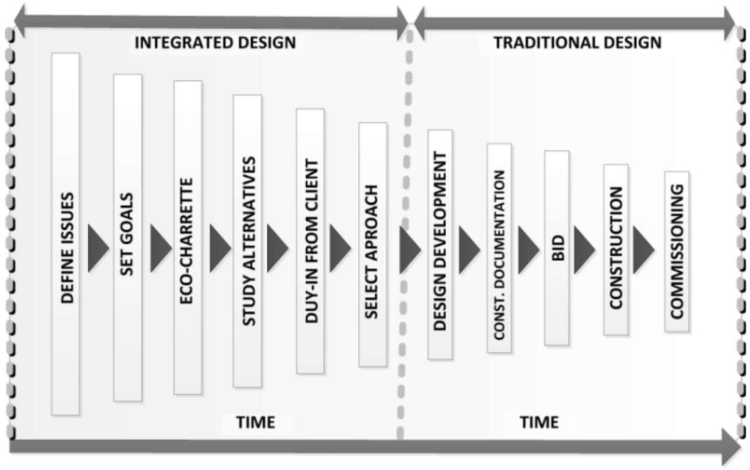

Figure 2-7 The opportunities for an integrated design team diminish over time; the process must be front-end-loaded (Yudelson 2008)

Achieving an integrated design process is an obligation, from the initial design stage through commissioning, detailing, and construction. Early decisions, such as the site's selection, building's location, and configuration, deeply affect the building's energy performance and environmental impact.

In *A Green Vitruvius: Principles and Practice of Sustainable Architectural Design*, Cofaigh et al. (1999)[5] outlined green strategies[6] that demonstrate the design and construction process at different stages, as shown in Table 2-1. The design process is not the architect's exclusive responsibility. At all stages, from pre-project, through the project and the detailing to construction and acceptance; however, the architect must work within the design team (Figure 2-6). Also, the architect is guided by national building regulations. The project's quality, which includes reasonable value for money, is the first responsibility for the architect, regardless of the accuracy of the architect's cost estimate (Cofaigh et al. 1999).

According to Cofaigh et al. (1999), the input of the architect and the design team differs greatly from stage to stage: "The extent to which the architect can influence the environmental impact of the completed building also varies with the stages, but at every

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[5] James & James Ltd. published this book for the European Commission (Directorate General XVII for Energy) and the Architects' Council of Europe.

[6] Designed base on the 1994 ACE breakdown.

stage environmental performance can be improved." (p. 7) The potential for design improvement is greatest at the initial stages and least at the later stages. Improvements to a building design when foundations are being casted will maybe be very costly and extremely troublesome to the operational process. Figure 2-8 graphs how the chance to make changes decreases significantly and the costs to change design concepts increase dramatically as the processes advance. As shown in the figure, the biggest payoff is at the beginning of the development curve where integrated design can be most beneficial. (Zimmerman and Eng 2006)

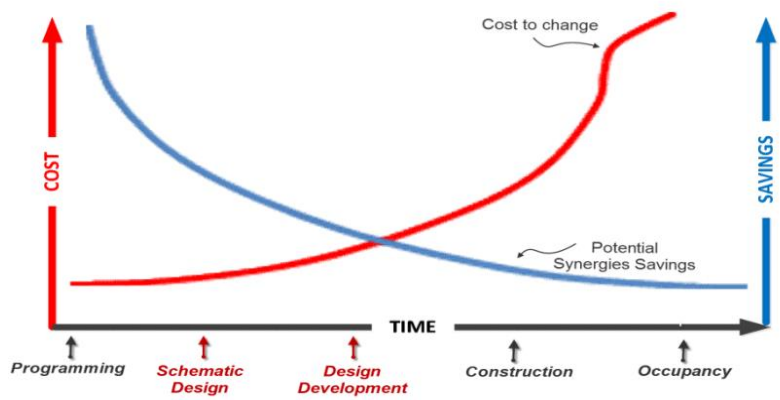

Figure 2-8 Opportunities for Change and the Design Sequence, adapted from BC Hydro, IEA Task 23 (Zimmerman and Eng 2006)

The green strategies that are associated with every design stage (Table 2-1) vary with climate condition, and then with project location. Building size, complexity, and use influence those issues by altering the demand for heating, cooling, ventilation, or daylight. However, the design process can balance these strategies, and the architect has an obligation to manage and deal with all those strategies, especially at the early stages (Cofaigh et al. 1999).

Table 2-1 Green strategies at different stages; adapted from (Cofaigh et al. 1999)

	Stage	Issues
DESIGN	Inception	• Briefing: identify green design as issue to be considered • Agree environmental performance target • Prefer brownfield to greenfield sites
DESIGN	Design – preliminary studies	• Analyze sites for sunlight, shelter and available shading • Research the building type and analyze good practice examples • Consider what is achievable given the cost constraints
DESIGN	Sketch studies	• Site layout: use passive solar strategies, including daylight • Provide solar access to residential living spaces • Use thermal mass to dampen temperature fluctuations • Maximize daylight penetration using plan and section • Consider water supply and waste handling methods • Use locally produced materials • Make iterative studies of design concepts to assess performance
DESIGN	Pre-project	• Consider room heights for heating, cooling and daylighting • Consider thermal mass for building use pattern: intermittent or continuous • Optimize proportion and distribution of external envelope openings with heating and lighting in mind • Specify design criteria for services • Calculate predicted building performances and assess against targets
DESIGN	Basic project	• Finalize layout (plans, sections, elevations) for statutory approvals: implications for daylight/ventilation/passive and active system • Select materials and construction methods having regard to thermal mass, opening and shading, sourcing of materials
DESIGN	Execution of Project	• Develop specifications for good workmanship and site management • Detail for thermal performance, daylight, controlled ventilation • Specify window and external door frames for environmental performance • Consider internal and external finishes for environmental friendliness • Consider environmental performance in selection of heating and cooling plant, radiators, controls • Specify electrical lighting equipment and controls for lowest consumption • Speedy sanitary fittings for low water consumption
CONSTRUCION	Tender procedure	• Explain the requirements of green design to tendering contractors • Specify more demanding constructs practices and tolerances
CONSTRUCION	Supervision	• Protect the natural landscape of the site as much as possible • Ensure completeness of insulation coverings and no thermal bridging at openings • Contractor should not substitute materials or components without architect's approval • Ensure acceptable methods of waste disposal
CONSTRUCION	Acceptance	• Make sure client and users understand building concepts and systems (provide maintenance manuals) • Show how to get maximum value from the active systems controls
CONSTRUCION	Defects period	• Monitor active systems for actual as against projected performance
MAINTENANCE AND REFURBISHMENT		• Use green finishes materials where these were originally applied • Use environmentally-acceptable cleaning and sanitation materials • Undertake energy audit prior to commencing project • Survey the potential for upgrading of active services • Survey the potential for upgrading of envelope • Consider indoor air quality and healthy building environment

2.4.3 Inclusion of Environmental Factors

The inclusion of environmental factors, such as through climate analysis, site analysis, sun and solar analysis, and daylighting analysis, were typically not part of design process 30 years ago, but now they are inherent in the design of environmentally responsive buildings.

2.4.3.1 *Climate Analysis*

Urban climates often differ from the climate of their surrounding regions, and there is a strong relationship between urban forms and space and, energy-efficient urban design (Cofaigh et al. 1999). Each site has its own unique climatic characteristics that need to be analyzed. Climate analysis of the site is required to determine how the building will modify the site's microclimate conditions (Hyde 2000). The microclimate must be identified not only for its natural elements, but also for how any non-natural elements, are affecting the site. For example, for buildings and landscaping, creating a shelter that protects against the winter winds or the sun can change the microclimate of the site significantly. The factors most affected by the site are as follows:

Temperature: Large cities tend to be considerably warmer than the surrounding countryside—about 1-2°C higher daily mean temperatures. This is caused by buildings, transport systems, and industry. For example, buildings impede wind flow, reducing its potential cooling effect (Cofaigh et al. 1999) (Hyde 2000).

Wind: Average air movement in cities tends to be slower than in the countryside because buildings and other structures create obstacles. It has been reported that wind velocity within a city is half of what it is over open water (Cofaigh et al. 1999). In all cases, the sites should be selected to maximize exposure to breeze and summer cooling. Therefore, the elevation and orientation of the building are crucial factors in climate analysis for a specific site (Hyde 2000).

Sunlight: Solar access is a constant factor of microclimate. Buildings, vegetation, and other urban structures obstruct direct sunlight and solar access to some degree. Reflectance from adjacent buildings and ground surfaces is a secondary problem (Hyde 2000). "Whether this is a benefit or disadvantage depends on other parameters of the microclimate. Depending on latitude, exposure to or protection from summer sun can be the more important" (p. 48) (Cofaigh et al. 1999).

2.4.3.2 *Site Selection and Analysis*

Sustainable site selection must consider the site's and the future building's place in and its contribution to the wider environment. According to McNicholl and Lewis (1996):

> *Decisions on how to use the site, if indeed it should be built on at all, establish the base on which all later design decisions rest. The site provides the context for the buildings, but the buildings in turn modify the site. The local ecosystem is altered, habitats changed and flows of energy, water, nutrients and pollutants modified. Neighbouring buildings and distant communities are affected.*

Site analysis is a critical early step in developing a green solution to an architectural problem. According to the Rocky Mountain Institute (1998):

Careful site assessment can enable developers to capitalise on the land's potential views, solar access, natural drainage opportunities, natural shading through vegetation, cooling from prevailing winds - while minimising or avoiding damage or disturbance to the site and surrounding areas. (p. 130)

During site analysis, the design team identifies what characteristics of a site may benefit or constrain the design. For example, a site will have its own resources and materials, features, and constraints, including drainage patterns, infrastructure, notable topography, vegetation, existing structures, and microclimates. The natural and existing characteristics of a site influence the feasibility and cost of building there, as well as building design elements, including building shape, architectural massing, building materials, surface-to-volume ratio, building footprint size, and solar orientation (Kwok and Grondzik 2011).

2.4.3.3 *Sun and Solar Analysis*

Architects and designers have always paid great attention to sun and solar analysis. Buildings in colder, higher latitudes may benefit from the sun's warmth, especially during the winter months, but buildings in tropical regions may not. The amount of heating required depends largely on the latitude and the function of the building.

The building design can integrate sunlight to supplement the lighting of interior spaces. However, excessive sunlight will overheat the building. A design can shed solar energy during summer or collect it to provide lighting and, during winter months, heating. When this type of system functions without the aid of technical systems, it is known as passive solar architecture. The main goals of passive solar design are to reduce the fossil fuel consumption of buildings as well as to produce buildings that act in conjunction with natural forces, not against them.

Passive solar heating requires two primary elements: south-facing glass and thermal mass to absorb, store, and distribute heat. In *Solar in Architecture*, Christian Schittich (2003) states that to achieve the most effective form of solar architecture, the building itself must make direct use of solar energy by virtue of its placement, geometry, building components, and materials:

The clever selection of the site, placement, shape and orientation, deliberate window arrangement, considered selection of materials and wall structures – these are the factors that make it possible to absorb and store heat, to maintain comfortable temperatures in a climate-conscious envelope and utilize light to the best effect. (pp. 13-14)

Designs with south-facing windows are encouraged in the northern region of the northern hemisphere; this can harness more solar energy in the winter. Elements that store thermal energy, such as concrete floors, masonry, water walls, and roof ponds, are often used in conjunction with south-facing windows (Kwok and Grondzik 2011).

A building's form and orientation to the sun can play a significant role in energy reduction. Cofaigh et al. (1999) say that energy consumption can be reduced by 30% to 40% at no extra cost if the building is designed with the right shape and correct orientation. They further add that zoning and orienting spaces in relation to their heating, cooling, lighting, and ventilation needs can minimize the total energy demand of the building. Moreover, they emphasize locating spaces that require nonstop heat in the winter season on southern facades so they can gain as much solar energy as possible, while locating the unimportant spaces on the northern side of buildings. For optimal performance of passive solar heating, heat-gaining spaces should all face within 15° of due south (Cofaigh et al. 1999).

The first strategy in passive cooling is to avoid solar heat gain, which can be achieved primarily through shading and glazing selection. Shading devices must be used to control and block unwanted sunrays in summer. This can be designed with the aid of solar angle charts for specific dates, times, and regions. For example, the areas in latitudes from 15° to 30° north and south of the equator have a hot, dry climate[7] (Hyde 2000, Kwok and Grondzik 2011).

2.4.3.4 ***Daylighting***

Daylight availability depends on the location of the site and the orientation of the building within the site. A climate analysis is absolutely essential in the planning of building designs and particularly in daylighting design. As Kahn said, “No space, architecturally, is a space unless it has natural light…” (p. 15) (Kahn 2011).

According to Schittich (2003), daylight differs qualitatively and quantitatively from artificial light in many different aspects. He gave the example of spectral composition and brightness and its variation over a day. This variation is why daylight is very important and cannot be replaced by artificial lighting. However, daylight can only be used as a supplement to artificial lighting and not as a main source of light.

Buildings should be designed to capture as much daylight as possible and thus reduce the amount of generated energy they consume. Depending on its function, a building may or may not be oriented to face the sun. For instance, the north-south axis is unwelcome for residential buildings design. This is because of the low morning and evening sun angle that can penetrate directly into the building interiors and cause glare discomfort. Commercial buildings may be orientated to the east-west axis to capture the long sun rays for practical and aesthetic reasons. The east-west axis is welcomed by both residential and commercial buildings design. This is because of optimal performance of passive solar heating, daylighting, and natural cooling.

Nick Baker (1999) states that for artificially lit buildings, “lighting is the single largest user of energy, but can be reduced by more than half in daylight…” (p. 42). Artificial lighting accounts for about 50% of the energy used in offices buildings and a significant amount of the energy used in other non-residential buildings (Cofaigh et al.

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[7] The climate of Saudi Arabia is hot and dry during summer season (latitude is 24° N)

1999). Baker gives the example of a typical shallow-plan office building: with a plan depth of 15 m, occupied during regular working times, such a building could achieve 70% of the working illumination by daylight (Baker 1999).

Finally, Cofaigh et al. (1999) say that, in recent years, the combination of the use of daylighting and high-performance lighting has reduced energy consumption between 30% and 50%, while 60% to 70% savings are possible in some cases. Therefore, a building's characteristics, such as its function, energy and environmental targets, hours of use, type of user, and requirements for view, privacy, and ventilation, all affect the requirements for daylighting design.

2.4.4 New Technologies and Building Systems

New technologies and advances in building systems such as heating, ventilation, and air-conditioning (HVAC) and water and waste management; new materials; and new building enclosure components have all had an impact on building performance and should be involved in the design process. These new technologies should support better living and working conditions for building occupants.

Prize winning *New York Times* columnist Thomas L. Friedman says, "Green technology is going to be the industry of the 21st century…green is the new red, white, and blue" (Urban Land, 2006). There are other indicators that world culture has grown more environmentally aware and active. The public reception to Al Gore's film *An Inconvenient Truth* has been generally positive. The massive increase in hybrid vehicle sales, the continuing 15% to 20% annual growth in organic food sales, and many other indicators suggest that a paradigm shift is well underway (Jerry Yudelson 2006, Tango 2009).

The direction for the twenty-first century is clear for the architectural community. We must recognize that the majority of our buildings consume massive amounts of energy as shown in (Figure 2-2, Figure 2-3).

2.4.4.1 ***HVAC***

HVAC systems are responsible for maintaining comfortable conditions in most buildings. These systems, along with lighting, consume a large percentage of a building's energy supply and hence are a major impact on the environment. In residential buildings, heating and cooling account for more than 45% of the buildings' total energy consumption. Currently, buildings use either central or local systems to provide thermal comfort. Central heating systems use a furnace, boiler, or heat pump to transfer heated air, water, or steam through ductwork or radiators (Attmann 2009).

A variety of new technologies have been developed and tested to improve the energy efficiency of building heating and air-conditioning systems. In their book *FUNDAMENTALS OF HEAT AND MASS TRANSFER*, Incropera et al. (2006) say that the average change efficiency of gas furnaces for space heating in the past was about 80%, while today, systems with 90% or higher efficiencies have replaced these old, less efficient furnaces in many commercial buildings and residences (Han et al. 2010).

Indoor air quality often depends on the ventilation systems that circulate air within the building and exchange the interior air with the exterior air. Ventilation systems also control temperature and humidity levels and remove airborne bacteria, odor, and dust (Cofaigh et al. 1999, Attmann 2009).

There are two types of ventilation systems: natural and mechanical. Natural ventilation is often the preferred method, as it uses operable windows and direct outside air circulation, when the temperature, wind, precipitation, humidity, and pollution levels are acceptable. For example, in hot climates, cool air should be circulated at night and then retained within the structure throughout the day by preventing additional air circulation. Natural ventilation can save a building up to 10% to 15% of its energy consumption if used correctly (Attmann 2009).

If natural ventilation alone is not adequate, supplementary mechanical ventilation can increase the ventilation rate (Cofaigh et al. 1999). Mechanical systems force ventilation and circulate the air, remove odors, and control humidity within the buildings when needed, especially in wet spaces not naturally ventilated, such as bathrooms (Attmann 2009).

The HVAC technologies used in buildings should be efficient, effective, and productive. Technology efficiency should apply to the entire building cycle, including water and energy efficiency. These elements should also be effective—by producing desired results—and productive—such as by changing and storing energy and water.

2.4.4.2 ***Enclosure***

According to Paul Scheckel (2005), "The first place to look to minimize the impact of a mechanical system isn't the equipment, however; it's the building's design and construction." In the design process, architects and designers should focus on the building's envelope and use appropriate insulation, windows, roof systems, and walls systems to minimize the need for supplemental air conditioning.

HOK, a leading architecture firm in sustainable design, says, "Integrated design solutions allow for cost shifting to occur within a conventional budget envelope" (p. 13). Increasing spending on the building's envelope and on improved lighting can decrease the size and cost of mechanical systems (Mendler, Odell, and Lazarus 2006).

In other words, a building envelope that insulates walls, roofs, windows, and floors, along with a good level of envelope air-tightness, will not only reduce heat loss but also reduce the required capacity of the mechanical heating system. At the same time, increasing south-facing glazed areas of the building will increase passive solar heating and daylighting, yielding savings in heating system capital cost.

New solar technologies are promising in terms of creating green, nonpolluting energy from an infinite source. The main active solar collection systems today are flat plates, concentrating troughs, and tracking dishes, and every system has its specific physical characteristics and its challenges to integrate into a building. For example, solar panels might be installed as shading devices on vertical wall planes and installed at particular angles (based on the site's geographic latitude) to take full advantage of solar collection, or a building could have an entire solar array functioning as a roof plane or as a plane to collect water (Tango 2009).

Glazing selection is also an important consideration in window design because it determines the visual, thermal, and optical performance of the window. Uncontrolled solar gain results in high cooling loads, excessive illumination, and glare. Architects should use knowledge of the sun and the sun's path to design buildings to fully utilize the available solar energy and also to shed excessive solar energy.

Roofs lose a large amount of a building's heat because of their relatively large surface area and because of nighttime radiation to the sky. Roof insulation plays a significant role in reducing the consumption of energy for heating and cooling. Insulation is measured by an R-value: the higher the R-value, the greater the insulating capacity of the material. Green roofs have recently become more popular worldwide. According to the third annual Green Roof Market Industry Survey, the installation of vegetated roofs in the United States increased by 30% between 2006 and 2007 (Tango 2009). The United States follows Europe and Asia in the use of green roofs. For example, 10% of the roofs in Germany are green while in Tokyo, a 2001 law mandated that all new and remodeled buildings must have 20% of the roof area covered in vegetation (Tango 2009).

A study of the City of Chicago City Hall rooftop garden tested its cooling effects and ability to sustain a variety of plants in three different depths of growth media. Results from the garden's first summer showed a roof surface temperature reduction of 70 degrees and an air temperature reduction of 15 degrees (Tango 2009). The insulation value of soil depends on its moisture content and density; values for conductance range from 0.7-2.1 W/m^2K, given a U-value of 0.15-0.4 W/m^2K for a 200-mm-thick layer. However, the main benefits of green roofs are aesthetic. They can provide a haven for wildlife in a city and may moderate local microclimates if present in sufficient quantity (Cofaigh et al. 1999).

Walls are not less important than the roofs, and they too have new technologies. The double-façade curtain wall is an architectural technology designed to combine the aesthetic benefits of a high glazing ratio (more than 90%) with the energy efficiency and comfort of a solid envelope. Double façades consist of an outer façade, an intermediate space, and an inner façade. One or even both skins may be double-glazed; the outer skin (a non-load-bearing curtain wall) provides weather protection and a first line of acoustic isolation. The intermediate space is used to buffer thermal impacts on the interior (Cofaigh et al. 1999, Kwok and Grondzik 2011).

Cofaigh et al. (1999) list environmentally responsive strategies for envelope design that should be taken into account at an early design stage:

- *Respond to orientation. The world about the building is not symmetrical. Modify the envelope to respond to the problems and opportunities presented by different facade orientations.*
- *Keep the fabric warm. Place insulation as close as practicable to the exterior face of the envelope. This allows the envelope to contribute to the thermal mass of the building, helps to even out interior temperature fluctuations, and raises the radiant temperature of the interior.*
- *Design for durability. Specify for long life and low maintenance to minimize the use of energy and materials over the life of the building.*

- *Keep it simple. Do as much as possible by architectural means before resorting to service installations to fine-tune the indoor environment.* (p. 63)

2.4.4.3 ***Materials***

As a whole, a building's design cannot easily be separated from the choice of material and components that will go into it. Their selection profoundly influences design and performance and should be based on their efficiency, effectiveness, and productivity. Designers can select more efficiently produced materials, such as recycled elements with minimal waste, or they can add engineered components, such as engineered lumber.

The criteria for building materials have changed. For example, material requirements for environmental considerations and human health were not part of the design process 30 years ago, but they are now. Architecture firm HOK has made the persuasive case that the old decision model based on cost, schedule, and quality is no longer valid (Figure 2-9). Designers need to become equally familiar with the consequences of their decisions on the environment and human health. The new decision model now has five points, with the addition of human health and safety as well as earth health (ecology), as shown in Figure 2-10 (Mendler, Odell, and Lazarus 2006).

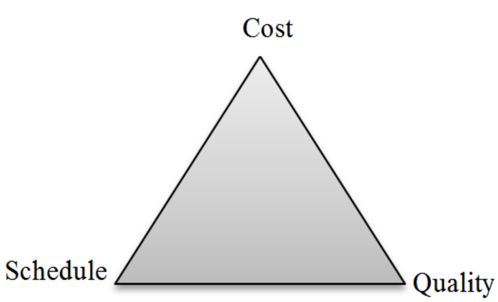

Figure 2-9 Old decision model (Mendler, Odell, and Lazarus 2006)

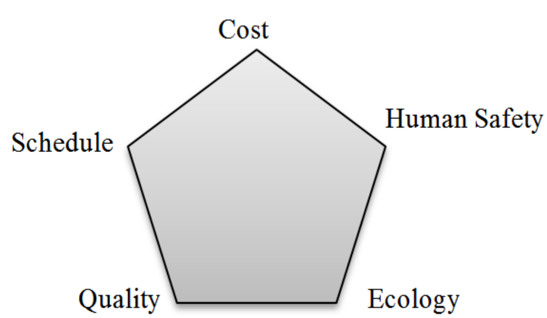

Figure 2-10 New decision model (Mendler, Odell, and Lazarus 2006)

Cofaigh et al. (1999) discuss the multifaceted nature of analyzing a building's environmental impact:

> *To establish the true environmental impact of a building, the analysis may be carried out in a way that reflects the relative importance of different*

building elements and processes, and the priorities for reducing environmental impacts. This is called life cycle analysis.[8] (p. 39)

Comprehensive life-cycle analysis requires a substantial amount of information for a whole building, and the task may not be feasible for all elements. However, it is possible to analyze selected building elements or components. While the notion of cradle-to-grave analysis may be out of reach for all building elements, professionals know that such analysis can help rationalize material selection (Cofaigh et al. 1999).

Although numerous factors influence the different stages of a building's lifetime, careful planning and construction can account for and, if necessary, counteract nearly all of them. Decisions made during the materials selection stage determine the level of resources and energy consumption during future stages, such as maintenance, renovation, conversion, and restricting (Figure 2-11) (Berkeley-Lab 2008).

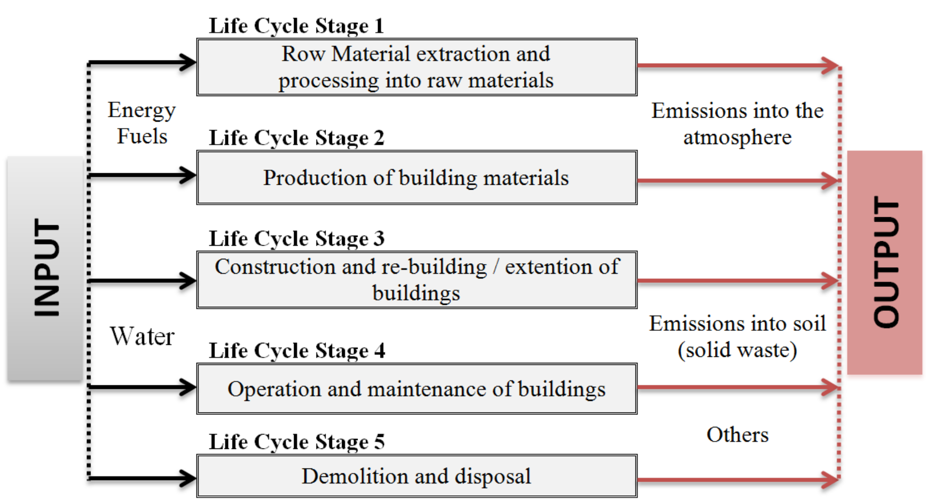

Figure 2-11 Building life cycle flow chart adapted from Cofaigh et al. (1999)

Any architect who is concerned about the environmental impact of the selected materials must consider several issues. A brief checklist of these issues follows (Cofaigh et al. 1999).

For materials used in quantities of 250 kg or less, consider the following issues:

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[8] Scientists, manufacturers, and policymakers frequently use life-cycle analysis (LCA) to expose the opportunities to reduce environmental impacts across the whole life cycle of products, from production to disposal (Berkeley-Lab 2008).

- *Impact of the material's production: habitat destruction, toxins released;*
- *Any hazards to health or local environment during construction or use;*
- *Life span of the material;*
- *Eventual destination of the material after the building's life. Re-use is better than recycling, which is better than incineration or landfill;*
- *Reduction/separation of construction waste and avoidance/careful disposal of toxic waste.* (p. 113)

For bulk materials, consider all the above issues and also

- *the nature of the resources involved: renewable or non-renewable, scarce or abundant;*
- *emissions of CO^2 (in kg/kg) during production or, if information is not available, embodied energy (in kWh/kg);*
- *how far and by what mode(s) the material will be transported, and emissions/energy use due to this.* (p. 113)

Last but not least, the use of non-toxic, natural materials contributes to the well-being of the users and to a feeling of connection with the bounty of the natural world. The use of durable, attractive, and environmentally responsible building materials is a key element of any green building effort.

2.4.5 New Simulation Tools

Three decades ago, the steady-state method was commonly used to calculate heat loss and gain. This method was used to determine heating and cooling peak loads and HVAC equipment's sizes, but these calculations give only a fractional picture of the thermal performance under design load conditions, either in summer or in winter. The steady-state method does not yield the overall energy performance of the building. It also insufficiently deals with daylighting, solar loads, and thermal capacitance effects. Today, computer simulation tools are an essential component of the whole-building design process. A dynamic, hour-by-hour computer simulation of a typical climate year will complete the picture of energy use by revealing energy cost, peak load, and comfort performance. In the design process, computer simulation can identify areas of specific concern and areas for potentially important energy savings (LANL 2002).

Architects and designers use these tools to determine the factors affecting the performance of a particular building, support their decisions on the optimal combination of design solutions, forecast the actual building performance, and identify performance problems after construction is completed.

To achieve these benefits, designers should incorporate computer simulations of the proposed building early in the design process. Decisions made in the early stages of design often have a significant impact on energy efficiency and the quality of the building's internal and external environment. Simulation tools can support the integration of green design principles, including user comfort as well as the productivity of its inhabitants while minimizing resource utilization and waste generation (Yeang and Spector 2011).

In the book *SUSTAINABLE DESIGN GUIDE*, the Los Alamos National Laboratory recommended six steps in the design process for which computer simulation should be used (Figure 2-12) (LANL 2002):

1. ***Pre-design:*** *Simulation helps identify and prioritize potential envelope-based energy efficiency strategies.*
2. ***Schematic design phase:*** *Add the building massing, fenestration, and envelope constructions to the model to determine if energy targets are still being met.*
3. ***Design development:*** *Test the performance of the full building together with the HVAC systems.*
4. ***Construction:*** *Evaluate how design changes proposed during construction will affect the building[s] performance before implementing the change.*
5. ***Commissioning:*** *Run a simulation of the as-built construction to provide a baseline building performance that can be used for actual performance comparisons.*
6. ***Post-Occupancy:*** *Periodically update the simulation after the building is occupied to reflect variations in operations, use patterns, and unique climate conditions. These conditions may dramatically affect the actual performance of the building.* (p. 55)

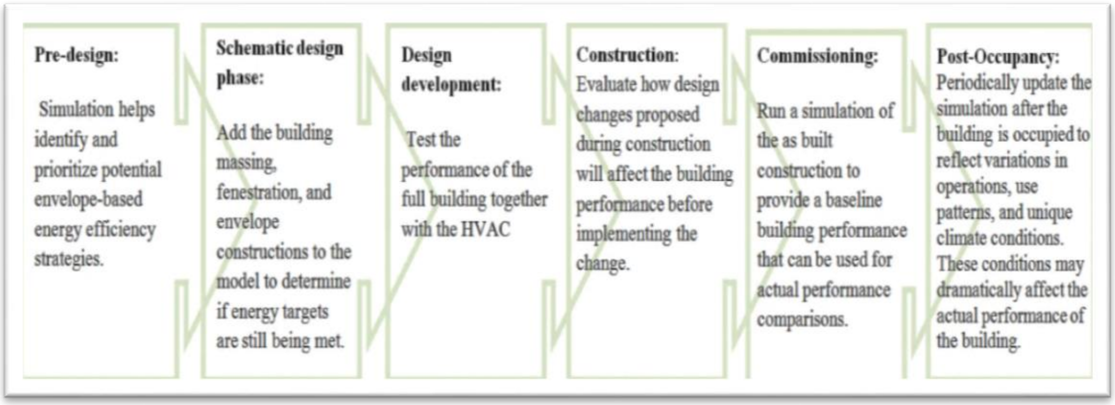

Figure 2-12 Building design steps where computer simulation should be used

2.5 Green Architecture

2.5.1 History

In the mainstream American and British architectural discourse, environmental consciousness emerged in the period surrounding the oil crisis of 1973. In the United States, public pressure to address energy conservation caused President Carter to sign the National Energy Act (NEA) and the Public Utilities Regulatory Policy Act (PURPA). In 1977, President Carter convinced Congress to create the United States Department of Energy (DoE), with the goal of conserving energy (Attmann 2009). In the same year, the federal government began to provide solar tax credits as a subsidy to lower the cost of investing in solar energy systems. Also, several states adopted model energy codes that incorporated new efficiency standards (Furr, American Bar Association. Section of Real Property, and Law 2009, Attmann 2009). The oil crisis led to greater interest in renewable energy and encouraged research on other energy sources, including solar, wind, and nuclear power. A number of green architecture practitioners, such as Andrew Scott, as well as the Canadian Centre for Architecture's 2008 exhibit *1973: Sorry, Out of Gas*, support the chronology that the architectural response to environmentalism appeared after the oil crises in the 1970s (Baweja 2008).

The architecture field followed the trend closely and started to change. A number of architects adopted new energy strategies, and hundreds of solar homes started to appear across Europe and the United States. The development of environmentally responsive concepts in architecture became imperative, and green building rating systems started showing up. In the 1990s, the Building Research Establishment's Environmental

Assessment Method (BREEAM) was one of the first acknowledged rating systems to evaluate the sustainability of new office buildings in the United Kingdom. Subsequently, the Environmental Resource Guide was published in 1992 by AIA, and in the same year the Environmental Protection Agency (EPA) and the DoE launched the Energy Star program. A year later, the U.S. Green Building Council (USGBC) was created, and in 1998 it launched the Leadership in Energy and Environmental Design (LEED) pilot program (Trusty 2000). Most architects in the United States were not excited about the LEED program because they knew it was just a copy of the British system BREEAM, whose success stemmed from a swelling of user demand for better environments for commercial buildings (Scott 2006).

In his paper *Design Strategies for Green Practice*, Andrew Scott (2006) expressed his interest in design strategies for green practice. He believes the current sustainable architecture criteria are not enough for good architecture:

> *The existence of sustainability is not a guarantee of good architecture, and in many cases it can and does become a bandwagon for somewhat mediocre design that emanates from a points-based approach to environmental stewardship that is too disconnected from innovation.* (p. 12)

Scott added that in 1996, when the "Dimensions of Sustainability" conference was organized at MIT, "sustainable architecture" was a new term, with roots in the back-to-the-earth ecological movement of the 1970s: "off the grid solar power, ecologically based materials, and construction techniques with a strong dose of 'alternative-ism' but with little relationship to advanced design and sophisticated applications of new technologies or production methods" (p. 11). He also criticized Lord Norman Foster's meaning of sustainable design, "doing the most with the least means," because it framed sustainable architecture as a technical challenge, rather than a matter of design or general mentality. Sustainability was being considered mainly as about lifestyles and alternative buildings while the urban dimension was almost missing (Scott 2006). However, in 1970, a mix of multidisciplinary groups of academics and leading practitioners (engineers, ecologists, landscape architects, space planners, urban designers, and architectural theorists) met to discuss how their work was responding to environmental issues, what kind of design processes they were using, and what the larger issues were that they saw emerging. This meeting created a new, multidisciplinary platform for exchanging notions about sustainable architecture and the challenges of the new environmentalism, including energy and climate change, but most importantly for sharing ideas on design (Scott 2006).

Ten years later, the picture had changed significantly. Ideas about environmental responsiveness, such as definitions and categories, had thoroughly penetrated the public consciousness. The publication market was saturated with internationally published books and magazines about sustainable design and many related topics, such as “green design, sustainable architecture, ecological architecture and construction, ‘eco-tech,’ bioclimatic building, low energy design, energy-conscious design, zero energy design, zero carbon buildings, zero environmental impact, biomorphic architecture, sustainable development, and so forth” (Scott 2006) (p. 12).

2.5.2 Green Architecture Today

According to Spector (2011), “We have now completed the ‘conceptual stage’ in designing for our sustainable future, and next we have to delve deeply and quickly into the ‘design development stage’ of green design and clean green technologies” (p. 6).

Scott (2006) puts sustainability into a larger context:

> *Sustainability is as much about enhancing culture, livability, health, and place-making as it is about the development and application of technology for reducing energy dependence, CO^2 production, and mitigating the abundant use of resources. It is about understanding the relationship of the design project to the conditions of a larger ecological system within which we operate and survive and where we understand our impacts on water resources and ecological landscapes. It is also about designing WITH the climate instead of AGAINST it so that the form, typology (the type characteristics of building), and tectonic (material) language of the architecture enhance the notion of passive or benign technologies. Architectural projects must adopt an attitude toward their lifespan and longevity, and be designed for permanence, disposal, or to be recycled, while at the same time be able to map their life cost, resources, emissions, and energy profile. (p. 13)*

Green design is an approach that produces buildings that are environmentally responsible and resource efficient throughout their life cycle. The objectives of this strategy are to provide a safe place for the occupants and conserve resources.

Many architects think that green design is about achieving the highest level of rating on a performance scale. Few deny the importance of rating systems such as BREEAM or LEED as useful references for buildings, but these systems are not comprehensive. They work as a limited checklist of green design considerations (Yeang and Spector 2011). In other words, this checklist encourages points-chasing but does not identify and reward the larger ideas in a project that create greater design innovation in significant ways or change the form of architecture. For example, a building can be based on weak architectural ideas and still receive a high LEED rating. LEED certification does not seek to quantify or recognize a building's integration, environmental responsiveness, and architectural sophistication (Scott 2006).

Green design is about much more than reducing energy use, water use, or carbon emissions. Green design should address a variety of interrelated issues, including social, cultural, psychological, and economic dimensions (Buchanan 2005), which are as important as energy efficiency and low carbon emission. Ken Yeang says that architects do not fully understand green design, and most think that is about the use of photovoltaics, wind-powered generators, compliance, and other technological and regulatory matters. Green design is more than that; it is complex and not as easy as had been imagined (Yeang and Spector 2011). Tango (2009) added that the building industry is well positioned to have the strongest influence on the direction of energy conservation through architects and engineers, but they must never lose sight of the fact that buildings are designed for people and should be designed for their comfort, not just to meet energy requirements.

Scott says, "The challenge for architects now is to merge the qualitative with the quantitative aspects of sustainability and green building and to expand the boundaries into other material and ecological systems issues." Such a merger would look at the design process with a more sophisticated understanding and combine interdisciplinary design practice with demanding environmental objectives that can be applied at the micro scale of a building or at the macro scale of urbanism (Scott 2006).

Buchanan (2005) referred to 10 key characteristics (

Table 2-2) that should be considered in green design, along with examples that combine environmental responsibility with formal ambition. He described projects that embody these characteristics, such as the Beyeler Foundation Museum in Switzerland 1992-97, Commerzbank Headquarters in Germany 1991-97, and others. These projects range broadly both in the ways they incorporate environmental solutions and in formal structure. Through these examples, he creates a background for understanding and evaluating all works of architecture and land planning in terms of concerns from technical efficiency to communal well-being to emotional character (Buchanan 2005).

Table 2-2 The ten key characteristics of green design adapted from Buchanan (2005)

1-Low Energy/High Performance	Achieved by making maximum use of natural light and ventilation as well as by using sunshades and/or light shelves, insulation and multi-layered facades and roofs, appropriate thermal inertia (high in temperate climates, low in tropical), solar heating, evaporative cooling, water chilled ceilings, displacement ventilation in tall volumes and the redefinition of comfort standards.
2- Replenishable Sources	Buildings as well as power plants can harvest the non-depletable ambient energies of the sun, wind, waves, gravity and geo-thermal power. Build with constantly replenished materials, such as wood, or near inexhaustible ones, such as clay (for brick) and sand (for glass).
3-Recycling: Eliminating Waste and Pollution	Reuse old building materials, design buildings that are easily reused and build them with easily reused materials and components. Recycle water and heat. Avoid materials that are toxic in use or manufacture, or need to be cleaned with toxic materials.
4-Embodied Energy	With energy efficiency, embodied energy becomes increasingly significant in relation to life-time energy use. The material with lowest embodied energy is wood, then brick, and that with most embodied energy is
5-Long Life, Loose Fit	Built with materials that endure and improve with age, green buildings not only accommodate change easily but [also] are relatively timeless and pleasant in character so that people prefer to conserve them.
6-Total Life Cycle Costing	Accounts for more than initial capital costs, to include running and wage costs. Also looks at costs to environment and society of all aspects of the building, right from extracting the materials to their eventual degradation back to earth.
7-Embedded in Place	Green buildings fit seamlessly into, help reintegrate and minimize negative impacts upon their settings. Depending on the projects, drawing on local wisdom and updating the vernacular, or using scientific surveys and predictive computer modeling, are equally appropriate approaches to achieving this.
8-Access and Urban Context	To be green, a building must be close to public transport and other quotidian uses. Achieving a green built environment will involve rethinking not just buildings, but cities and other forms of human settlement.
9-Health and Happiness	Natural light, fresh air and absence of toxic materials and off-gassing combined with the contact with outdoors and community life makes occupants of green buildings healthy and happy. This leads to diminished absenteeism and staff turnover as well as increased productivity.
10-Immunity and Connection	To help achieve sustainable culture, green buildings must regenerate a sense of community and connection with the natural world thus giving a sense of belonging and chance to discover one's deeper self in opening up to other and the cosmos.

In his book *Green Design from Theory to Practice*, Ken Yeang lays out five strategies for getting the built environment as close as possible to stasis with the natural environment (Yeang and Spector 2011):

1. *The first strategy is to view green design in term of the weaving of four strands of infrastructure: the 'grey' (the engineering infrastructure, being eco-sustainable engineering systems and utilities), the 'blue' (water management and closing of the water cycle with sustainable drainage), the 'green' (the green eco-infrastructure, or nature's own utilities) and the 'red' (our built system, spaces, hardscapes, society and regulatory systems.) Green design is the blending of these four stands into a seamless system.* (See Table 2-3)

Table 2-3 The Four Strands of Eco-Infrastructures (adapted from (Yeang and Spector 2011)

GREEN	GREY	BLUE	RED
Ecological Eco-Infrastructure: Nature's Utilities, Biodiversity Balancing, Ecological Connectivity, etc.	Engineering Eco-Infrastructure: Renewable Energy Systems, Eco-Technology, Carbon Neutral System, etc..	Water Eco-Infrastructure: Sustainable Drainage, "Closing the Loop", Rainwater Harvesting, Water Efficient Fixture, etc..	Human Eco-Infrastructure: Enclosures, Hardscapes, Use of Materials, Products, Lifestyle and Regulatory Systems.

2. *The second design strategy is to regard green design as a seamless and benign environmental bio-integration of the artificial (the man-made) with the natural environment.*
3. *The third strategy is to regard green design as 'ecomimesis', imitating eco-systems' processes, structure, features and function. This is one of the cornerstones of eco-design. Our built environment must imitate eco-systems in all aspects, e.g. recycling, using energy from the sun for photosynthesis, and increasing energy efficiency, achieving a holistic balance of biotic and abiotic constituents in the eco-system.*
4. *The fourth strategy, eco-design can be regarded as not only creating new artificial 'living' urban eco-systems or rehabilitating existing built environments and cities, but also restoring existent devastated eco-systems within the wider landscape of our designed system.*

5. *The fifth strategy for eco-design is to regard our designed system in the context of the biosphere globally as a series of interdependent interactions environmental stasis and the repair of the environmental devastation by humans, natural disaster and the impact of our human built environment, activities, and industries (Yeang and Spector 2011).*

Green architecture has evolved through the work of Ken Yeang and through 'Ten Shades of Green' by Buchanan, included, the criteria for green design and the roots of green architecture. Architectural education must support these changes and new criteria for design.

2.6 Architecture Education

2.6.1 History

Masterbuilder

Five thousand years ago, the architect was seen as a design-build professional, an artist of the built environment, where he was both a designer and a builder. The history of the master builder extends all the way back to the building of the pyramids of Egypt and the world's first civilizations. The most significant and beautiful built places in the world—whether houses, villages, or cities—were designed and built by a master builder, who was responsible for the entire built environment. Moreover, he was responsible for educating, guiding, and mentoring his fellow craftsmen. Architects were educated through an apprentice relationship while working toward master builder status.

The ancient Greeks gave early master builders the name ἀρχιτέκτων (architekton), from which the Romans derived the Latin name, *architectus*. Both words literally mean "master builder." The modern English word *architect* was derived from the Greek and Roman terms and, up to the eighteenth century, was used to refer to someone who assumed overall responsibility for design and construction, which is slightly broader than today's usage of the word (H. Robert Dinsmore 2008).

In his book *The Culture of Building,* Howard Davis (2000) says, "In traditional society, the masterbuilder combined the functions of design and construction that are now assumed by separate professionals, and the system of apprenticeship taught people to take these functions on in a way that combined thinking and doing" (p. 108). The master builder's responsibility was not only to make drawings but also to work on the building site, including organizing trades and supervising workers.

H. Robert Dinsmore (2008) gave profound details of the master builder's responsibilities:

- *Responsibility for design—encompassing deep artistic abilities; drawing skills; profound understanding about how people live and dwell; art / design knowledge for actual shaping, constructing, all elements of the built environment (including buildings / parts of buildings, interiors, exterior landscapes, urban environments).*
- *Responsibility for construction—encompassing expert craftsmanship in the building arts; knowledge about how a beautiful building (or other environment) is built, as gained from actual construction experience; on-site project management (involving leadership, organizing / supervising workers, financial oversight, artistic discernment).*
- *Complete and total authority on the building site—authority over on-site design / construction decisions; authority over all workers; unquestioned authority over the entire construction phase from start to finish.*

According to Dinsmore, when all these skills meet in one person, it is easy to see why the masterbuilder was so much respected in society: "He differs greatly from today's architect or contractor, in breadth, scope, and depth of responsibilities."

Design Education (Bauhaus Model)

In 1919, the Bauhaus school was founded by Walter Gropius in Weimar, merging the Grand Ducal School of Arts and Crafts and the Weimar Academy of Fine Art (Fleming, Honour, and Pevsner 1999). The original school program at Bauhaus included all practical and scientific areas of creative work such as craft, as well as drawing, painting, science, and theory.

During an international exhibition held in Weimar in 1923, the Bauhaus coined the slogan "Art and Technology: A New Unity" (Emanuel et al. 1980). This was a turning point in educational strategy, which recognized the role and importance of technology as a new area to be considered in architecture design curriculum. This was the theoretical model in which the Bauhaus movement was grounded. The curriculum's distinction between “artistic instruction” (*Formlehre*) and “practical instruction” (*Werklehre*) is the most visible embodiment of this model (Findeli 2001).

In 1925, under the planning of Walter Gropius, Bauhaus developed a new curriculum that included practical instruction, form instruction (practical and theoretical), and supplementary areas of instruction (Findeli 2001). As can be seen in Figure 2-13, Bauhaus employed a threefold technology/art/science structure, instead of the polar art/technology structure, to support the curriculum.

In 1937, the New Bauhaus was established in Chicago under the direction of Lazló Moholy-Nagy. His ideas were introduced in a 1937 lecture, in which he said, “We don’t want to add to the art proletariat that already exists . . . we don’t want to teach what is called ‘pure art,’ but we train what you might call ‘art engineer’” (Moholy-Nagy 1969) (p. 149). He implies that “pure art” will be unprofitable if it does not integrate engineering. To counter this eventuality, Moholy-Nagy introduced changes in the structure and the content of the school’s curriculum. His new structure relied heavily on the philosopher Charles Morris’s[9] belief in combining the three main dimensions of design: art, science, and technology (see Figure 2-13) (Findeli 2001).

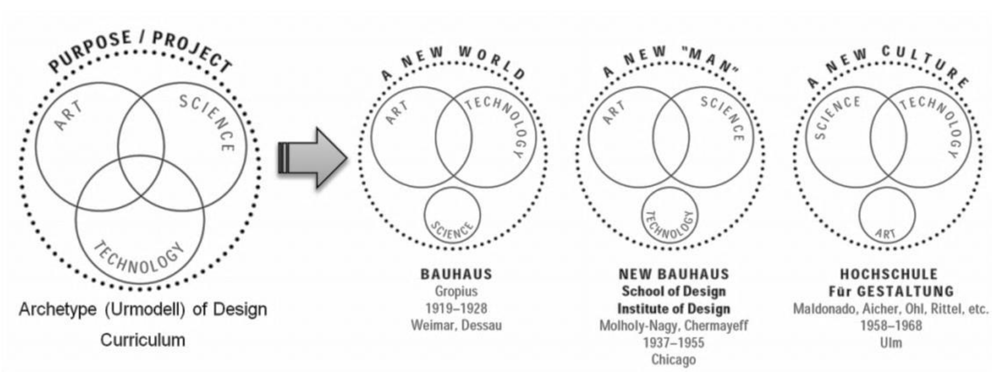

Figure 2-13 Historical embodiments of the archetype adapted from (Findeli 2001)

In the early 1950s, the Hochschule für Gestaltung (HfG) was opened at Ulm, under the direction of Tomás Maldonado, who declared that “these ideas [had] now [to] be refuted with the greatest vehemence, as well as with the greatest objectivity” (Findeli 2001). The

[9] Charles Morris is one of the main representatives of the Vienna Circle in the United States, and coeditor of the Encyclopedia of Unified Science, which can be considered the “Bible” of logical positivism (Findeli 2001).

new curriculum for the HfG increased the emphasis on scientific content, while the original curriculum became less and less important. “Science and technology; a new unity” could well have been the new slogan at Ulm (Findeli 2001).

As a consequence of Bauhaus’ influence, the latest educational model still roots art and craft in design practice. Everyone tends to agree on the necessity of including art, science, and technology in a design curriculum. The dynamics of this school produced a new philosophy and approach to design education, which has since influenced many programs in the United States and Europe.

2.6.2 Discussion of theoretical models for education

The design studio is at the core of architects’ education. Design-studio learning has been rapidly developing around the world to support a variety of progressive pedagogical models. The idea of the architecture design studio was started in the 18th century by the Ecole des Beaux-Arts. Its students were taught theory in the classroom and design in its early version of the studio, called atelier. The studio was in the professional office of an architect to provide academic architectural training, ensure the quality of work, and qualify the students to practice in the field (Frederickson 1991). In the 19th and early 20th centuries, other schools in France, England, and America followed suit (Moffett, Fazio, and Wodehouse 2003), and the idea attracted several architects from the United States (Conway 2005). During the 20th century, architectural design studios continued operating through the offices of architects such as Le Corbusier, which then started schools of art and design that have led more recently to schools of architecture (Eigbeonan 2013).

2.6.2.1 ***Teacher – Centered (Teacher Delivered Models)***

Learning models in the Beaux-Arts tradition centered on the studio-master or teacher and emphasized the product rather than the process. In this model, students were the recipients of information from instructors and contributed very little individually to the teaching-learning process (Elmasry 2007). Students learned by being involved in projects and preparing drawings for the studio-master in order to present their work to architecture competitions. The instructor decided the goals, objectives, and timetables, while the student’s role was simply to follow the instructor’s directions. Being teacher-centered and product-oriented are two characteristics that recent studies have shown to be detrimental to effective problem-based learning and self-regulated learning (Powers 2006).

In the early 20th century, many schools of architecture were established in the United States based on the style of the Ecole des Beaux-Arts, but with important differences. American architecture education incorporated courses in theory, history, and technology to complement the studio work. This increased the frequency, originality, and intensity of studio projects and also encouraged a shift away from competitions and toward student participation and interaction (Frederickson 1991, Powers 2006). This was a turning point in architecture education, in which studios shifted from the teacher-centered and product-oriented Beaux-Arts tradition toward American approaches focusing more on a social, independent, student-oriented studio. It's arguable that these changes were small changes between the Beaux-Arts and American approaches, associated with the increasing influence of Germany's Bauhaus School, led to contemporary teaching methods (Powers 2006).

Frederickson (1991) stated that there were three differences between the Ecole des Beaux-Art and Bauhaus educational views. First, Bauhaus focused on creativity, synthesis, and innovation derived from different sources, including the student, while the Ecole des Beaux-Arts defined knowledge as embodied in historical precedent. Second, the Bauhaus School fully incorporated social and functional issues into design, while instructors in the Ecole des Beaux-Arts school hardly discussed social or functional issues (Broadbent 1995). Finally, the Bauhaus approach changed the roles of the student and teacher by emphasizing process over product (Powers 2006). Gropius allowed students to take initiative, actively participate, and become more interactive, process oriented and open minded in the learning process, and he encouraged collaboration by giving students more responsibility for the studio project. In addition, the project became more about solving problems rather than representing a solution (Powers 2006). As a result, interest in alternative educational approaches to architecture design education has been gradually increasing and has led to increased student engagement through learning models such as self-regulation, problem-solving, problem based learning (PBL), and constructivism.

2.6.2.2 ***Student – Centered Model***

Students need to become more actively engaged in the studio project, and they should be able to set goals, monitor learning, and respond appropriately. Collins and O'Brien (2011) gave a description of student-centered instruction (SCI) that can be a good starting point for conversations about student-centered approach:

> *An instructional approach employing creative methodologies in which students become the center of the learning process by influencing the content, activities, materials, and pace of learning. If properly implemented, the SCI approach strengthens retention of knowledge and increases motivation to learn. (p. 446)*

The instructor provides students with opportunities to learn independently and increases the interaction between students themselves and between students and teachers by teaching the skills students need to do so effectively. Problems with projects in the studio cannot be solved by following a text's example; they requiring critical, creative thinking. Students need to learn both domain knowledge and strategies for thinking. Collins and O'Brien say that correctly implemented student-centered instruction can increase learning motivation, deepen understanding, improve knowledge retention, and improve students' attitudes toward the subject being taught.

The "Reflective Practitioner" philosophy of Donald Schön (1983) placed particular emphasis on architectural and engineering education. It was developed from Bauhaus principles and led initially to the introduction of "Problem-Based Learning" by Donald Woods (1985). Woods' learning approach aimed to make "integration of diverse knowledge and skills, and problem-solving praxis to meet 'real world' relevance expected by employers, all brought together through reflection" (Gu and Wang 2011) (p. 142).

Many design educators root themselves in so-called scientific design education approaches that discourage design innovations. However, some parts of these programs apply combinations of studio-based approaches and scientific approaches, with master classes and studio-based tutorials. Other parts emphasize practical, analytical approaches, and they often use parts of Schön's and Woods' theories to defend the existing conventional master-class design and studio-based tutorial teaching practices (Gu and Wang 2011). Constructivism can be employed as a design teaching approach because it integrates different learning approaches. Soygenis, Soygenis, and Erktin (2010) stated that it constructivism the common point of intersection of different theories of learning.

2.6.3 Design as a Discipline

In his book *Designerly Ways of Knowing*, Nigel Cross (2006) says that the 1960s were a "design science decade." In this decade, Buckminster Fuller called for a "design science revolution" based on science, technology, and rationalism, to overcome the human and environmental problems that he believed could not be solved by economics and politics. At the end of the decade, Herbert Simon (1969) outlined "the sciences of artificial" and called for development of "a science of design" in the universities: "a body of intellectually tough, analytic, partly formalizable, partly empirical, teachable doctrine about the design process" (p. 120) (Cross 2006).

Nevertheless, in the 1970s there arose a reaction against design methodology and a refusal of its underlying values, particularly by some of the first innovators of the movement such as Christopher Alexander and J. Christopher Jones. In his book *The State of the Art in Design Methods*, Alexander (1971) says, "I've disassociated myself from the field... There is so little in what is called 'design methods' that has anything useful to say about how to design buildings that I never even read the literature anymore... I would say forget it, forget the whole thing" (p. 120) (Cross 2006). In *How My Thoughts About Design Methods Have Changed During the Years*, Jones (1977) says, "In the 1970s I reacted against design methods. I dislike the machine language, the behaviourism, the continual attempt to fix the whole of life into a logical framework" (p. 120) (Cross 2006). However, it should be remembered that the failure of the application of scientific methods to everyday design practice in that time occurred in the cultural and social climate of the late-1960s: campus revolutions and radical political movements, the new liberal humanism, and rejection of conservative values—for Alexander and Jones, rejection of design methods (Cross 2006).

Nevertheless, design methodology continued its robust development, especially in engineering and some branches of industrial design. This was evident by the number of books on engineering design methods and methodology in the 1980s, including Tjalve (1979), Hubka (1982), Pahl and Beitz (1984), French (1985), Cross (1989), and Pugh (1991). Also, new journals of design research, theory, and methodology started to appear throughout the 1980s and into the 1990s, including *Design Studies* in 1979, *Design Issues* in 1984, *Research in Engineering Design* in 1989, the *Journal of Engineering Design* in 1990, *Languages of Design* in 1993, and the *Design Journal* in 1997 (Cross 2006).

Nigel Cross (2006) contends that there remains some confusion about the design-science relationship. He defines three different interpretations of this relationship: (1) scientific design, (2) design science, and (3) a science of design (Figure 2-14).

Scientific design “refers to modern, industrialized design - as distinct from pre-industrial, craft-oriented design - based on scientific knowledge but utilizing a mix of both intuitive and non-intuitive design methods” (p. 122). Scientific design is just a reflection of the reality of modern design practice (Cross 2006).

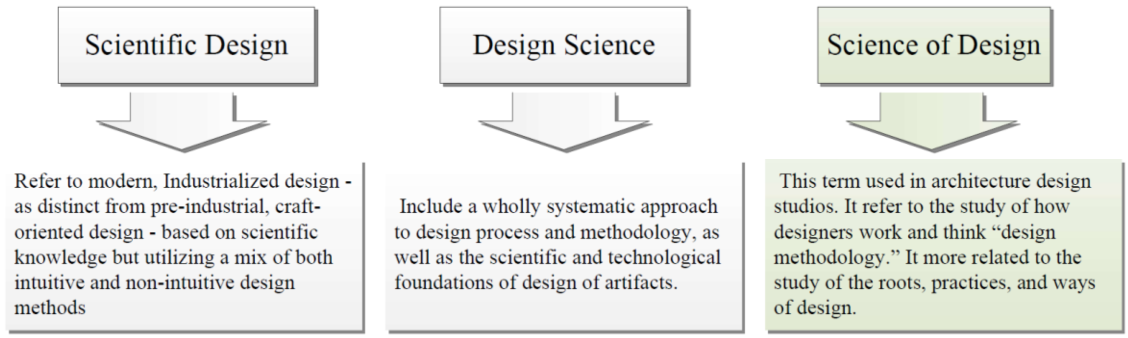

Figure 2-14 The three different interpretations of design-science relationship

Hubka and Ernst Eder (1987) interpreted design *science* as the following:

> *Design science comprises a collection (a system) of logically connected knowledge in the area of design, and contains concepts of technical information and of design methodology…. Design science addresses the problem of determining and categorizing all regular phenomena of the systems to be designed, and of the design process. Design science is also concerned with deriving from the applied knowledge of the natural sciences appropriate information in a form suitable for the designer's use. (p. 124-125)*

This description extends beyond scientific design to include a wholly systematic approach to design process and methodology, as well as the scientific and technological foundations of design of artifacts.

Lastly, Grant (1979) stated that *science of design* is the study of design or the “design methodology”: “the study of designing may be a scientific activity; that is, design as an activity may be the subject of scientific investigation” (p. 123) (Cross 2006). Science of design is more related to the study of the roots, practices, and ways of design. Therefore, *science of design* is the term used in architecture design studios, as supported by Anita Cross (1984):

> *the study of how designers work and think, the establishment of appropriate structures for the design process, the development and application of*

new design methods, techniques and procedures, and reflection on the nature and extent of design knowledge and its application to design problems. (Cross 1984, Cross 2006)

2.6.4 Current Approaches

Architectural education can play a vital role in societies and affect all walks of life. Learning in architecture is not limited to architecture professionals. It is essentially perceptual and sensory. It is about the entire life and living of humans and their societies, continuing traditions, and progress. Architectural education is not a simple matter of information dissipation. It must be value-based and be able to shape a thinking society (Shah 2008).

In terms of enhancing the environmentally responsive awareness in society, Sandra Earley (2005) echoed Daniel Pearl's assertion that architecture education is the key to creating awareness and demand for green buildings:

> *The underlying premise is that education is a key part of creating awareness and demand for green buildings, and enhancing the ability of design professionals to deliver them. Since the environmental values that students hold while at architectural school typically stay with them throughout their professional lives, this transformation must logically begin with reassessing design education.* (p. 11)

The role of higher education worldwide should be to create a more environmentally responsive future. The aim would be to train the professionals, students, and society to be environmentally literate. For the academies and students of architecture schools, it is a challenge to reconcile the green architecture principles with architecture design.

In June 1993, the UIA/AIA released the *Declaration of Interdependence for a Sustainable Future*, which stated that the architectural profession should strive "to achieve ecological sustainability within the limited time that is likely to be available." In 1996 UIA/UNESCO released *Charter for Architectural Education*, which records educational goals under the title "an ecologically balanced and sustainable development of the built environment."

Since then, many architecture schools have changed or added courses, such as "Energy-Conscious Design" or "Bioclimatic Architecture," on the practical aspects of environmentally responsive design. The present research reviewed several studies that document the integration of environmentally responsive strategies in schools of architecture up to now.

Jong-Jin and Brenda (1998) indicated that not many schools have embraced the subject in a thorough manner, pointing at "the low level at which sustainable design concepts have been incorporated into the regular curriculum" (p. 6) and noticing that "environmental education in architecture has been done on an ad-hoc basis, fragmented and insufficient" (p. 2). Environmentally responsive design requires teaching methods that are quite different from the long-established ones (Posada 2004, Stasinopoulos 2005).

Glyphis (2001) discussed how the change in the curricula of architecture schools up to now has been achieved on an acceptable, localized level. Though a number of schools across the world have formed the necessary context and guidance with which to move forward, the degree to which schools are integrating green issues into design pedagogy needs to be hurried. To build a context for reformulating the curriculum, it is necessary to start creating workshops that take a larger look at the role of architecture in society. Glyphis believes that this would reveal a new, clear description of the key role for architects in the transition to green architecture and a clearer model of the curriculum.

Rider et al. (2010) reviewed the curricula of U.S. architecture schools to understand larger program categories with respect to themes of environmental responsive design and to understand which types of programs might host these themes most effectively. This study found that every one of the reviewed schools tends to agree on the need to include art, science, and technology in an architecture design curriculum. The review discovered a program with a building science emphasis, one with an ecological design integration emphasis, and programs that mixed the two.

According to Rider et al. (2010), a number of architecture schools in the United States are perceived to be "green" by reputation; however, few programs have developed in this field. There is not much literature on how architecture education has addressed issues of environmentally responsive design. The study documented the current approaches of U.S. programs and identified the hotspots in green design education. The program websites for the University of Oregon, Cal Poly at San Louis Obispo, Carnegie Mellon University, and Ball State University showed that though "the course descriptions of these schools do not all read outwardly as being dedicated to green, a solid thread runs through the programs that [is] difficult to pinpoint but widely recognized" (Rider et al. 2010). In other words, there are signs that green themes are being included in courses and curricula through a common understanding within green design education circles; however, course titles or descriptions at these programs may show no sign of the themes of green or sustainability.

The University of Oregon architecture program is one of the most successful programs to hybridize ecological design and building science as a type of green or sustainability program within architectural education. Most of the program's reputation has been earned by students' exposure to building science and research, which is not commonly or aggressively pursued by old-style design programs. Cal Poly San Louis Obispo has another hybrid program with comparable elements and qualities. Ball State University's program emphasizes building science elements by connecting the program with its Center for Energy Research/Education/Service (CERES) (Rider et al. 2010).

In European architectural schools, new criteria for environmentally responsive design are starting to emerge. For example, the European Commission funded the EDUCATE program, which started in June 2009 and concluded in May 2012. The mission of this program was to "foster knowledge and skills in sustainable environmental design at all stages of architectural education, aiming to achieve comfort, delight, well-being and energy efficiency in new and existing buildings within a culturally, economically and socially viable design process" (EDUCATE 2009).

This study reviewed the curricula of seven architecture schools at European universities: the University of Nottingham, the Architecture Association School of Architecture, Catholic University of Louvain, the Technical University of Munich, the University of Rome La Sapienza, the University of Seville, and Budapest University of Technology and Economics. The study showed that all schools tend to agree on the need to including art, science, and technology in an architecture design curriculum. The science side of these programs emphasized ecological design integration, buildings science, and environmental science. The course descriptions on the schools' websites describe the courses as being dedicated to green principles and sustainability approaches. All of these schools may be an indication of sustainability or green themes in course titles or descriptions at these programs, with a common understanding within green design education circles that these themes are being included in courses and curricula.

The present research will use the Department of Architecture and Built Environment at the University of Nottingham as a case study of a program in which environment-related technical modules are giving way to more design-oriented teachings, such as “Human Response” and “Environmental Design 1, 2 and 3” and their later incarnation, “Environmental Design and Tectonics.” The “Environmental Design” modules emphasize human interaction with the environment and integrate human behavior with the field of environmental design. They show a respect for climate as an integral part of the design process. Also, the modules emphasize the relationship between the built environment and physical forces such as light, heat, air, and sound, and they offer important parameters that influence human comfort. They also emphasize both composition of spaces and energy-related issues in architectural design (EDUCATE 2012b).

After reviewing U.S. and European architecture programs, it appears that the best-case scenario and most well-rounded opportunity for students is to attend a program that mixes building science and ecological design, so that they can benefit from both perspectives. As these types of programs become increasingly available, well formed, and fully evaluated, their success can be a good example for other schools looking to enhance their programs in green building.

2.6.5 NCARB Curriculum

Today in the United States, much of the architecture curriculum is determined by the National Council of Architectural Registration Boards (NCARB). NCARB was founded in May 1919 by 15 architects representing 13 states. The Council’s first chairman was Emil Lorch. NCARB is a nonprofit organization and is a federation of the architectural licensing boards in each of the 50 states. Its membership includes 54 boards that cover all 50 states as well as the District of Columbia, Guam, the Northern Mariana Islands, Puerto Rico, and the Virgin Islands. One of its goals is to improve the general educational standards of the architecture profession in the United States (NCARB 2004b).

NCARB is as much concerned with raising the level of professionalism in architecture as it was with raising the standards of competency. The need to improve the quality of architectural education became apparent not only to NCARB but also to the profession as a whole. To achieve this, the National Architectural Accrediting Board (NAAB) was created by NCARB, the AIA, and the ACSA and began its work in 1945. NAAB establishes validation criteria that all architectural programs seeking accreditation must meet. The Broadly Experienced Architect (BEA) process has since been implemented and offers alternate criteria to NCARB certification (NCARB 2004b).

The BEA process is based on the NCARB education standard, which comprises six areas of architectural education linked to specific content and durational settings. Education Evaluation Services for Architects (EESA) requires architecture education programs to be compared on these six subject areas. These areas of education, summarized and listed below, parallel NAAB student performance criteria for accreditation (see **Table 2-4**) (NCARB 2013):

- general education—English, humanities, mathematics, natural sciences, and social sciences
- history, human behavior, and environment
- technical systems—structural systems, environmental control systems, and construction materials and assemblies
- practice—project process, project economics, business management, and laws and regulations
- design
- electives

The NCARB Education Standard represents the requirements of a professional degree from a NAAB-accredited degree program. One of the NAAB requirements is the integration, in both breadth and depth, of the issues of ecological literacy and environmentally responsive design into architectural curricula. Ecological literacy requires a fluid manipulation of both soft and hard skills, qualitative and quantitative skills, and technical and conceptual skills. These skills include eco-climate awareness, systems thinking methodologies, regional and vernacular sensitivities, materials and methods research, preservation and adaptive reuse strategies, active and passive design concepts, and the inclusion of ecological decision making in professional ethics canons. These must be shown in topics across the curriculum (AIAS 2008).

The imperative to implement and integrate environmentally responsive strategies in architecture design is requiring a large modification of the architectural education process, starting with the development of curricula in higher education and feeding into the continuing professional development of practicing architects. This will help close the gap between architectural education and field practice.

Table 2-4 NCARB Education Standard (adapted from (NCARB 2013)

Subject Area and Category	**Semester Credit Hour Requirement[10,11]**
1. General Education	45 hours
A. Communication Skills	3 hrs. min. in English Composition
B. Humanities and Arts	N/A
C. Quantitative Reasoning	N/A
D. Natural Sciences	N/A
E. Social Sciences	N/A
2- History and Theory, Human Behavior, and Environment	**16 hours**
A. History and Theory	6 hrs. min.
B. Human Behavior	3 hrs. min.
C. Environment	3 hrs. min.
3. Technical Systems	**24 hours**
A. Structural Systems	6 hrs. min.
B. Environmental Control Systems	6 hrs. min.
C. Construction Materials and Assemblies	6 hrs. min.
D. Building Service Systems and Building Envelope / Enclosure Systems	3 hrs. min.
4. Practice	**9 hours**
A. Project Process	3 hrs. max.
B. Project Economics	3 hrs. max.
C. Business Management	3 hrs. max.
D. Laws and Regulations	3 hrs. max.
E. Technical Documentation	3 hrs. max.
F. Ethics and Social Responsibility	3 hrs. max.
5. Design	**50 hours**
• Level I	8 hrs. min. / 12 hrs. max.
• Level II	8 hrs. min. / 12 hrs. max.
• Level III	8 hrs. min. / 12 hrs. max.
• Level IV	8 hrs. min. / 12 hrs. max.
• Level V	8 hrs. min. / 12 hrs. max.
6. Electives	**16 hours**
TOTAL	**160 HOURS[12]**

[10] If the total number of hours obtained in a subject area exceeds the total minimum required hours or maximum allowable hours for the categories in the subject area, the remaining hours may be in any category of the subject area. *(NCARB 2013)*

[11] Hours in excess of the maximum allowable number of hours for any category may be used to satisfy the Electives subject area. *(NCARB 2013)*

12 The minimum number of hours in each subject area totals 144 hours. The additional 16 hours may be in any one or more of the five subject areas and/or acceptable Electives. (NCARB 2013)

2.7 Architecture Education in Saudi Arabia

2.7.1 Historical Role of Architect

A hundred years ago, the *banna*, or builder, was seen as an architect and was both a designer and a builder. The term *banna* was used by Ibn Khaldun,[13] one of the most widely known Arab scholars during the fourteenth century best known for his book *The Muqaddimah*. His description of the craft of building emphasizes mostly technical matters rather than design. He describes technical connections between materials and relationships and possible conflicts between neighbors (Akbar 1985). Five centuries later, Jamel Akbar said, “A builder often does not create a new design, but, rather, follows the convention in his society and, possibly, improves existing models through consultation with the owners.” In other words, a builder copies and improves design rather than creating and developing a new design. Therefore, the function of the builder was to follow an agreement with the owners and utilize high technical skills (Akbar 1985).

The development of oil resources in the late 1940s and mid-1970s caused rapid economic growth in Saudi Arabia, which has witnessed an accelerated transformation process of the physical environment and building development. The transformation was accelerated by the migration of people to urban centers, which transformed architectural styles. Buildings started to change from old-style vernacular architecture to imported “modern” architecture to meet the increasing demand for various types of buildings, including housing, commercial, and industrial buildings (Abu-Ghazzeh 1997).

In response to pressures from modernization architecture over the past 70 years, embraced the international style. Abu-Ghazzeh says, “They are often striking, but they are not congruent with the local urban values, the national heritage and the cultural and custom norms of the society.” He also added, “In many cases, the results have been technical, aesthetic and social failures.”

Current development in Saudi Arabia reflects the demands for large commercial and government projects and housing projects that are driven by increased cooperation and

[13] Ibn Khaldūn (1332- 1406 AD) was an Arab historiographer and historian, regarded to be among the founding fathers of modern historiography, sociology, and economics. He is best known for his book *The Muqaddimah*.

exchange with a number of countries. At the same time, many of Saudis went abroad to pursue higher education.

Abu-Ghazzeh indicates that the foreign labor and professionals brought into Saudi Arabia resulted in a number of problems. Including a large number of projects, large and small, that was not climatically responsive. He says, "Usually, the solution adopted to maintain comfortable thermal conditions inside such buildings was the installation of [mechanical] cooling systems. However, such solutions were seen as inappropriate because of the wasteful energy consumption and high maintenance cost[s]." Also, design concepts from Western cultures were not responsive to Saudi climate conditions, and many built housing projects in Riyadh, Jeddah, and Dammam were inappropriate to the culture context of the Saudi society. While Saudi architects should benefit from the expertise of western countries in implementing environmentally responsive strategies in architectural design, they should develop their own buildings based on their climate and cultural conditions.

Currently, the majority of houses designed for the public[14] is based on the homeowner's requests[15] and often are not environmentally responsive. Architects often do not create a new design, but rather follow societal conventions and, possibly, improve existing models through consultation with the owner. This happens in the absence of building legislation, especially in the public buildings sector. The design of most buildings is not responsive to local climatic conditions in Saudi Arabia. For example, site analysis, climate analysis, building orientation, daylighting, view, and materials used should be part of early design studies.

2.7.2 Evolution of Architecture Schools

Saudi Arabia's well-known economic boom from the early 1970s through the early 1980s coincided with the founding of several architectural programs. Five programs were established between 1967 and 1983 (Salama and Amir 2005). In 1967, King Saud University (KSU) was the first university to establish a department of architecture. The University of Dammam (UOD) followed in 1975, King Abdul-Aziz University (KAU) in 1976, King Fahd University of Petroleum and Minerals (KFUPM) in 1980, and Umm Al

[14] People that have low and middle income and are looking for cheap neighborhoods.

15 Asking the architect to copy or modify an existing concept for their home design.

Qura University (UAU) in 1983 (Salama and Amir 2005, Akbar 1985). More recently, Qassim University (QU) established its college of architecture and design in 2008 and accepted its first students in the 2008-2009 academic year (QU 2013).

Table 2-5 shows some of the characteristics of the six current programs. These schools share program length, design structure, and unit requirements for degree. Five of the six schools have a 5-year program that includes a year for learning the basic skills (preparatory year) except King Abdul-Aziz University, which has a 6-year program that includes a preparatory year. The preparatory year is an early opportunity to acquaint the students with the different majors in the field of sciences and architecture. It aims to improve students' facility with the English language, mathematical and analytical techniques, basic science, and computer science. It also meets the higher education ministry's desire for the first year of all college academic programs to have similar tracks. Design studio is not taught in the preparatory year for most programs; the University of Dammam and Umm Al-Qura University incorporate basic design studio (1 and 2) into the other basic skills classes.

Jamel Akbar (1985) states in his paper *Architectural Education in the Kingdom of Saudi Arabia* launching four schools of architecture within 10 years by different organizations should mean diversity of programs and curriculums structure. Though these programs differ in length of study, distribution of courses, and other factors, they are very similar in content.

Akbar suggests that the establishment of architectural programs in such a short period was due to the lack of Saudi architects during the peak periods of construction in the late 1970s. In the last 25 years, most of the Saudi architecture programs have tried to become self-sufficient and independent from North America, Turkey, Egypt, and other places. This is supported by many Saudi scholars returning to Saudi Arabia from their academic appointments in western countries after acquiring new knowledge.

Architectural schools in Saudi Arabia adopted a Bauhaus-generated American model. Saudi Arabia was the first country in the Arab world to introduce colleges of architecture based on this model. The curriculum emphasizes design pedagogy supplemented with history and theory courses (Al-Hassan and Dudek 2008).

According to Al-Hassan and Dudek (2008) in their paper *Promoting Sustainable Development in Arabia through Initiating an Arab Architecture Accrediting Board*, graduates of this model lack concern for the long-range effects of their designs. Numerous Saudi architects are applying western design concepts, such as the use of huge blocks of steel and glass, as a sign of the country's rapid economic and technological development.

Table 2-5 Current architecture schools in Saudi Arabia

Institution, College & Department	Founding Year & Location	Design Structure	Unit Degree Req.
King Saud University College of Arch. and Plan. • Department of Architecture and Building Sciences • Department of Urban Planning	1967 in Riyadh	1 preparatory year, 4 years design studio	170
University of Dammam College of Architecture and Planning • Architecture • Urban & Regional Planning • Building Technology • Landscape Architecture • Interior Architecture	1975 in Dammam	5 years design studio (includes preparatory)	170
King Fahd University of Petroleum College of Environmental Design • Architecture • Architecture Engineering	1980 in Dhahran	1 preparatory year, 4 years design studio	147
King Abdul-Aziz University Faculty of Environmental Designs • Architecture • Urban and Regional Planning • Environment Architecture	1976 in Jeddah	1 preparatory year, 5 years design studio	165
Umm Al-Qura University College of Eng. and Islamic Arch. • Islamic Architecture • Electrical Engineering • Civil Engineering • Mechanical Engineering	1983 in Mecca	5 years design studio (includes preparatory)	165
Qassim University College of Architecture and Design • Architecture	2008 in Buraydah	1 preparatory year, 4 years design studio	171

Higher education in Saudi Arabia is totally under the control of the government. Regulation of practice and supervision of architectural education is not controlled by professional organizations such as the AIA in the United States and the RIBA in the United Kingdom. Consequently, there is no planned monitoring of what is happening in architectural schools. In this regard, Abu-Ghazzeh says, “This has not been needed as the government has been concerned with developing a university educational system which measures up to international standards.”

Accreditation (validation) boards are not yet used in Saudi Arabian architectural schools. The schools are regularly inspected by NAAB’s visiting teams, who provide them with advice but do not accredit their programs. For all of the above reasons, it is recommended that Arab countries take advantage of expertise of those countries around the world while establishing their own accreditation (validation) boards (Al-Hassan and Dudek 2008).

Abu-Ghazzeh (1997) states that the curricula of architecture schools have been developed by international standards, not local issues. Therefore, there are similarities between architecture schools in Saudi Arabia and those of the organizations from which they were derived. For instance, the curriculum at the University of Dammam (previously King Faisal University) was revised in the autumn of 1985 with the cooperation and advice of Rice University; the architecture curriculum at King Saud University was developed in 1967 by the United Nations Educational Scientific and Cultural Organization (UNESCO); and the curriculum at King Abdul Aziz University was developed by Harvard University.

Saudi Arabia should benefit from the expertise of western countries in implementing environmentally responsive strategies in architectural education, but the model should be based on conditions within Saudi Arabia.

2.7.3 Current Models

As in many schools around the world, design takes priority in the architectural curricula of Saudi Arabia. This is because architectural design is a creative activity that enjoys the greatest freedom from the external environment. Other courses, such as in history, the sciences, and technologies, are considered to be minor subjects that have less importance in developing the students’ ability to create architectural projects. Architectural schools in Saudi Arabia adopted a Bauhaus-influenced American model that emphasizes design pedagogy supplemented with history and theory courses (Al-Hassan and Dudek 2008).

The researcher conducted an initial curriculum review at three Saudi architecture schools to better understand the incorporation of environmentally responsive design themes in their current program criteria. The course descriptions on the websites of King Saud University, the University of Dammam, and King Fahd University of Petroleum were selected to represent architecture education in Saudi Arabia, and they articulate the following points:

- None of the core course titles at any of the three schools indicates the inclusion of green, ecological, or sustainability themes. However, these themes are being included in courses and curricula, so the course titles alone may not be sufficient evidence.
- The University of Dammam (UOD) offers courses titled “Environmental Design 1 and 2” and “Environmental Control Systems 1 and 2.” Also, courses named “Construction Systems and Assemblage” and “Site Planning” place special emphasis on sustainability and how it can be incorporated in construction and site selection. These courses represent 7% of the total curriculum credit hours (170 credits required for the degree of Bachelor of Architecture), while design, technical, and, collectively, history, theory, and humanities courses represent about 28%, 19%, and 27%, respectively (Figure 2-15 and Table 2-6 Characteristic of courses at the three schools of architecture).
- King Saud University (KSU) in Riyadh offers only two courses in the core area that involve environmentally responsive design (two credits each): “Environmental Control” and “Man & Built Environment.” The descriptions of the courses “Site Analysis & Landscape,” “Building Construction-2,” and “Lighting and Acoustics” address ecological balance, sustainable building elements, and the requirements of visual and auditory comfort, respectively. The number of credit hours that are devoted to design makes up about 24% of the 170 credits required for the degree of Bachelor of Architecture. Students in the School of Architecture spend more than 28% of their time in the design studio. Technical courses and courses on history, theory, and humanities represent about 25.5% and 20.5%, respectively; of the required credit hours (see Figure 2-15 and Table 2-6).
- A quick review of the curriculum at King Fahd University of Petroleum (KFUPM) in Dhahran indicates that there are three courses that emphasize environmental issues: “Man & Built Environment,” “Acoustics and Illumination,” and “Design Determinants for Arid Regions,” representing 5% of the 147 credits required for

the degree of Bachelor of Architecture. Courses in the history and theory of design make up 17%, while 30.5% and 29.5% of the total credits are devoted to the design studio and technical subjects, respectively (see Figure 2-15 and Table 2-6).

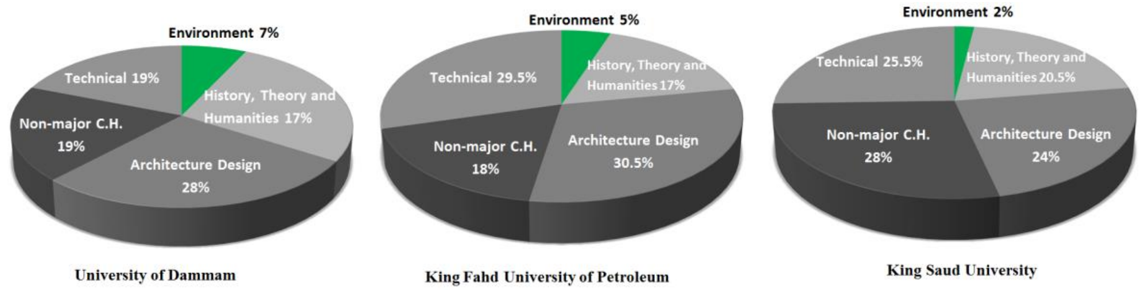

Figure 2-15 Characteristic percentages of courses at the three schools of architecture

A quick review of the architecture curricula at all six schools of architecture (Table **2-5**) shows that green architecture principles are not widely incorporated. Also, the terms *green design*, *ecological design*, and *sustainable design practices* do not appear at all in any of the core course titles, though some of the programs include an elective course titled "Sustainable Architecture" and some curriculum content emphasizes the importance of environmental issues.

Elective courses at KSU and UOD offer areas of study that emphasize sustainability, environmental control systems, and energy simulation. These courses are titled "Building Performance Evaluation through CAD," "Building Integrated Renewable Energy Technologies," "Sustainability in the Built Environment," Building Energy Conservation and Management," and "Climate and Architecture."

The architecture program in Saudi Arabia can be completed over 10 semesters (five years). Some schools, such as KSU and KFUPM, designate the first year for preparatory courses that aim to develop a student's skills in the English language, mathematics, communication skills, and so on. At the UOD, students are registered for two years in general studies that aim to develop their basic design skills and drawing abilities while assimilating theoretical knowledge related to the built environment disciplines. Then, in the beginning of the third year, students start their specialized studies either in architecture design or in building science.

A building's design in Saudi Arabia needs to reflect its surrounding environment, satisfy its users' physical and psychological needs, and maintain our natural resources. In this context, architectural education plays a fundamental role in training future building designers and architects. Saudi Arabia needs a new architectural education model to address this movement.

Table 2-6 Characteristic of courses at the three schools of architecture

Institution's name & College's name	Program Design Structure	Degree Req.	Courses			
			Env.	Tech.	Design	Hist. /Hum.
King Saud University (KSU) College of Arch. and Plan. Department of Architecture and Building sciences	5-year study plan	170 units	2%	25.5%	24%	20.5%
University of Dammam (UOD) College of Arch. and Plan. Architecture	5-year study plan	170 units	7%	19%	28%	27%
King Fahd University of Petroleum (KFUP) College of Envi. Design Architecture	5-year study plan	147 units	5%	29.5%	30.5%	17%

2.8 Fundamental Knowledge Base of the Framework

2.8.1 Data, Information, Knowledge and Wisdom

Alryalat and ALHawari (2008) present a distinction among these words: data, information and knowledge. Data viewed as unprocessed facts and uncooked number, with no interest of any value and purpose. Information is a prepared data with value to determine the purpose. Knowledge is the result of merging and an interpretation of information with practice, perspective and expression to enhance the understanding of the knowledge objectives.

2.8.2 Knowledge Definition

Knowledge is defined as "acquaintance with facts, truths, or principles, as from study or investigation; general erudition: knowledge of many things" (Dictionary.com 2014). The study of the nature of knowledge, or the relation between the knower and the would-be-known, is called epistemology (Groat and Wang 2002). Epistemology separates knowledge into two general types. The first, propositional knowledge, is the knowledge of facts and can be thought of "knowledge-That." For example, it is known that one plus one equals two. The second is “knowledge-How” or skills—personal knowledge that emerges from our experience gained from education or practice. It is an almost instinctive knowledge that exercises intellectual capacity or the proper use of the body (Aravot 1993).

Epistemology is also related to notions of belief and truth (Klein 1971). Belief is viewed as subjective, while truth is viewed as an objective reality. Knowledge requires belief, and a person’s knowledge cannot conflict with that person’s belief. On the other hand, belief does not necessarily require confirmation of its truth.

2.8.3 Characteristics of Architectural Knowledge

Architecture is multidisciplinary and complex. Foqué (2010) states three important preconditions are needed for a productive and meaningful multidisciplinary collaboration: “a clear understanding of one's own expert knowledge; an understanding of and respect for the expert knowledge of the other relevant disciplines; and the ability to mutually communicate this knowledge” (p.176-178).

Foqué summarizes the essential definition and characteristics of architectural knowledge in seven points Foqué (2010) (p. 177-180):

1. ***Architectural knowledge is both multidisciplinary and multilayered.*** *There is a layer of knowing, involving an acquaintance with knowledge belonging to different bodies of scientific disciplines, ranging from the natural sciences to the socio-cultural sciences and everything in between. There is the layer of integrated application of these different sets of knowledge, and the layer of interpretation of how to apply the knowledge in a design situation.*
2. ***Architectural knowledge is contextual.*** *Architectural knowledge derives its relevance from the specific physical, environmental, historical, socio-cultural, and economic environment in which it is applied. Architectural knowledge becomes meaningful only when put into context.*
3. ***Architectural knowledge is value-sensitive.*** *Underlying individual and societal value systems, including ethics, determine the degree of importance of particular knowledge pockets. Boundaries must be set, within which architectural knowledge is applied, and choices must be made of what knowledge is relevant and what is to be discarded. Individual attitudes, likes, and dislikes jointly determine the relative importance of the elements that constitute the body of knowledge.*
4. ***Architectural knowledge is meta-knowledge.*** *It relates to the problem level, the process level, and the product level. This means that architectural knowledge offers insights into how to formulate an architectural problem, how to conceptualize possible solutions, how to realize that solution through physical building, and providing the means to do that.*

5. ***Architectural knowledge is systemic.*** *This means that it can describe not only the elements of an architectural product but also the relationships among these elements and how a combination of them can create additional value and synergy.*
6. ***Architectural knowledge is bipolar.*** *It is subject to internal reflection and external validation. This means that architectural knowledge is not universal, but subject to constant individual interpretation, alternating between analytical exploration and synthetic problem-solving.*
7. ***Architectural knowledge is transformational.*** *This means that the individual elements of micro-knowledge, derived from several disciplines — and as such relevant in their own disciplines on the micro-level when brought together transform their content into wholes, which become relevant on an architectural macro-level* (Foqué 2010).

2.8.4 Fundamental Knowledge Base of Architectural Education in Saudi Arabia

Knowledge is "the outcome of the assimilation of information through learning…[it] is the body of facts, principles, theories and practices that is related to a field of work or study… without necessarily being able to see its implication or application" (p. 16) (EDUCATE 2012b). In the context of the proposed framework for architecture design education in Saudi Arabia, knowledge is described as theoretical and/or factual.

Architectural knowledge is both multidisciplinary and multilayered (Foqué 2010). It derives its relevance from the specific physical, historical, socio-cultural, and economic environment context—the genius loci, if you will—of the places where architectural knowledge is applied. The local context in Saudi Arabia determines the importance of economic, social and cultural dimensions that has variation from the context of the western countries. In architectural education programs, this knowledge base should be measured against natural processes and contextual conditions, and it should account for the environmental attributes of various built forms and building types. The acquired knowledge should be interpreted to elaborate bioclimatic strategies that guarantee the comfort and well-being of users, appropriate management of energy and material resources, and, eventually, adequate services and systems (e.g., HVAC).

2.8.4.1 *History and Architecture*

Universities do not teach the history of architecture simply to fill students' brains with data—the names of monuments, dates, measurements, decorations, styles, origins of forms or patterns, what is "Islamic" and what is not, all in chronological order from

Pharaonic pyramids to post-modern architecture. The primary goal of architectural history is to create awareness among architects and then help them acquire knowledge within related topics such as customs, laws, decision-making processes, basic structure, material and geometry, technical durability, simplicity, adaptability. Acquire the knowledge and values that are rooted in Islamic art and geometry. Acquire the spirit of Islamic architecture that can be seen in floor plans, building techniques that reflect cultural factors, and available local materials appropriate for the harsh climate.

Future architects will build their knowledge around the roots of the modern architectural movement: the industrial revolution and the emergence of modern architecture from the models of Bauhaus and the Chicago School as well as contributions of grand masters such as Le Corbusier, Mies Van Der Rohe, and Walter Gropius. However, their knowledge base will also include the European experience, from classical Greece up to Gothic architecture, and will address structure, function, and aesthetics in different cultural contexts. Architects' knowledge should encompass principal architectural thoughts and events, from Vitruvius' "Ten Books of Architecture," through the European Art Nouveau movement (1890-1910), to the early influence of reinforced concrete, to the development of major architectural and town planning theories. Architects should be able to discuss and critically analyze concepts and theories from all these periods, as well as the concepts of architectural space, form, and vocabulary.

Study of the history of Islamic civilization, from the Umayyad period in Syria and Iraq through the classical and late classical periods in Spain, North Africa, and the Middle East, can help architects acquire the knowledge and values rooted in Islamic art and geometry, as well as variations in cultural attitudes that were reflected in architectural styles, which themselves influenced other international architectural styles. The physical or spatial aspects of the traditional Muslim built environment can be seen as the end product of a process (Akbar 1985). But the spirit of Islamic architecture can be seen in floor plans, building techniques that reflect cultural factors, and available local materials appropriate for the harsh climate.

In Saudi Arabia, vernacular architecture has a strong, characteristic local identity that reflects both cultural and Islamic values and the norms of its residents. Vernacular settings are social patterns that require specific forms, in order to use the available resources, and that are conditioned by economy, environment, climate, and site. Vernacular buildings in Saudi Arabia are characterized by a healthy respect for human scale, human values, and human society. Architects should be able to discuss and critically analyze concepts and theories from all past periods, as well as the concepts of architectural space, form, and vocabulary.

The knowledge that can be gained from the study of vernacular architecture can be used to renew the focus on objective standards. Future architects in Saudi Arabia need to distinguish between a judgment of value and a judgment of goodness. Judgment of value is subjective, while judgment of goodness is an objective evaluation of the nature and form of an architectural object. Both are necessary for the architect, as value judgments significantly speed the selection of objective elements (Saalman 1990, Abu-Ghazzeh 1997).

2.8.4.2 ***Socio-Cultural***

The study of diverse architectural traditions shows that all architecture has a cultural base (Norberg-Schulz 1979a). Every architectural tradition comprises a tradition of attitudes toward a socio-cultural system, and each tradition's underlying culture has a different hierarchy of values. Architecture is a language of cultural expression (Norberg-Schulz 1985).

Culture can have a major impact on the built environment through many small acts over many generations (Johnson 1977, Rapoport 1980). In Saudi Arabia, traditional architecture was built by people who took into consideration their requirements, societal conditions, environmental factors, and materials. This architecture has a local identity that reflects both Islamic values and the cultural standards of its occupants. Most of their designs were also extremely sensitive to the ecological context (Abu-Ghazzeh 1997).

It is important that future architects understand how traditional architecture came about, the importance and function of the built forms within the community, the community's priorities, and the hierarchies of enclosed spaces (Abu-Ghazzeh 1997). An architect should know which socio-cultural and environmental requirements resulted in the construction of a vernacular architecture.

The practice of the contemporary built environment in Saudi Arabia is alienating, and it faces the challenge of not being responsive to its heritage. This is in part because Saudi Arabian architecture incorporates progressive elements deemed necessary today and continues to adopt superficial aspects of Western culture. At the same time, most of the architectural education programs in Saudi Arabia concentrate on modern architecture and technical competency with little attention to philosophical issues and their importance in the design of the built environment (Abu-Ghazzeh 1997). In the long term, this may affect architects' designs and cause buildings to lose their character.

Culture performs a significant role in the design of the built environment in Saudi Arabia due to religious rules. For example, privacy is a significant requirement, which is demanded by both the people and their religion and has to be included into the basic design. Religious issues influence architectural characteristics and design in Saudi Arabia. In this context, Islamic culture has little control over private property its design. For example, in traditional architecture, no property owner could construct a door without the neighbors' consent (Akbar 1984). However, houses no longer accommodate the traditional concern for privacy and family life and are built to a modern plan. The free-standing villa[16] is a symbol of social prestige and an overreaction to the desire for privacy. For example, the private and cool inner courtyards found in many traditional houses 50 years ago have been replaced by narrow, two-meter setback spaces that surrounded the villa with concrete walls approximately three meters high. This maintains the owner's privacy from neighbors, adjoins streets, and provides daylight and ventilation to villa's interior. Recently established municipalities have even codified these characteristics into regulations (Akbar 1985).

Another example of privacy affecting architectural design in Saudi society is the separation of male and female domains, based on a legal status of women that is quite different from the Western concept. This separation is reinforced by all of the Islamic institutions. For example, to strengthen their social relationships, males are encouraged to pray collectively, preferably in a mosque, five times every day (Abu-Ghazzeh 1997). Architects should understand the processes of society to operate within them and possibly improve them, rather than fight them.

In conclusion, socio-cultural factors have determined the formation of places, conditions within them, and, consequently, social relations. Architects should know about

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[16] A villa is two-story house that accommodates a single family and is constructed of reinforced concrete as a structural frame and is enveloped by concrete blocks.

socio-cultural and religious issues and their significance to architecture practice, including the historical role that social and cultural factors have played in shaping the current context within which architecture work takes place. In addition, Architecture elements and local regulations work together to provide users with a suitable privacy that respect religious issues. Elements such as courtyard, setback spaces, windows opening and placement, floors plan design, buildings height, privacy from neighbors and adjoins streets, and more, are part of socio-cultural context and need to be taken into account in architecture design. In addition, architects need to critically examine how theories and practices shape the field of architecture and impact society.

Regionalism

Schools of architecture in Saudi Arabia are located in different regions, and every region has its own unique set of architectural characteristic, available resources, geography, and climate. For example, builders in western Saudi Arabia have historically used stone and red brick, while Jeddah's builders have used coral from the Red Sea. In the central areas, builders preferred adobe for its malleability, availability, and insulating qualities. Modern Saudi architects should look to the traditional building designs and Islamic concepts in their own regions for inspiration. They should also think of ways to combine tradition with the ultra-modern, which will reinforce the link between the valued past and an innovative future. It is important to relate new buildings to the specific architectural character of a particular region. Unfortunately, the majority of modern buildings in Saudi Arabia fail to retain or revive their regions' traditional style (Abu-Ghazzeh 1997), further separating the past and present of the built environment.

To revive regionalism in the architecture of Saudi Arabia, each school of architecture should adopt and emphasize its regional architectural character and materials.

2.8.4.3 ***Economic Environment***

Saudi Arabia's economy is based on petroleum; about 75% of incomes and 80% to 90% of export earnings come from the oil industry (Energy Information Administration 2001). This suggests an economic over-dependence on oil and a need for new strategies that can help overcome Saudi Arabia's post-oil economic challenges.

Saudi population rose sevenfold from 1960 to 2010 (Economic 2011) that causes unemployment, decline in per capita income, and increase the need of housing. The estimated Saudi homeowners less than a quarter of the population (Jeffreys and Group 2011). This due to the absent of a mortgage system and poor planning strategies. Many citizens in Saudi Arabia encounter economic difficulties when they start to build their own homes, including high land prices and the rising prices of construction materials and labors. This due to the absent of a mortgage system. In the other hand, the government faces some economic issues regarding spending on housing projects, more demand for single-family houses, provide public services and infrastructure, a huge bill for servicing land for housing, limited lands, and more. Therefore, these issues are taken into account in the new knowledge framework.

Architecture design gave economic aspects such as life cycle cost and profit, deliver affordability, ensure durability and quality, enable adaptability, and buildings maintenance, a priority and important in the new knowledge framework. In addition, local materials is important to relate new buildings to the specific architectural character of a particular region. To revive regionalism in the architecture of Saudi Arabia, each school of architecture should adopt and emphasize its regional architectural character and materials.

2.8.4.4 *Environment*

2.8.4.4.1 Humans and the Built Environment

Studies of the natural and built environments should consider their interactions, humanity's vision, and architecture by studying the theories of perception, cognition, and mental maps. Architects should understand the environmental impacts of the interaction between humanity and environment at all levels of architecture. As they do with pollution, changes to the microclimate, noise, and other artificial phenomena, architects should also consider how environmental conditions could affect human requirements, such as for privacy, territoriality, and personal space. Moreover, architects should emphasize individual requirements and how the social sciences can provide to architectural design and practice. They should also consider the impact of additional factors such as climate, materials, technology, and environmental context, and they should formulate design principles from cross-cultural examples of world architecture.

Abu-Ghazzeh indicates that many projects, large and small, are not climatically responsive: "Usually, the solution adopted to maintain comfortable thermal conditions inside such buildings was the installation of [mechanical] cooling systems. However, such solutions were seen as inappropriate because of the wasteful energy consumption and high maintenance cost [s].” Environmentally responsive strategies such as site planning, building geometry, glazing properties and location, material selection, and the incorporation of natural heating, cooling, ventilation, and daylighting techniques became a significant part of building design and should be taken into account in design process. Design concepts from Western cultures were not responsive to Saudi climate conditions, and many new-built housing projects in Riyadh, Jeddah, and Dammam were inappropriate to the climate and cultural context of Saudi Arabia. Saudi architects should benefit from the expertise of Western countries in implementing environmentally responsive strategies in architectural design; they should also develop their buildings based on their climate and cultural conditions.

Professionals and architects should design buildings in Saudi Arabia to improve the quality of life, decrease the demand for and consumption of energy, optimize the use of materials and other resources, and minimize waste. In other words, architects need to know how to balance social and economic well-being with cultural traditions and respect for the Earth's natural resources.

Environmental aspects in Saudi Arabia covered under six aspects included climate and comfort issues, energy use, water resources, materials use, health and safety issues, and urban development’s issues. These aspects covered the environmental impacts of the interaction between humanity and environment at all levels of architecture. The following aspects represent the current of the local environmental issues:

a) Climate and Comfort. The climate in Saudi Arabia is harsh, desert conditions with extreme temperature differences ranging from 52 F to 122 F (Piccolo 2014).
Consequently, buildings in Saudi Arabia depend on cooling systems more than heating systems. In addition, sandstorms/dust storms frequently and periodically occur during February to July with the strong winds blowing the dust from the dry deserts to the cities, which require design solutions, for example, minimizing dust penetrations and considering windows opening size and orientation, and the useless of using balconies in buildings. Therefore, implementing suitable bioclimatic strategies in a design are required to guarantee the adaptive comfort and well-being of users. Also, environmentally responsive strategies such as site planning, building geometry, glazing properties and location, material selection, and the incorporation of natural cooling, ventilation, and daylighting techniques became a significant part of building

design in Saudi Arabia. These strategies can be supported by adequate services and systems (e.g., HVAC).

b) Water Resources. Because of the nature of the desert in Saudi Arabia, there is a big shortage of water resources. Due to the limited and erratic rainfall, and the much limited conventional water resources such as fresh surface water and renewable groundwater, options sources such as desalination of the seawater have been adopted since the 1960's (Stensgaard 2008). However, due to the great energy embodied to provide potable water through desalination, water conservation should be considered as priority criterion in the Saudi Arabia.

The building and construction sector is one of the major users of water resources and, at the same time, is a major producer of water waste (Al-Swat, 2004). Therefore, green buildings criteria such as minimize water consumption, water recycle and reuse, will lead to a reduction in water losses.

c) Energy Consumption. Today in Saudi Arabia, most buildings use air conditioning, artificial lighting, and desalinated water. Electrical power and water supply are subsidized, lowering prices of these commodities for householders. There is growing concern that Saudi Arabia will not be able to support these subsidies in the future, especially during the post-oil period. Residential buildings' energy consumption in Saudi Arabia became problem. The rate of power used in residential buildings in Saudi Arabia is about 70% of total production, which is a very high rate compared to some developed countries (Al-Swat 2004, Alulayet et al. 2012). Taleb and Sharples (2011) stated that cooling systems alone use about 80% of the total electrical energy consumed by residential buildings in Saudi Arabia that natural systems can be used to meet this need. This reliance on electrically powered cooling is a result of the rapidly increasing population and rampant economic growth, which makes it necessary to act very quickly to avoid causing problems for the coming generation. In addition, Saudi Arabia with its immense solar resources can play a central role in provide more electrical power by implementing large-scale photovoltaic projects. Dependence on oil as the only source of energy is not the good solution for the country future. Therefore, applying the concept of green architecture practices to reduce the use of conventional electricity in the buildings and encourage the use of renewable energy strategies will lead to reductions in power use in residential buildings and thus will achieve significant economic savings for the Saudi community.

In conclusion, architects should understand the impacts of buildings on resource conservation in Saudi Arabia, and their work implementing environmentally responsive strategies in architectural design processes should begin by clarifying the buildings' most important and relevant aspects. For instance, the strategies should incorporate a certain level of improvement in energy efficiency over conventional usage, indicate a percentage of renewable energy strategies and equipment to be used, specify requirements for site design, provide rules for indoor environmental quality, and indicate levels of resource conservation and recycling (John 2004).

a) **Buildings Materials.** The Saudi knowledge framework need to focus on optimize the use of materials and other resources, minimize construction waste, recycle and reuse construction materials.
b) **Health and Safety.** Enhance the local environmental issues that improve the quality of life included indoor and outdoor comfort, health and well-being, and design building to meet human needs and happiness. Also, enhancing environmental criteria that are dealing with public area pollution, and minimizing CO2 emission.
c) **Urban Development.** This aspect covered access and urban context. For example, buildings and its relation to public transport and other quotidian uses, cities and other forms of human settlement. In addition, issues related to maximize efficient use of land, conserve and develop costal regains, and protecting biodiversity, and flora and fauna.

2.9 Pedagogical Framework

2.9.1 Agenda for Environmentally Responsive Design Principles in Architecture Education

Knowledge and skills in environmental design that aim to achieve comfort, well-being, delight, and energy efficiency in buildings must be underpinned by principles of environmentally responsive architectural design in education. All stages of the architectural education system must promote a culturally, economically, and socially viable design process. EDUCATE developed the following ten principles for its Agenda for Sustainable Architecture Education (EDUCATE 2010):

- *Sustainable environmental design must be seen as a* ***priority*** *in the education of building professionals from the beginning of their studies.*

- *Academic institutions, students and professional bodies must all be* ***committed*** *to this educational priority.*
- *A sustainable environmental education must* ***enthuse*** *and* ***inspire*** *students to rigorously and creatively address contemporary design challenges.*
- *Educators should seek to promote this through* ***direct experiential learning****, using appropriate methodologies, tools and techniques.*
- *A sustainable environmental education must* ***encourage critical awareness, responsibility*** *and* ***reflection*** *of the numerous interdependencies within the design process.*
- *The pedagogy must support* ***investigative discourse*** *between the various parties and professions involved.*
- *Adequate research, human, financial and time* ***resources*** *must be devoted to this process.*
- *Educators and professionals must continually evolve the* ***knowledge base*** *of sustainable environmental design through exemplar research and architectural practice.*
- *This knowledge base must be* ***disseminated*** *in a manner that is easily accessible to students, educators, practitioners and the general public.*
- *A successful education must have the* ***full backing*** *of accreditation and regulatory bodies.*

2.9.2 Pedagogical Methodologies for Knowledge Transfer

Learning theories are often formalized in pedagogical frameworks that emphasize a particular approach. Specific learning theories associated with particular pedagogical perspectives can be used to produce models and frameworks. Figure 2-16 shows how these artifacts mediate between learning theories and actual learning and teaching practice, which itself can be divided into narratives and case studies, tables and matrices, visualizations, and vocabularies (Conole 2014).

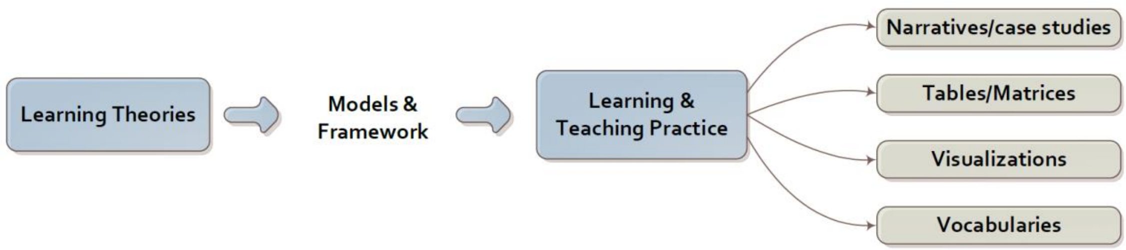

Figure 2-16 the relationship between theory and practice and types of Mediating Artifacts, (adapted from Conole (2014))

The educational literature features many theories and models of learning styles. However, the present discussion will propose only the most frequently used learning style models in architectural education such as experiential learning theory (Kolb's learning cycle), problem-based learning (PBL), and constructivist learning environments. All these styles were defined according to the cognitive learning perspective (Figure 2-7 Table 2-7) and work as transformations in internal cognitive structures. Pedagogically, these styles are characterized by processing and transmitting information through communication, explanation, recombination, contrast, inference, and problem solving. They give rise to constructivist and experiential or reflective positions.

Table 2-7 Cognitive perspective and models

Cognitive Perspective	**Approaches**	constructivism, constructionism, reflective, problem-based learning, inquiry-learning, dialogic-learning, experiential learning
	Characteristics	learning as transformations in internal cognitive structures; learners build their own mental structures; task-orientated, self-directed activities; language as a tool for joint construction of knowledge; learning as the transformation of experience into knowledge, skill, attitudes, values, and emotions
	Models	Kolb's learning cycle
		constructivist model
		problem-based learning (PBL)

2.9.2.1 *Experiential Learning Theory (Kolb's learning cycle)*

Experiential learning theory presents an action-based or "learning by doing" approach through a four-stage cycle calls "Kolb's Learning Cycle": experience, reflection, abstraction, and experimentation, which becomes a concrete experience for reflection (Figure 2-17) (Demirbaş 2001, Demirbaş and Demirkan 2003). In Kolb's learning cycle, concrete experience is followed by reflection and observation. This leads to the creation of abstract concepts and generalizations, and then the implications of concepts in new situations are tested through active experimentation (Kolb 1984, Smith and Kolb 1996, Demirbaş and Demirkan 2003).

2.9.2.1.1 Learning Styles Inventory (LSI)

A learning styles inventory (LSI) can identify an individual learner's style and evaluate a student's position on both of the bipolar dimensions that define the four learning modes (Kolb 1984). The axis between abstract conceptualization (AC) and concrete experience (CE) reflects how a student perceives new information or experience, while the axis between active experimentation (AE) and reflective observation (RO) reflects how a student processes what he or she perceives (Figure 2-17). The student's position relative to both these axes shows the student's preferred learning style (Demirbaş and Demirkan 2003).

The four different learning styles, as described by Kolb (1984), that result from the two bipolar scales are accommodating learners (AE/CE), divergent learners (CE/RO), assimilating learners (RO/AC), and convergent learners (AC/AE) (Figure 2-17). Table 2-8 shows the characteristics, strengths, and weaknesses of each learning style, though no one learning style is better than any other (Demirbaş and Demirkan 2003).

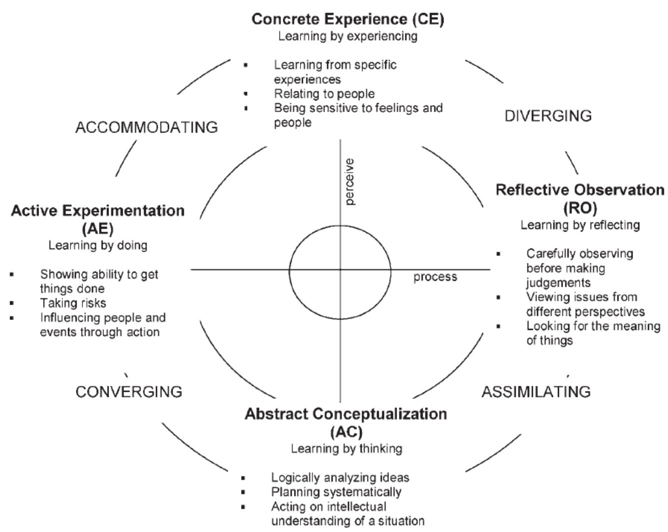

Figure 2-17 four learning modes of experiential learning theory (Demirbaş 2001)

According to experiential learning theory and its characteristics, and because architecture students are experiencing different learning modes and confronting different learning conditions during the process of critique, experiential learning theory can be used in architecture design education. Also, the effects of the four different learning preferences of LSI (Table 2-8) are "considered according to the various learning activities within the studio process. learning styles inventory is aimed to find out the effects of different learning styles in various stages of design studio education through a design experiment" (Demirbaş and Demirkan 2003).

Table 2-8 The characteristics, strengths, and weaknesses of each learning style

Learner Modes	Author	Characteristics
Accommodating learners (AE/CE)	(Kolb 1984) (Hsu 1999) (Smith and Kolb 1996)	-Learning lies in doing things. -Learners use their feelings and action to transform information obtained. -Learners are seeking out new experiences. -Learners tend to solve problems in an intuitive, trial-and-error manner, and they rely on others for information instead of their own analytic ability.
Diverging learners (AC/AE)	(Smith and Kolb 1996) (Hsu 1999)	-Learners are interested in people and tend to be imaginative and emotional. -Less thoughtful, systematic, or scientific.
Assimilating learners (RO/AC)	(Smith and Kolb 1996)	-Learners experience their world symbolically and transform it to information through thought. - It is more important for assimilating learners that the theory is logically sound and precise.
Converging learners (CE/RO)	(Hsu 1999) (Smith and Kolb 1996)	-Learners bring a logical, pragmatic, and unemotional perspective to any situation. -Learners are more concerned with the relative truth than absolute truth.

2.9.2.2 *Constructivist Environment*

The term *constructivism* refers to the idea that students construct knowledge for themselves, each individual student constructing meaning as she or he learns (Hein 1991). Von Glasersfeld (1987) talks about constructivism as a theory of knowledge and says that the constructivist view involves two principles: (1) knowledge is actively constructed by the learner, not passively received from the environment, and (2) coming to know is a process of adaptation based on and constantly modified by the learner's experience of the world (Jaworski 1996, Gu and Wang 2011).

Powers (2001) stated that the constructivism approach is an excellent way of teaching in the design studio (Gu and Wang 2011):

> *Studio is an excellent place for the outgrowth of constructivism. The nature of design with its uncertainty and irregularities are congruent with the epistemology and ontology of constructivist pedagogy. Inclusion of constructivist ideology within the current curriculum and studio courses will help add theoretical credibility to existing studio teaching practices and most importantly increase learning and advance construction of knowledge. (p. 134)*

A workshop on "constructivism as a paradigm for teaching and learning" by the Educational Broadcasting Corporation (2004) shows the benefits of using constructivism as a teaching style for architecture design studio. According to Eigbeonan (2013), the benefits of constructivism can be broken down into four specific areas of learning: (1) develops thinking skills, (2) develops communication and social skills, (3) encourages alternative methods of assessment and helps students transfer skills to the real world, and (4) promotes an intrinsic motivation to learn.

An example of constructivism environment was developed by Jonassen et al. (2002). He proposed that learning environments should provide active, intentional, complex, contextualized, reflective, conversational, collaborative, and constructive learning (Figure 2-18). The model consists of five parts[17] (Conole 2014):

- *Active and manipulative: learning takes place when learners develop knowledge and skills in response to their environment, manipulating objects and observing and learning from the results.*
- *Constructive and reflective: learning occurs as learners reflect on activity and observations and articulate what they have learned.*
- *Intentional: learning occurs when learners are motivated to achieve a cognitive goal.*
- *Authentic (Complex and contextualised): learning is situated in a meaningful context rather than being oversimplified and presented in isolation.*
- *Cooperative (Collaborative/Conversational): learning relies on socially negotiated understandings that help learners build on and learn from their own and each other's knowledge in order to construct new knowledge.*

These benefits of constructivism are clearly advantageous for teaching in the architecture design studio. Constructivism can also make architectural design studio teaching more collaborative, integrated, adaptable, and motivating.

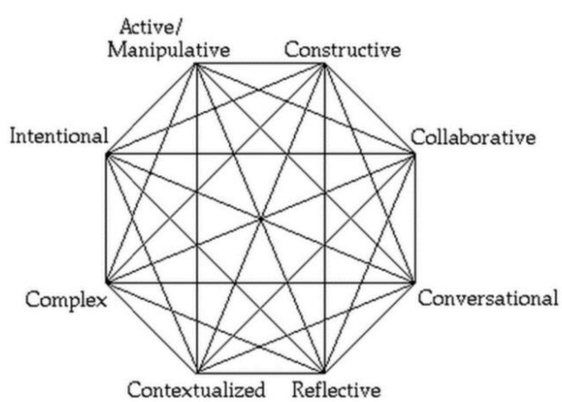

Figure 2-18 The Constructivist Learning environment (Sarapas 2002)

[17] Adapted from Clough, G. and Ferguson, R. (2010). 'Virtual Worlds are Authentic Sites for Learning' in Virtual Worlds: Controversies at the Frontiers of Education. (eds Sheehy, K., Ferguson, R. and Clough, G.) Nova Science Publishers, New York

2.9.2.3 ***Problem-Based Learning (PBL)***

PBL can be included under more general teaching methods such as constructivism. West (1992) defined PBL as the learning that comes from the process of working toward the resolution or understanding of a problem. The studio project in architecture tends to focus on the process of design and problem solving in which students work in groups but each member is also responsible for independent research. The role of the instructor is considerably less direct in problem-based learning than in other constructivist models (Hannafin, Land, and Oliver 1999). The purpose of PBL is to help students develop knowledge by merging learning with problem-solving in a professional setting and teach students problem-solving skills, self-directed learning, effective collaboration skills, and intrinsic motivation (Hmelo-Silver 2004, Albanese and Mitchell 1993).

Finkle and Torp (1995) break down the basic instructional sequence of PBL into four phases: engagement, inquiry, performance, and debriefing (Powers 2006). In his doctoral dissertation, Powers indicates that authors such as Barrows (1980), and Hadwin (1996) suggest that PBL can foster the following student capabilities, which align with Schön's (1987) ideas for professional education: creativity and critical thinking, adoption of holistic problem-solving skills, appreciation of diverse viewpoints, successful team collaboration, effective communication skills, leadership skills, and the use of relevant and varied resources. These capabilities can also be the pedagogic purpose of the studio-based architecture project.

Kvan (2000) notes that it is design studio teaching that is typically framed as "reflection-in-action" is highly compatible with the PBL model:

> *Schön's formulation of the method as "reflection-in-action" has permeated the teaching of many other professions, including teaching itself. In recent years, we have seen another theoretical framework appear, that of problem based learning (Koschmann, et al. 1994). Those who teach architecture are proud to note that studio teaching predates problem-based learning by many decades, if not a century. Common to both these theories of teaching is that they are process focused, not looking at the ends themselves. (p. 6)*

According to Savery and Duffy (1995), in-studio, PBL can be enhanced by four critical criteria: "(1) an authentic, complex problem; (2) a learning environment that simulates a professional setting; (3) a teacher that serves as a facilitator or guide; and most importantly for this study, (4) the use of self-regulated learning" (Powers and Miller 2008), (p. 17). The literature reviewed above makes it clear that constructivism integrates different learning approaches, which can help teachers institute PBL and incorporate self-regulated learning in architecture studios.

2.10 Linking the Knowledge to the Proposed Framework

To produce top quality graduates, the new knowledge should be transferred, through the knowledge transfer framework, to the proposed framework for the Saudi architectural education system.

Many knowledge management processes have similar steps for transferring knowledge: Alavi and Leidner (2001), Bouthillier and Shearer (2002), Peachey and Hall (2005), Karadsheh (2009), and more. They often start with knowledge gathering, understanding, storing and organizing, distributing, and applying.

For example, posited six steps of the knowledge transfer process in case studies: Discovery, Acquisition, Creation, Storage and Organization of the Knowledge, Sharing, and ultimately, Use and Application. Discovery identifies the current knowledge of the proposed case study. The next step acquires the needed knowledge from the external source into the proposed case study. The Creation step analyzes information from different sources to generate new knowledge. The Storage and Organization step provides more understanding of the collected knowledge. Eventually, the knowledge is shared with experts and practitioners and then applied.

2.10.1 Knowledge Transfer Framework Process

The intent of the knowledge transfer framework (KTF) proposed in this research is to provide processes and guidelines for successful knowledge transfer, save time and effort, and avoid mistakes. The proposed framework (Figure 2-19) is based mostly on a thorough investigation of various models by several authors, including Alavi and Leidner (2001), Bouthillier and Shearer (2002), Peachey and Hall (2005), Karadsheh (2009), and more. Their steps share similar emphases on the process knowledge infrastructure, filtering, repositing, sharing, applying, and finally communicating knowledge. The process of the knowledge transfer framework helps transfer new knowledge to the proposed framework, meeting this research's objectives and goals as well as developing and informing the proposed framework. The processes of the framework are discussed below.

2.10.1.1 *Knowledge Infrastructure*

The knowledge infrastructure is the first stage that supports learning and understanding of a knowledge field or domain and includes the requirements for knowledge (Lai and Chu 2000). This stage plays a major part in the success or failure of the KTF cycle execution. Successful knowledge discovery, capture, and creation rely on this stage. If the knowledge infrastructure does not support the knowledge worker's contributions, the KTF cycle will fail (Karadsheh 2009).

Building the knowledge infrastructure comprises three steps: knowledge discovery, knowledge acquisition, and knowledge creation. These three steps define the requirements for knowledge (Lai and Chu 2000). In the knowledge discovery step, the researcher locates and extracts knowledge from the existing domain knowledge, which in this proposed application is Saudi Arabian architectural education. In this process, the researcher digs out information and valuable intellectual capital from data sources, as in data mining, to discover expected and unexpected knowledge (Sun and Hao 2006) and then documents the AS-IS model of the domain.

The second step, knowledge acquisition, focuses on extracting knowledge from an external source (Bouthillier and Shearer 2002, Sun and Hao 2006). In this research, for example, the external sources were relevant pieces of literature, case studies, and experts' knowledge.

Lastly, in the creation step, the researcher creates new knowledge from different sources by linking internal knowledge with another internal knowledge and analyzing the information (Bouthillier and Shearer 2002, Sunassee and Sewry 2002). Knowledge creation can use technological tools and techniques such as brainstorming, data mining, and knowledge discovery tools (Ying-Hsun, Chou, and Gwo-Hshiung 2007). In the current research, knowledge creation is based on recognizing and understanding the requirements and knowledge needed by architectural education in Saudi Arabia.

Using these three steps in the domain of the current research can increase the understanding of the domain's fundamental knowledge, architectural education, and green building issues. The steps of forming the knowledge infrastructure can cooperate with each other to improve the knowledge gained. The discovered, acquired, and created information must be combined and prepared to go through evaluation, filtration, and then storage to prepare it for sharing and then transfer to the proposed framework.

2.10.1.2 ***Knowledge Evaluation***

In the evaluation stage, the researcher measures the value, accuracy, and relevance of the knowledge acquired in the previous process. Sun and Hao (2006) note that knowledge needs to be evaluated to ensure it is accurate and valuable before it can be shared. Knowledge can be evaluated based on the relevance of its research goals and objectives (Sunassee and Sewry 2002). The evaluation stage is important for determining if the new knowledge is worth additional development (Sun and Hao 2006) and also for assessing the quality of knowledge and synthesizing knowledge for future application (de Rezende and de Souza 2007). In this stage, the researcher builds trust in the relevant knowledge and culls unnecessary knowledge. At the end of this stage, the researcher should have acquired deeper and broader knowledge and understanding of the domain.

2.10.1.3 ***Knowledge Filtering***

In this stage, the knowledge acquired through the previous processes is classified, categorized, organized, and stored. In the current research, knowledge is categorized into three domains: architecture knowledge, green criteria, and Saudi Arabia context. The architecture knowledge domain addresses the main issues in architecture, including design, technology, and science. The green issues domain addresses green issues, including a condensed version of the ten characteristics of green architecture by Buchanan (2005), the five green design strategies by Ken Yeang, and other aspects from the literature and cases study. Saudi Arabia context will focus on the historical, environmental, economic, social, and cultural perspectives.

Lai and Chu (2000) suggest that knowledge can be classified according to an index and then linked, combined, and integrated. Additionally, knowledge filtering structures is the indexed information involved with organizing knowledge and then links and catalogs it for the knowledge repository (Parikh 2001).

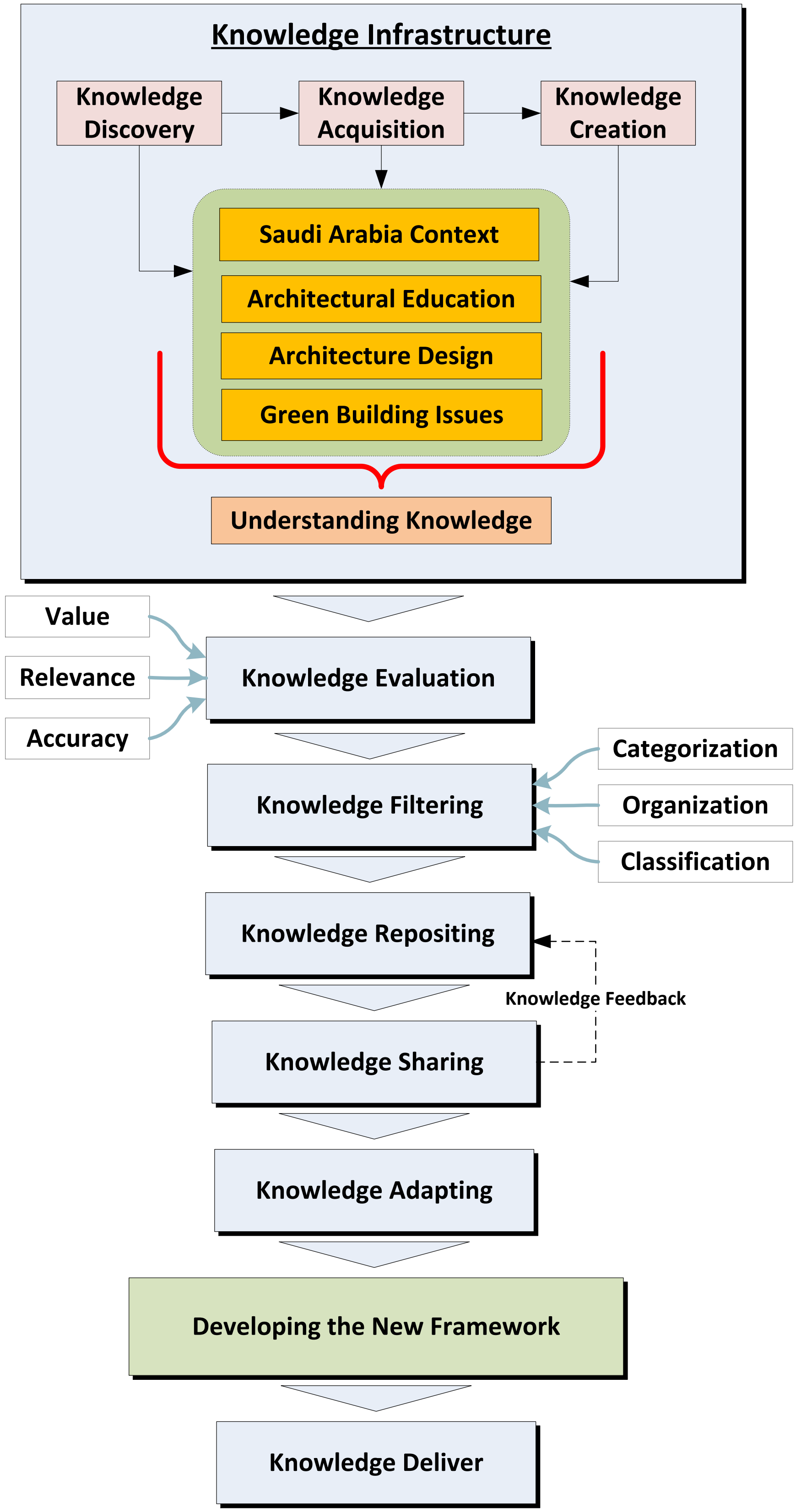

Figure 2-19 Framework for knowledge transfer process

2.10.1.4 ***Knowledge Repository***

The knowledge selected in the previous stages will be organized and stored in the repository. Karadsheh (2009) says, "Knowledge repository is viewed as organization memory and retention of knowledge assets." Moreover, this stage is necessary for retaining the explicit knowledge and promoting additional sharing (Lai and Chu 2000). Using a knowledge repository will help the researcher keep and organize selected knowledge. Additionally, stored knowledge requires updating time to time to make sure that the knowledge is not outdated. Karadsheh (2009) says, "It can be assigned to [a] particular knowledge worker to maintain up-to-date information and remove obsolete information."

2.10.1.5 ***Knowledge Sharing***

Before the transfer of the selected knowledge into the proposed framework, the knowledge repository will be presented to individual academic professors and experts chosen from within the schools of architecture in the United States. This process targets its interviews mainly at individual academics, architects, designers, and experts in the field—anyone who is trying to either teach green architecture or have an understanding of green architecture issues. This stage helps the researcher achieve and improve the validity, transferability, and accuracy of the knowledge. Furthermore, throughout sharing of the knowledge, new knowledge might be created by combining the shared knowledge and existing knowledge (Davenport and Prusak 1998).

This stage is considered a core process of the KTF because the main goal of the KTF is to foster the flow of knowledge among individuals (Chua 2004, Shin 2004). Knowledge representation is used to reintroduce knowledge in a more clear and storable way. Finally, this stage will support knowledge application and development of a new framework.

2.10.1.6 ***Knowledge Adapting***

The western knowledge will be synthesized into the Saudi Arabian context to produce the TO-BE knowledge. This step will combine the western knowledge of green knowledge with Saudi socio-cultural, historical, economic, and environmental dimensions. Furthermore, throughout the process of knowledge synthesis, new knowledge might be created by combining the western and the Saudi context. Eventually, this step will suggest lists of green architecture criteria that are suitable for Saudi Arabia.

2.10.1.7 *Developing the New Framework*

The purpose of the knowledge transfer framework is to represent information to knowledge seekers in an appropriate manner and enable them to apply it. Furthermore, the knowledge framework translates information into practical tools and using the knowledge into the real world.

The researcher should develop a new framework, including its inputs, assessment procedures, and evaluative categories, and map them all as a new framework. Transfer this knowledge into a logical, sequential structure that presents that knowledge in term of learning path. Integrating the new knowledge into the new framework will produce something new, or perhaps the AS-IS knowledge will have to change a little to accommodate the new knowledge.

2.10.1.8 *Knowledge Delivery*

In this step, it is important to know the delivery methods of the knowledge to the knowledge seekers. Is it teacher-centered or student-centered? In social learning, eventually, the researcher must propose a thoughtful framework that incorporates how the student learns, and the researcher must sequence the knowledge.

3. FRAMEWORK METHODOLOGY

3.1 Introduction

The main purpose of this research is to capture and structure knowledge that will inform the examination and development of a new knowledge-based educational framework for green building design in Saudi Arabia. The research has five objectives. The first is to identify the knowledge domains associated with green architecture knowledge, architecture design, and education through literature review, case studies, and interviews with experts in western universities. The second objective is to determine the AS-IS educational framework in western universities and identify the barriers to and constraints of incorporating green architecture knowledge into architectural education and practice. The third objective is to determine the Saudi Arabia framework, including the historical, environmental, economic, social, and cultural dimensions in Saudi Arabia. Investigating these dimensions is vital to understanding the nature, needs, and priorities of Saudi Arabia. The fourth objective is to interpret and adapt the Western knowledge (AS-IS) to inform the Saudi Arabia educational framework (TO-BE). The last objective is to develop a new framework for Saudi Arabian architectural education.

This research uses a grounded theory approach through a review and interpretation of the literate, Saudi schools documents review, and conducting case studies.

The following four sections describe the research procedures and strategies used in this study. The first section discusses the rationale and benefits of a qualitative approach that uses grounded theory inquiry. The second section describes data collection, data organization, and the study's setting. The third section describes the structure of the Saudi Arabia framework; the research method of interpreting, adapting, and transferring the knowledge to the proposed framework; and the development of the new framework, including a narrative of how to translate the western model into the Saudi Arabia model in practice. The last section discusses the stages and procedures of the research.

3.2 Qualitative Research Method - Grounded Theory

Qualitative research has five types of inquiry strategies: ethnography, grounded theory, case studies, phenomenological research, and narrative research (Creswell 2009, Merriam 1998). The present research will use the grounded theory approach developed by Glaser and Strass in the 1960s during their field observational study of how hospital staff dealt with dying patients (Glaser 1967). Grounded theory is a strategy of inquiry generated from a body of data (quantitative or qualitative) assembled by the researcher. This strategy can be executed in multiple stages of data collection followed by finding interrelationships between types of information (Creswell 2009). Groat and Wang (2002) state that, when using grounded theory, "the researcher seeks to enter a setting without preset opinions or notions, lets the going-on of the setting determine the data, and then lets a theory emerge from the data" (180). Merriam (1998) stated that grounded theory method in education "is designed to inductively build a substantive theory regarding some aspect of practice" and that it is "'grounded' in the real world" (p.12). In the present research, the proposed architecture educational framework for green building design in Saudi Arabia's schools is the emergent normative theory.

Groat and Wang (2002) stated the Strauss and Corbin (1998) definition of the grounded theory approach as follows:

> *In this method, data collection, analysis, and eventual theory stand in close relationship to one another. A researcher does not begin a project with a preconceived theory in mind (unless his or her purpose is to elaborate and extend existing theory). Rather, the researcher begins with an area of study and allows the theory to emerge from the data… Grounded theories, because they are drawn from data, are likely to offer insight, enhanced understanding, and provide a meaningful guide to action. (p. 181)*

Groat and Wang (2002) described three analysis stages of the grounded theory approach that use intensive, open-ended, and iterative processes: data collection, coding or data analysis, and documentation or theory building.

During the data collection stage, any type of data collection method can be used, according to Glaser (2006): "No one kind of data on a category or technique for data collection is necessarily appropriate" (p. 65). In addition, he stated that different collection methods or data sources give the researcher different views, or "slices," of data. The relevant literature, case studies, and interviews are the source of data in the present research.

In the coding stage, the researcher categorizes the collected data. The researcher describes the implications and details of these categories and draws the relationships between them. During the coding process, the relationships between different categories need to be identified and recorded in memos that will be sorted in a certain order to clarify the emerging theory (Groat and Wang 2002). These memos tend to be very open-ended in the early stages of coding and progressively focus in on the core concept as the coding process continues (Trochim 2006). The data are then transferred from the data collection process to the data analysis process.

3.3 Data Collection Methods

The process of developing the proposed framework will occur in four main phases (Figure 3-1): knowledge input, interpretation and organization, knowledge sharing, adapting the knowledge to the Saudi Arabian context and developing the new framework, and narrative merging of the Western model into the Saudi Arabia model in practice.

The present research draws data from multiple sources, casting a wide net to collect information supporting divergent thought processes and the discovery of previously unidentified associations and relationships. This research will use two types of data collection: review and interpretation of the literature and conducting case studies. The qualitative data will consist of "direct quotations from people about their experiences, opinions, feeling, and knowledge" (Patton 1990) (p. 10) obtained through literature review. Prescriptive and proscriptive information for the design and implementation of green architecture principles will be derived from the case studies.

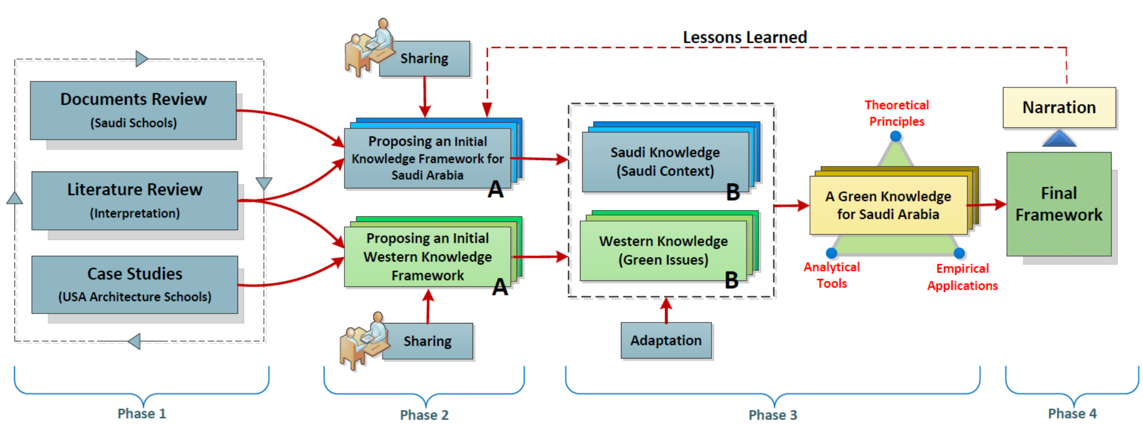

Figure 3-1 Research Methods Map

3.3.1 Literature Review and Interpretation

The literature review has two steps: 1) review the domains' general background and state of knowledge and 2) interpret the literature to inform the proposed framework. As a first step in developing the proposed educational framework, relevant literature will be identified from the overlap of the four domains (green issues, architecture knowledge, education, and Saudi Arabia context) (Figure 3-2). The second step, an interpretive and synthetic process, will enable the formulation of the initial structure of a new green architecture educational framework.

3.3.1.1 *Literature Review*

After determining the scope of this research, a variety of potential resources will be identified and explored, including (but not limited to) books, journal articles, dissertations, universities' collection databases, documents, and numerous websites such as those of the NCARB, AIA, and EDUCATE. These resources will inform the development of a list of primary and secondary sources of data relevant to the research objectives.

The purpose of the literature review is to provide the foundational contribution to the body of knowledge (Merriam 1998) and the foundation for the proposed educational framework. The literature review will encompass theory from previous studies concerning the historical, cultural, economic, and conceptual contexts related to the research problem. The literature review will seek to identify the relationships and the overlap of the four domains of this study (green architecture issues, architecture design, Saudi Arabia context, and education; see Figure 3-2). Merriam (1998) said, "The literature review can demonstrate how the present study advances, refines, or revises what is already known" (p. 51).

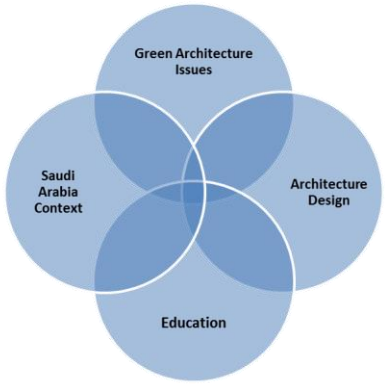

Figure 3-2 The Relationships and Overlap of the Three Domains of This Study

3.3.1.2 *Literature Interpretation*

Interpretation is the key to organizing evidence, evaluating it, and using it to construct a narrative that is holistic and believable (Groat and Wang 2002). Miles, Huberman, and Saldaña (2013) describe the tactics of the research process and the interactive relationship between collecting data, reducing data, displaying data, and drawing conclusions:

> *In this view, the three types of analysis activity and the activity of data collection itself form an interactive, cyclical process. The researcher steadily moves among these four nodes during data collection and then shuttles among condensing, displaying, and conclusion drawing/verifying for the remainder of the study. (p. 14)*

The interpretation steps of this study are similar to the steps described by Miles and Huberman and similar to the process that was described in chapter two (Knowledge Transfer Framework Process) and relate specifically to the research work: data collection, data evaluation and filtration, data adaptation, data display, and conclusion drawing. The literature review, case studies, documents review and interviewing that will be collected require multiple processes to be analyzed, interpreted, verified, and synthesized. The first step after data collection is to reduce and analyze the volume of the data into manageable pieces. A basic system will be required to code the pieces of the data into various themes or categories. This system can be as simple as photocopying all the collected data and making notes in the margins. This can help the researcher to easily describe and interpret the collected information. As Merriam (1998) said, “The categories describe the data, but to some extent they also interpret the data” (p. 187). Merriam added, “The categories can be fleshed out and made more robust by searching through the data for more and better units of relevant information” (p. 185). The next step is to display the data as tables, charts, or graphs. Some of these displays appear in the appendixes of this document. Once the data has been coded, reduced, and displayed, the researcher next has to move on to “identifying patterns, providing explanations, and evaluating the findings” ((Groat and Wang 2002), p. 194).

3.3.2 Case Study: Current Models and Criteria for Green Architecture

The case studies are expected to be a major source of knowledge for the development of the framework. According to Yin (2014), “A case study is an empirical inquiry that investigates a contemporary phenomenon (the 'case') in depth and within its real-world context" (p. 16). In this study, the case studies will be used as an instrument to discover and understand a set of real-world criteria for green building design. Guba and Lincoln (1981) stated that the best form of qualitative evaluation is case study. According to Merriam (1998), this is "because it provides thick description, is grounded, is holistic and lifelike, simplifies data to be considered by the reader, illuminates meanings, and can communicate tacit knowledge" (p. 39). Here, case study was selected as a research evaluation method, rather than other methods such as survey or experimental methods, because it fulfilled four different applications as described by the U.S. Government Accountability Office in 2009, (Yin 2014) (p. 19):

a. *To "explain the presumed causal links in real-world intervention that are too complex for survey or experimental methods."*
b. *To "describe an intervention and the real-world context in which it occurred."*
c. *"A case study can illustrate certain topics within an evaluation, again in descriptive mode."*
d. *"Case study research may be used to enlighten those situations in which the intervention being evaluated has no clear, single set of outcomes."*

Also, case studies can help generate and test hypotheses (Flyvbjerg 2006). However, case studies need to be linked directly to the research objectives.

3.3.2.1 ***Case study selection***

The case study criteria will guide the strategy for their selection. Merriam (1998) says, "To find the best case study, you would first establish the criteria that will guide case selection and then select a case that meets those criteria" (p. 65). For example, this research is interested in architecture programs that address green building criteria, so the cases selected must involve such a program.

A number of architecture schools in the United States and the United Kingdom that meet the criteria will be reviewed. Flyvbjerg (2006) explained two types of case selection: random selection and information-oriented selection. When the objective is to gather as much evidence about the case as possible, a random selection strategy may not be appropriate because the "average case is often not the richest in information" (p. 230). The information-oriented selection strategy is more appropriate for this research. Figure 3-3 lists Flyvbjerg's strategies for the selection of samples and cases, with the two selection types relevant to this research highlighted.

As shown in Figure 3-3, the information-oriented selection method consists of four strategies. The first strategy for a single-case selection is to select an extreme or unusual case that deviates from theoretical norms or everyday occurrences (Yin 2014), which is not the case in this research. The maximum variation cases strategy, according to Figure 3-3, is good for emphasizing the significant differences of the outcomes. This strategy is good when studying multiple cases that are very different on one dimension, which is not the situation in this study. The third strategy is to select critical cases representative of their population. This strategy is the most appropriate for this research and is expected to yield case studies that support the proposed model. As Patton (2002) says, this method can "yield the most information and [has] the greatest impact on the development of knowledge" (p. 236). The final strategy for the selection of cases is to choose a paradigmatic case, which "operates as a reference point and may function as a focus for the founding of schools of thought" (Flyvbjerg 2006). This strategy was also deemed appropriate for this research but is more difficult than the critical case strategy because "the paradigmatic case transcends any sort of rule-based criteria." (Flyvbjerg 2006)

Strategies for the Selection of Samples and Cases

Type of Selection	Purpose
A. Random selection	To avoid systematic biases in the sample. The sample's size is decisive for generalization.
1. Random sample	To achieve a representative sample that allows for generalization for the entire population.
2. Stratified sample	To generalize for specially selected subgroups within the population.
B. Information-oriented selection	To maximize the utility of information from small samples and single cases. Cases are selected on the basis of expectations about their information content.
1. Extreme/deviant cases	To obtain information on unusual cases, which can be especially problematic or especially good in a more closely defined sense.
2. Maximum variation cases	To obtain information about the significance of various circumstances for case process and outcome (e.g., three to four cases that are very different on one dimension: size, form of organization, location, budget).
3. Critical cases	To achieve information that permits logical deductions of the type, "If this is (not) valid for this case, then it applies to all (no) cases."
4. Paradigmatic cases	To develop a metaphor or establish a school for the domain that the case concerns.

Figure 3-3. Strategies for the selection of samples and cases (Source: (Flyvbjerg 2006)

3.3.2.2 ***Research cases study***

The current educational models for green architecture education and the criteria for green building design will be determined by performing case studies of the existing curriculum programs at the United States' Universities: The University of Oregon and The University of Arizona. These programs will be studied to understand the knowledge components that focus on green architecture issues.

Table 3-1 summarizes the main attributes of the case studies. There are a limited number of schools with green architecture design programs in the United States and the United Kingdom whose information was also accessible; these case studies were selected to inform the proposed model of green architecture education.

According to *DesignIntelligence (2014)*, the University of Oregon's architecture program was number one in the nation in 2013, 2014, and 2015 for sustainable design practices and principles, says America's Best Architecture and Design Schools. According to the survey results, "the top-ranked UO program has been recognized multiple times as leading sustainable design education among the 154 accredited architecture programs in the United States." (UO 2014)

Brook Muller, the dean of the UO School of Architecture and Allied Arts said, "The UO's programs have been committed to teaching and research on energy-efficient design, reuse and adaptive design, ecological design and green products and practices for decades." (UO 2014)

The National Architectural Accrediting Board (NAAB) recognized the architectural studies program at the University of Arizona. The College of Architecture, Planning and Landscape Architecture (CAPLA) is an international leader in sustainable design and planning solutions for arid regions of the world. Its program emphasizes solar architecture, energy and water conservation, emerging materials and technology, healthy communities, historic preservation, sustainable housing and transportation systems (UA 2015).

Finally, the University of Southern California (USC) School of Architecture program begins intensively with architectural studies in the first year and provides for a mix of architectural and general university studies throughout the program. The curriculum has two levels of study. The first (years 1, 2, 3) provides a foundation in understanding architecture, concluding with integrative studies after two years of introductory work. The second level, four semesters, provides the opportunity to explore many aspects of architecture and to develop individual strengths and interests. The USC's architecture program recognized by NAAB and it is one of the top five schools in the nation for the best design, sustainable design practices and principles, construction methods & materials (Arch-Daily 2014). Its program emphasizes architectural design, design for the thermal and atmospheric environment, design for the luminous and sonic environment, building structures and seismic design, materials and methods of building construction, and culture and community (USC 2015).

Table 3-1 Main attributes of the selected case study programs

The University of Oregon (Source: University of Oregon website)	
Degree name:	Bachelor of Architecture
Department name:	Department of Architecture
Course credits:	A total of 231 credits
Type and duration:	5-year UG
Location:	United States, Oregon
The main themes of the discipline:	Architectural design, structures, building construction, building enclosure, environmental control systems, systems integration, and the history and theory of architectural design.
Program ranking:	According to *DesignIntelligence*, the University of Oregon Architecture program was number one in the nation in 2013, 2014, 2015 for sustainable design practices and principles. The undergraduate Bachelor of Architecture program is ranked sixth for public universities.
The University of Arizona (Source: Arizona State University website)	
Degree name:	Bachelor of Architecture
School name:	The College of Architecture, Planning and Landscape Architecture (CAPLA)
Course credits:	174
Type and duration:	5-year UG
Location:	United States, Tucson, Arizona
The main themes of the discipline:	Humanities, Fine Arts, and Design; Building technology; Material fabrication; Architectural programming; Materials and methods; Environmental control systems; Structures; history and Theory of architecture; and Contract documents.
Program ranking:	Recognized by the National Architectural Accrediting Board (NAAB).
University of Southern California (USC) (Source: The USC website)	
Degree name:	Bachelor of Architectural
Department name:	School of Architecture
Course places:	160 Semester Credit Hours
Type and duration:	Five-Year Curriculum for the Bachelor of Architecture Degree
Location:	United States, Los Angeles, California
The main themes of the discipline:	Architectural Design, Design for the Thermal and Atmospheric Environment, Design for the Luminous and Sonic Environment, Building Structures and Seismic Design, Materials and Methods of Building Construction, and Culture and Community
Program ranking:	According to Arch-daily website, the University of southern California Architecture program was number five in the nation in 2014 for the best Design, sustainable design practices and principles, Construction Methods & Materials (Arch-Daily 2014).

The case studies will use documents describing the universities' current models (available on the internet) and previous studies of these programs. Merriam (1998) said, "Documentary data are particularly good sources for qualitative case studies because they can ground an investigation in the context of the problem being investigated" (p. 126). Guba and Lincoln (1981) said that analysis of these documents "lends contextual richness and helps to ground an inquiry in the milieu of the writer. This grounding in real-world issues and day-to-day concerns is ultimately what the naturalistic inquiry is working toward." (p. 234).

3.3.3 Documents Review: Saudi Arabian Context (TO-BE Framework)

According to Merriam (1998), mining data from documents is not much different from gathering data via interviews or observation. Merriam describes documents as "a ready-made source of data easily accessible to the imaginative and resourceful investigator" (p. 112). He also describes their relative stability:

> *Unlike interviewing and observation, the presence of the investigator does not alter what is being studied. Documentary data are "objective" sources of data compared to other forms. Such data have also been called "unobtrusive." (p. 126)*

The main purpose of the document review conducted in the present study was to determine the current context—the historical, environmental, economic, social, and cultural perspectives—of the six schools of architecture in Saudi Arabia. Investigating these perspectives is vital to understanding the nature, needs, and priorities of the country.

Documents from the six schools in Saudi Arabia are available online as PDF files on each university's website. These documents were assumed to be reliable, updated, and stable. An initial review of the curricula of the six Saudi architecture schools was conducted to understand their similarities and differences regarding the five context dimensions. Significant similarities were found (see chapter 5 for more detail). Saudi Arabia is not a federation like the United States. It is a kingdom controlled by a monarch and unified, it occupies a narrower economic sector, and it has its own social, cultural, environmental, and religious issues. Consequently, the contextual dimensions of the six schools will be considered the same and will be taken as a group, one to represent them all.

To facilitate the study's analysis and interpretation, a basic coding system was designed to sort the documents' data into four categories: historical, environmental, economic, and socio-cultural. Each category was defined by a number of indicators or criteria. The number and nature of criteria varied among categories, in accordance with the category's importance to the local context.

3.4 Interviews as a Research Method

Interviews helped the researcher achieve and improve the validity and accuracy of the study's assessment of current western knowledge. The interview was designed to allow the subject to express his or her experience with green architecture knowledge within the context of a specific case study.

Stake (1995) suggested that case studies should be selected based on their contribution to the understanding of the research question rather than the amount of information they have. The same criteria could be applied in the selection process for the questionnaire respondents. Because the purpose of this study is mainly to capture and validate the knowledge related to implementing green criteria in the architectural education system, the interviews targeted primarily individual academics, architects, and experts in the field—anyone who is trying to either teach green architecture or understand green architecture knowledge.

In this research, the interviews were conducted person-to-person as a mix of semi-structured questions. Merriam (1998) says, "Interviewing in qualitative investigations is more open-ended and less structured" (p. 74). According to Creswell (2007), this open-ended format allows for previously unidentified information to be revealed. With this in mind, the interviewer asked all participants the same set of predetermined questions to facilitate the evaluation and comparison of the participants' responses. Theses more structured interviews prompted the interviewees to give the basic information needed for the study. The researcher built relationships with the interviewees to get honest and open responses. The researcher gave each interviewee a prepared, two- to three-page summary of the initial AS-IS knowledge (green architecture criteria domain) and asked them a list of questions to judge the summary's accuracy and validity. The interviewees read and signed a consent form and then answered a list of questions.

In order to follow-up, the researcher then conducted additional less structured interviews as in informal, loosely structured conversations. The interviews were scheduled according to the interviewees' preference and availability; there was no pre-set sequence.

3.4.1 Structure of the Questionnaire

The structured interview questions, attached in Appendix A, were divided into three groups:

- Group 1: Introductory questions to establish a background about the respondent and the role he or she played in implementing green knowledge into an architectural education system.
- Group 2: Validation questions to help the researcher achieve and improve the validity and accuracy of the structure and contents of the presented framework (AS-IS knowledge).
- Group 3: Concluding questions to express further information and comments that were not covered during the interview.

3.4.2 Pilot Test

Oppenheim (1992) stated that "piloting can help us not only with the framing of questions but also with procedural matters such as the design of a letter of introduction…, the ordering of the question sequences and the reduction of non-response rate". Thus, the purpose of pilot testing was to make sure everyone in the sample would not only understand the questions but understand them in the same way. It would also show how long it would take to complete the interview in real time.

Depending on the availability of participants, the pilot-test interview was performed as follows:

a) After setting the primary goals of the questionnaire and constructing the first draft, the questionnaire was reviewed by the researcher's committee members.

b) A pilot interview was also held, to assist the researcher in understanding issues surrounding in-depth interviews and the process itself.

In conducting the pilot study, it was interesting to see how many topics were associated with the main subject of green knowledge in western architecture schools. Many of the conversations became focused on personal belief systems, as well as very specific personal experiences.

The researcher also learned to be more conscious of getting too far off topic, and understanding how to bring the participant back to the main question smoothly. There is a good deal of passion fuelling the answers and questions, and that passion should be maintained throughout the interview. However, the researcher also needs to be more aware of the possible (but hidden) applicability of the participant's answers. Therefore, a balance needs to be struck between steering the respondents back "on topic" too soon and missing some new piece of information or knowledge that the researcher was not previously aware.

The pilot study helped the researcher to understand the wealth of information that would surface during interviews. This is fantastic for the study, though the researcher was unaware of just how the actual practice of interviews would unfold. The study was incredibly informative and helped solidify the approach to the participant interviews.

In additional, the pilot study helped to get some suggestions regarding group 2 of the structured questionnaire and reduce the interview duration from 64 minutes to 45 minutes. The suggestions were to combine some questions in a way that did not affect the value and quality of the questions.

3.4.3 Minimizing Bias

The questions were designed to be open-ended. Stasko (1997) explained that these types of questions, with no predetermined set of responses, reveal unprompted opinions. He added that "open format questions are good for soliciting subjective data or when the range of responses is not tightly defined. An obvious advantage is that the variety of responses should be wider and more truly reflect the opinions of the respondents."

Stasko (1997) explained one type of bias that can occur with open-ended questions, which he called "prestige bias." He defined this as "the tendency for respondents to answer in a way that makes them feel better. People may not lie directly, but may try to put a better light on themselves." However, the solution he suggested is to make the questionnaire as private as possible and to let participants know about its confidentiality.

Beed (1985) identified another kind of bias: "Response bias comes about because the respondent reports either incompletely or inaccurately the information that is requested from him/her. This may be due to the wording of the question; it may also be due to the kind of information requested." According to Beed, there is no easy solution for this, but it may be reduced by carefully selecting the participants and quality-testing the questionnaire.

3.4.4 Anonymity and Confidentiality

The data collected from the participants was confidential, including their identifying information (e.g., name, e-mail address). Participants remained anonymous and were only identified by their codes (A, B, C, and so on). The researcher stored interview recordings and transcriptions were in secure locations. Confidential materials were accessible only to the researcher, his advisor, and the corresponding interviewees. The recordings and transcriptions were to be destroyed when the researcher deemed the study complete.

3.5 Narrative as a Research Method

In this research, the purpose of a narrative approach is to investigate the sequence of knowledge in the proposed framework and describe how this knowledge can be systematically applied and understood. The narrative approach can effectively argue for how western knowledge can be applied in and interact with the Saudi Arabian condition.

Lieblich (1998) and her colleagues offer the following definition:

> *Narrative research…refers to any study that uses or analyses narrative materials. The data can be collected as a story. It can be the object of the research or a means for the study of another question…It may be used for comparison among groups, to learn about a social phenomenon or historical period, or to explore a personality. (p. 2)*

Narrative inquiry often uses qualitative studies (Lieblich, Tuval-Mashiach, and Zilber 1998b). It can be considered "real world measures" that are suitable when "real life problems" are investigated (Lieblich, 1998).

In this research, narrative is about translating the AS-IS framework into the TO-BE framework in practice. This stage gives an example of how the TO-BE framework would be applied in Saudi Arabia—in other words, how the knowledge's interactions with the Saudi Arabian case will be implemented in practice. Building on the researcher professional and academic background (see chapter 1), it is assumed that the researcher is an appropriate instrument to identify the meaning of these interactions and translates them into the pedagogical situation of Saudi Arabia. The benefit of the researcher as an instrument of analysis is that the researcher has the flexibility to modify his approach as needed and can detect and elicit latent content inherent in the subjects.

Further, narrative facilitates understanding of what issues and knowledge domains need to be addressed. This information passes from early knowledge to intermediate knowledge to advanced knowledge. From the proposed framework, the researcher will select one theme or one interactive combination and then translate it to the Saudi case. For example, in the United States, water conservation is usually considered less important than energy conservation, but the two are equally important in Saudi Arabia.

Narrative inquiry describes and analyzes sequence knowledge using the language of a story. For instance, the field data gathered by researchers may include stories of a particular theme. These stories need to be analyzed, interpreted, and then unified by re-presenting them in the form of theoretical ideas or a narrative. Explanation of a particular theme should use available historically, culturally, economically and environmentally narrative models. For example, the climate in Saudi Arabia is harsh, desert conditions with extreme temperature differences ranging from 52 F to 122 F (Piccolo 2014). This result in buildings depending on cooling systems more than heating systems. Therefore, the acquired knowledge should be interpreted to design the suitable bioclimatic strategies needed to guarantee the adaptive comfort and well-being of users. These strategies can be supported by adequate services and systems (e.g., HVAC).

Moreover, these stories can be structured around a chronology that makes sense of that issue and addresses it as it passes from early to intermediate, advanced, and future knowledge stages and is situated within a specific context (Creswell, 2008). It is difficult to develop a convincing argument without first presenting some of the important developments in the history of ideas—developments that have led to a new way of understanding reality (Giovannoli 2000).

For the study to be considered valid, the narrative will need to be analyzed against certain evaluation criteria. Lieblich, Tuval-Mashiach, and Zilber (1998a) offer four criteria for the evaluation of narrative studies (p. 173):

1. Width: The Comprehensiveness of Evidence. This refers to the quantity of evidence that allows the reader to make an informed judgment on the evidence and its interpretation.

2. Coherence: The Way Different Parts of the Interpretation Create a Complete and Meaningful Picture. Coherence can be evaluated both internally, in terms of how the parts fit together, and externally, namely, against existing theories and previous research.

3. Insightfulness: The Sense of Innovation or Originality in the Presentation of the Story and Its Analysis. Close to this criterion is the question of whether reading the analysis of the life story of an "other" has resulted in greater comprehension and insight regarding the reader's own life.

4. Parsimony: The Ability to Provide an Analysis Based on a Small Number of Concepts, and Elegance or Aesthetic Appeal (which relate to the literary merits of written or oral presentations of the story and its analysis).

In addition, Riessman (1993) stated four ways of approaching validation in narrative work: persuasiveness, correspondence, coherence, and pragmatic use. Persuasiveness is similar to the first criterion of Lieblich et al.'s work, "Width," with Riessman's addition of the elements of plausibility and style. Correspondence refers to the researcher's ability to take the result back to those studied for verification and/or further discourse. Riessman identified coherence as three types: local, global, and themal[18]. These three types can be used to get differing perspectives on the story. Pragmatic use refers to the study becoming the basis for further research by other researchers; it is future-oriented (p. 65-68).

There is consensus between Riessman (1993) and Lieblich et al. (1998) that sharing narrative study would be one of the major criteria for validation, by which the "sharing of one's views and conclusions and making sense in the eyes of a community of researchers and interested, informed individuals" (p. 173).

In this research, the narrative part will be shared with individual academic professors and experts from Saudi Arabia or outside of it. This stage will help the researcher

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[18] Chunks of interview text about particular themes figure importantly and repeatedly (Riessman 1993).

achieve and improve the validity, transferability, and accuracy of the knowledge. This stage will allow the readers to make an informed judgment on the evidence and its interpretation. Furthermore, throughout sharing of the narrative, new knowledge might be created by combining the shared knowledge and existing knowledge (Davenport and Prusak 1998).

Finally, appropriate validation methods need to be selected according to the particular nature of the study, just as the judgment to use narrative methodology depends on the nature of the data and the research's goals and objectives. Reliability must be met in this part of the research. In narrative study, reliability usually refers to the dependability of the data. Systematic procedures to ensure the nearest possible representation from the raw data stage through that of analysis and the written report are indeed required criteria for judging narrative work.

3.6 Developing the Proposed Framework

The process of developing the proposed framework will occur in four main phases (Figure 3-4): knowledge interpretation and organization, knowledge sharing, adapting the knowledge to the Saudi Arabian context and developing the new Saudi Arabia educational framework, and narrative the merger of the Western model into the Saudi model in practice.

3.6.1 Knowledge Organization (Phase One)

3.6.1.1 *Introduction*

This phase of the research will examine what knowledge does and does not make sense for a new Saudi Arabian green architecture educational framework. In other words, this phase will filter potential knowledge domains of a model, retaining elements that are adaptable to Saudi Arabia criteria and rejecting elements that are not. Ultimately, the existing models (e.g., University of Oregon, Arizona State University, and the University of Nottingham's), and the literature review will be interpreted to determine what can be adapted to the proposed framework for Saudi Arabia.

3.6.1.2 *Knowledge Organization*

As shown in Figure 3-4, the knowledge captured, interpreted, analyzed, and verified through the evaluation techniques will be categorized into two knowledge frameworks: Western model, based on current practices in western schools, and Saudi Arabia model, which merges the Western model into the Saudi Arabian context.

Both frameworks are multidisciplinary and multileveled. Conceptually, they begin at the highest level of knowledge content and progress to its deeper layers. Structurally, each framework begins with its goal at the top, followed by the objectives from a broad perspective, through to the in-between levels, which include the criteria that subsequent elements depend on, down to the lowest level, which is usually a set of sub-criteria. To help efficiently prioritize the criteria, each one should have different sub-criteria. A brief overview of the two frameworks:

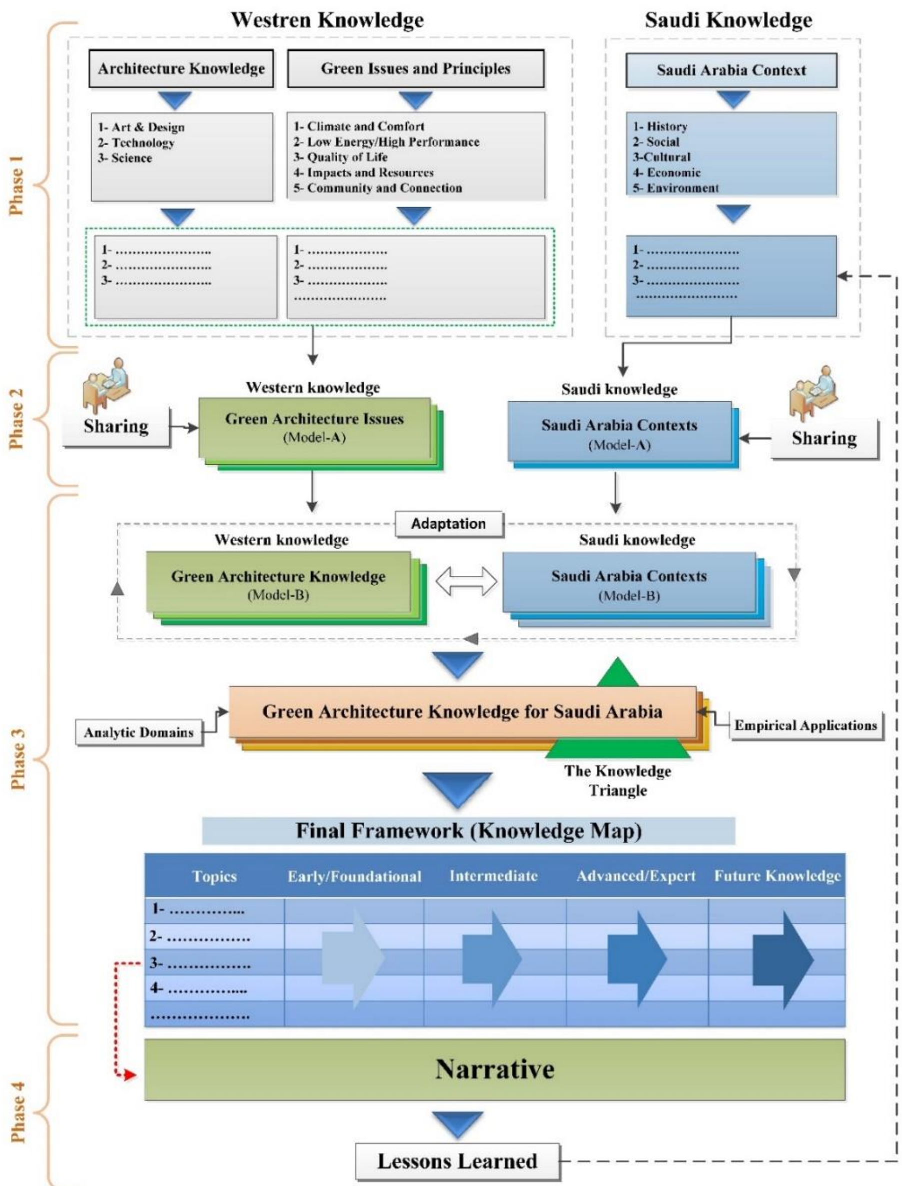

Figure 3-4 the Phases of developing the proposed knowledge framework

The Western Knowledge Framework

The AS-IS model contains two domains: architecture knowledge, and green issues and principles. The architecture knowledge domain addresses the main issues in architecture, including design, technology, and science. The green issues and principles domain addresses green issues, including a condensed version of the ten characteristics of green architecture by Buchanan (2005), the five green design strategies by Ken Yeang, and other aspects from the literature. The current practices in western schools (e.g., University of Oregon, Arizona State University, and the University of Nottingham) and the literature review will be a source of knowledge.

Structurally, each domain begins with its goal at the top, followed by the objectives from a broad perspective, through to the in-between levels, which include the criteria that subsequent elements depend on, down to the lowest level, which is usually a set of sub-criteria. To help efficiently prioritize the criteria, each one should have different sub-criteria. For example, architecture knowledge is the main goal of the first domain followed by its objectives (criteria) that place emphasis on design, technical, and science, down into deeper levels of sub-objectives (sub-criteria) included design principles, building systems, and buildings materials. While the sequence of the second domain (green issues and principles) is comparable to domain one in its procedure but different in its contents (Figure 3-5) (chapter 4).

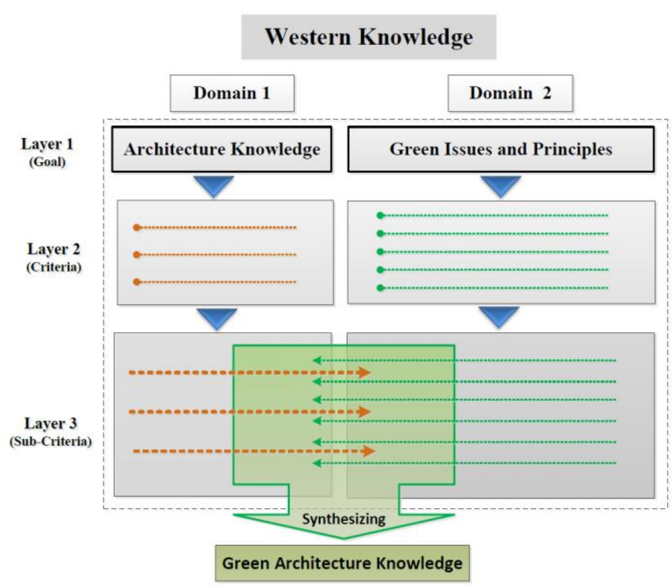

Figure 3-5 Hierarchy of the Western Knowledge Framework

The Saudi Arabia Knowledge Framework

The Saudi Arabian context framework will focus on the historical, environmental, economic, social, and cultural perspectives in Saudi Arabia. Investigating these perspectives is vital to understanding the nature, needs, and priorities of the country. Documents review, the literature review, and interviews with Saudi PhD students will be a source of knowledge.

Structurally, as shown in Figure 3-6, the Saudi Arabia knowledge framework contains one domain of three layers of knowledge contents; beginning at the highest level with the main goal (Saudi Arabia context) and progressing to the deeper objectives. For example, Saudi Arabia context is the main goal of the domain followed by broad criteria for that domain included Saudi history, social, cultural, economic, and environment dimensions. The broad level of the criteria progress to the lowest level, which is usually a set of targeted sub-criteria related to place and culture, vernacular architecture, religious and privacy issues, regionalisms, and economic issues. All these issues will be structured in an ontology consisted of Categories and Clusters (see Chapter 5).

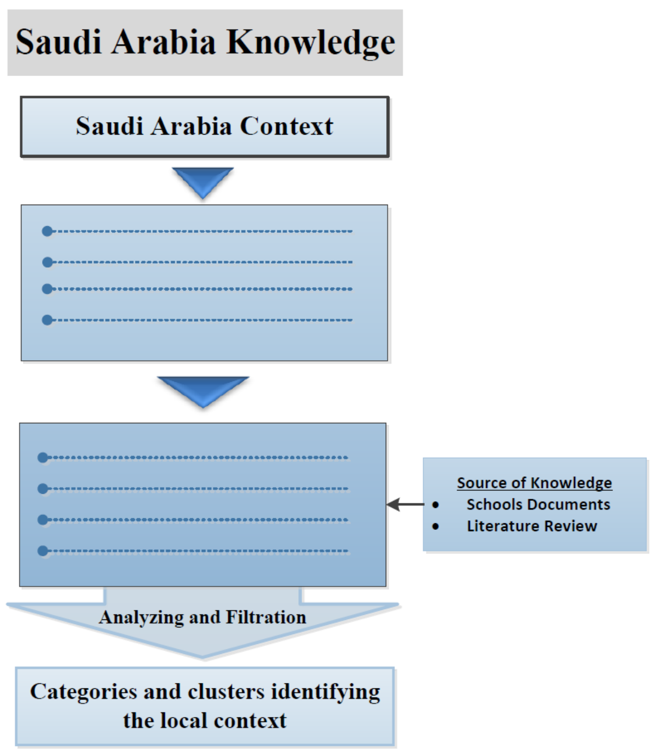

Figure 3-6 Hierarchy of the Saudi Arabia Knowledge Framework

3.6.1.3 *Combining and Synthesizing the Western Knowledge Framework*

The AS-IS knowledge framework will identify the boundary and the relationship between the two knowledge domains of architecture knowledge, and green issues and principles at the targeted layer (layer 3) (Figure 3-5). Eventually, the targeted layers of both domains will be synthesized, triangulated, and combined into one domain named Green Architecture Knowledge. For example, the combination of architecture knowledge included building site, space, form, materials, and systems with green issues such as climate and comfort, health and happiness, air conditioning systems, daylighting, water conservation, air quality, etc. and consider them as part of every design decision, resulting in green architecture criteria that create a high-performance building that saves utility costs, and occupancy comfort and satisfaction. The structuring of the emergent green architecture domain that will be shared with individual academic professors and experts from the United States, the contents can be structured in an 'ontology' consisting of Goals, Categories and Clusters. This part of the research will be described thoroughly in chapter 4.

3.6.2 Sharing the Western Knowledge Framework (Phase Two)

Before merging and translating the AS-IS knowledge (Green Architecture Knowledge Domain) into the Saudi context (TO-BE knowledge), the initial AS-IS knowledge will be presented to individual academic professors and experts chosen from the University of Oregon, and the University of Arizona. This process uses interviews as a research tactic mainly with individual academics, architects, and experts in the field—anyone who is trying to either teach green architecture or understand green architecture knowledge. This step will help the researcher achieve and improve the validity, and accuracy of the AS-IS knowledge. Furthermore, by sharing of the knowledge, new knowledge might be created by combining the shared knowledge and existing knowledge (Davenport and Prusak 1998). This step reintroduces and clarifies knowledge. For more detail, see chapter 4.

3.6.3 Merging and Transferring the Knowledge to the Proposed Educational Framework (Phase Three)

Once the interviewees provide feedback for the validity, transferability, and accuracy of the Western knowledge framework, it was ready to be adapted to the socio-cultural, historical, economic, and environmental dimensions of Saudi Arabia. The adaptation and transference of the knowledge to the proposed framework was to occur in two stages: adapting the knowledge to the Saudi Arabian context, and developing the new Saudi Arabia educational framework as described below.

3.6.3.1 *First Stage: Merging the Knowledge to the Saudi Arabian Context*

Adapting the knowledge to the Saudi Arabian context requires multiple steps:

First step. The AS-IS knowledge domain will be adapted into the Saudi Arabian context to produce the final TO-BE knowledge. This latter domain will triangulate and combine the clusters of the green architecture criteria (AS-IS knowledge) with the clusters of Saudi socio-cultural, historical, economic, and environmental dimensions (TO-BE knowledge). Furthermore, the process of knowledge synthesis might create new knowledge (Figure 3-7). Eventually, this step will suggest lists of green architecture criteria that are suitable for Saudi Arabia (see chapter 6).

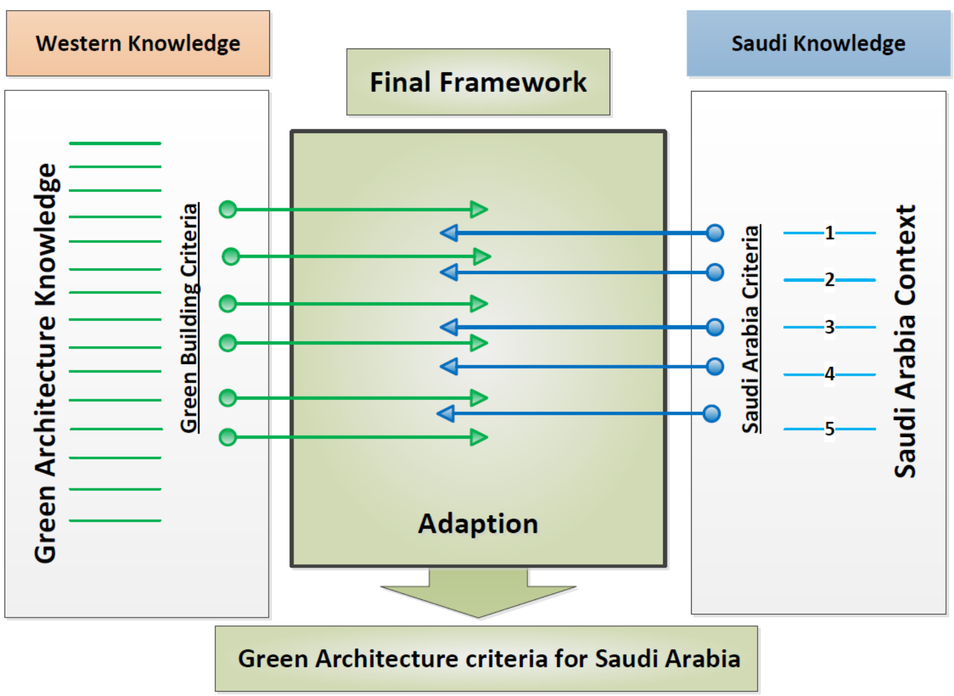

Figure 3-7 Adapting the Western Knowledge to the Saudi Arabian Context

Second step. Before transferring the acquired knowledge to the new framework, the comprehensiveness of the knowledge related to green building and its implementation needed to be assessed. To do so, the researcher used the Knowledge Triangle[19] cognitive framework, which Yannas (2014) proposed for systematizing and organizing knowledge so that it can be delivered transversely in an architecture education program. This cognitive framework categorizes the knowledge associated with environmentally responsive design into three domains: theoretical principles, empirical applications, and analytic domains (Figure 3-8).

After being merged with knowledge from western universities, the Saudi Arabia green knowledge needs to be triangulated and combined with its empirical applications (e.g., workplace, education, residential) and its analytic domain (e.g., simulation tools) to be comprehensive. Applications and analytical tools are already using knowledge of the Saudi Arabia situation could also use rules, concepts, principles, or theories in novel settings.

Each of the three domains has its own character and function, but each is an essential contributor to the other two. Though the pedagogical methodologies applied and the level of competence acquired at each phase of the curriculum may vary, all three domains of the framework should be relevant throughout the curriculum (EDUCATE 2012b).

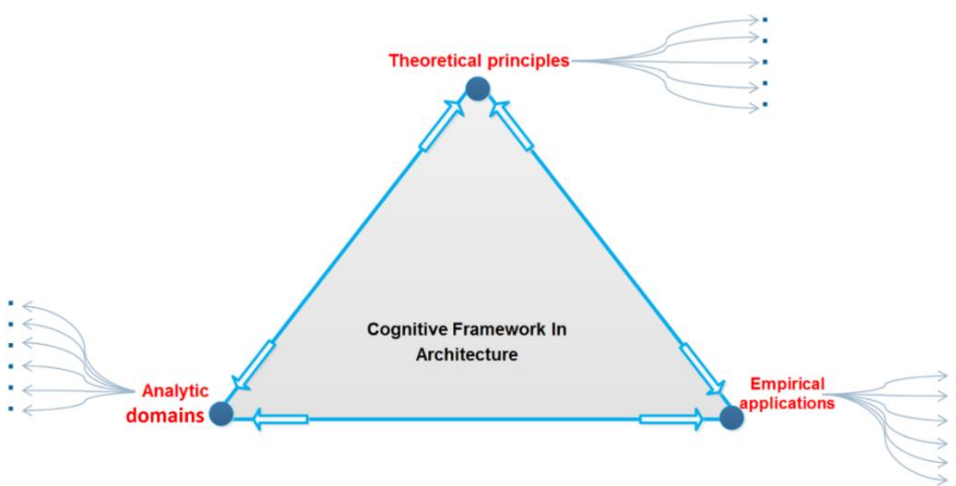

Figure 3-8 The Knowledge Triangle as an Integrated Cognitive Framework (adapted from Yannas 2014)

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[19] The "Knowledge Triangle" is modeled on the cognitive structure of the curriculum developed by Simos Yannas for the Architectural Association's MSc and MArch courses in sustainable environmental design (Yannas 2014).

3.6.3.2 *Second Stage: Developing the New Framework*

In this stage, the researcher should develop a new framework, including its inputs, assessment procedures, and evaluative categories and clusters. The knowledge will be transferred into a logical, sequential structure representing the learning path/knowledge map. The knowledge map should not be a sequential structure of years; its needs to be more general so that it can apply across all of the architecture schools in Saudi Arabia. Integrating the new knowledge into the new framework should produce something new, or perhaps the current knowledge in Saudi Arabia will have to change a little to accommodate the new knowledge.

In the new framework, as shown in Figure 3-4, the knowledge map will be designed according to four stages: early/foundational knowledge, intermediate knowledge, advanced/expert knowledge, and future knowledge. This path is a kind of sequence of growth in the education of architects. The development of the new framework will address how acquired knowledge layers start to interact and how these interactions start to relate to early knowledge, intermediate knowledge, and advanced/expert knowledge. These layers are then translated into a kind of knowledge sequence. For example, there are certain issues about energy efficiency that need to be identified in early knowledge, in intermediate knowledge, and in advanced knowledge.

The early knowledge stage concerns fundamental knowledge, such as the scientific, social, aesthetic, historical, technical, and environmental foundations of architecture, and knowledge areas that provide the broad context for the study and practice of architecture. The intermediate knowledge stage emphasizes design and integration of knowledge to meet human needs and behavior. The advanced/expert stage will discuss the practice and application of knowledge. Finally, the continually evolving future knowledge stage concerns new issues or technologies as they begin to emerge, and it interjects them into the advanced/expert knowledge. For example, the future knowledge stage might address new knowledge and technologies in the next five to ten years and how they will be accepted in architecture design.

3.6.4 Narrative (Phase Four)

The narrative is about translating the Western model into the Saudi Arabia model in practice. Unlike the previous stage, whose purpose is to map out the general interaction of the framework, the narrative stage gives an example of how the Saudi Arabia educational framework would be applied in Saudi Arabia—in other words, how the body of knowledge's interactions with the Saudi Arabian context will be implemented in practice in this case the design laboratory in a school of architecture. The narrative also identifies the meaning of these interactions and translates them into the pedagogical situation in Saudi Arabia.

3.7 Research Procedure

Figure 3-9 shows the relationships among the research stages, approach (grounded theory), and methods (literature review, interviews, case study, documents review), as well as the target objectives for each stage.

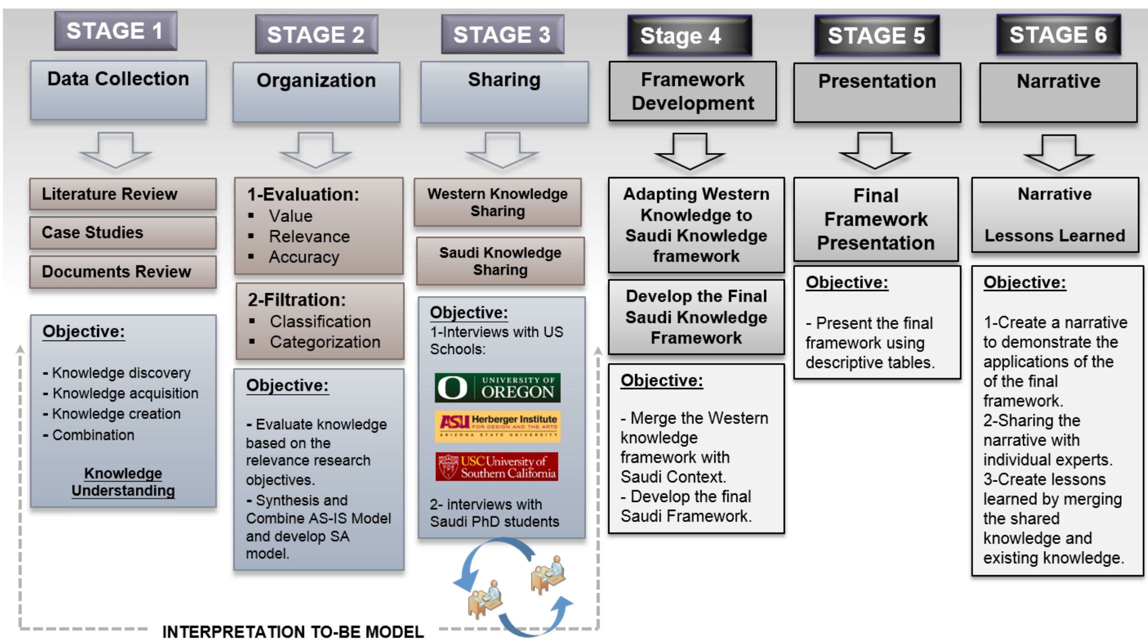

Figure 3-9 Research procedure

As illustrated in Figure 3-9, the research consists of six stages:

Stage 1: Collect data. Identify sources of relevant knowledge based on a grounded theory approach where the theory, in this case the framework, emerges at the end and is not hypothesized at the beginning. This step will be conducted using the following techniques:

a) Literature review. This technique is intended to determine the current state of the knowledge in the area of study. It will identify tools, applications, inputs, procedures, and evaluative categories related to green building design and architecture education.

b) Case studies of the University of Oregon, Arizona State University, and University of Nottingham. Case study is an instrument to discover and understand a real-world case of the criteria for green building design. It also fills the gaps from the literature review, provides practical information, and may suggest new inputs for the new proposed framework (see chapter 4).

c) Documents review in the Saudi Arabia context. The historical, environmental, economic, social, and cultural perspectives in Saudi Arabia will be extracted from these documents. Investigating these perspectives is vital to understanding the nature, needs, and priorities of the country (see chapter 5).

Stage 2: Data organization. This stage will include two steps: First, evaluation step, the researcher measures the value, accuracy, and relevance of the architecture, green issues, and Saudi context knowledge acquired in the previous process. Selected knowledge needs to be evaluated based on its relevance to the research goals and objectives to ensure it is accurate and valuable before it can be shared.

Second, filtration step, the knowledge acquired through the previous processes is classified, categorized, organized, and stored. In the current research, knowledge is categorized into three domains: architecture knowledge, green criteria, and Saudi Arabia context. The architecture knowledge domain addresses the main issues in architecture, including design, technology, and science. The green issues domain addresses green issues, including a condensed version of the ten characteristics of green architecture by Buchanan (2005), the five green design strategies by Ken Yeang, and other aspects from the literature and cases study. Saudi Arabia context will focus on the historical, environmental, economic, social, and cultural perspectives.

At the end of the data filtration step, the researcher develops and prepares the initial-AS-IS knowledge framework by synthesizing the first two domains into one domain named Green Architecture Knowledge to be shared in the next stage. In addition, the researcher will prepare lists of Saudi Arabia criteria to be used in the adaptation stage (stage 4).

Stage 3: Western model sharing. Before the transfer and adaptation of the selected knowledge into the Saudi Arabian context, the Western knowledge will be presented to individual academic professors and experts chosen from the University of Oregon, Arizona State University, and University of Southern California for their feedback. The interviewees will be asked to comment on the validity, transferability, and accuracy of the Western knowledge (green architecture domain).

Stage 4: The green architecture domain will be adapted to the Saudi Arabian context into one domain by combining the western knowledge in term of green issues with Saudi socio-cultural, historical, economic, and environmental dimensions, to develop the new Saudi Arabia educational framework. The development will include a list of green architecture criteria suitable for Saudi Arabia applications. These criteria will map them all as a sequential map of knowledge from beginning to end.

Stage 5: Present the final Saudi framework, using descriptive tables and graphs.

Stage 6: A narrative is used to demonstrate the application of the Saudi knowledge framework and how it was translated from the Western model in practice. Eventually, create lessons learned by merging the shared knowledge and existing knowledge.

4. THE WESTERN KNOWLEDGE FRAMEWORK

This chapter presents two main steps of the Western framework. The first step is to combine and synthesize the Western knowledge framework. The second is to present the questions, results, and analysis of the interviews to establish an adaptation for the Saudi Arabia knowledge framework proposed in Chapter 6.

4.1 Pedagogical Framework

The Pedagogical Framework aims to provide green architecture criteria for the architectural education system. These criteria should maintain sufficient flexibility to allow the framework to be adapted to a diversity of contexts, pedagogical systems and approaches, local requirements, and environmental targets in order to be applied to the educational structure.

The Pedagogical Framework has been structured around the following components:

4.1.1 Agenda for Environmentally Responsive Design Principles in Architectural Education

The following five principles[20] need to be taken into account by higher education institutions to foster the successful implementation of green architecture knowledge at each level of progression towards professional practice.

a) Schools' architectural programs must see environmentally responsive design criteria as a priority from the beginning of each student's studies.
b) A green architecture knowledge framework needs to excite and inspire students to rigorously and creatively address contemporary design challenges.
c) Educators should seek to promote this through direct experiential learning, using appropriate methodologies, tools, and techniques.

[20] Adapted from the 10 principles of the Agenda for Sustainable Architecture Education (EDUCATE 2010).

d) A green architecture pedagogical framework must encourage critical awareness, responsibility, and reflection of the numerous interdependencies within the design process.
e) Educators and professionals must continually evolve the knowledge base of green architecture design through exemplary research and architectural practice.

4.1.2 Knowledge Framework and Priorities

What does a learner need to know? In answering this question, the cognitive domain of green architecture knowledge can be organized into different domains of knowledge, including physical, physiological, and psychological philosophies associated with the design of the built environment that is responsible for providing its dwellers comfort and well-being (EDUCATE 2012b). The knowledge domains should also include the evaluation of the technologies and strategies that assure a suitable management of energy in buildings and urban design while at the same time reducing environmental impacts by minimizing waste and conserving resources. In addition, the knowledge domains should include basic principles and examples of systems and solutions, addressing global, environmentally responsive design challenges and their local expression in architectural and urban development.

The architecture school program should convey a clear awareness of the current environmentally responsive design issues and offer basic green knowledge needed to realize the operation of buildings, which should be undertaken with an understanding of users' requirements and needs. Some environmentally responsive design issues should be measured against natural processes and contextual conditions in Saudi Arabia, including historical, environmental, socio-cultural, and economic dimensions (see Chapter 5).

Moreover, architectural knowledge, as already noted in Chapter 2, involves meta-knowledge and is multidisciplinary, multilayered, contextual, value-sensitive, systemic, bipolar, and transformational (Foqué 2010).

Green architecture knowledge needs to be built on a comprehensive integration of the current state of the art of academic pedagogies.

The proposed knowledge framework will be based on three separate but interlocking priorities. Numerous previous studies, such as Boyer and Mitgang (1996), Buchanan (2005), Yeang and Spector (2011), EDUCATE (2012b), and others, have stated some of these priorities. The following priorities should be taken into account in the design, construction, and operation of each intervention, such as when defining the contents of the knowledge in educational architecture programs:

a) Promote the creation of a healthier, more environmentally green architecture that respects precious resources. This is the most important goal of this knowledge framework. Architecture should concentrate on new green design strategies, summarized in the following list:

    1. Protect the environment: Control climate change and global warming through the development of environmental policies and legislations. In architecture domain, develop green building legislations base on the goal of reducing the building's impact on the environment throughout all phases of its lifecycle, including siting, design, construction, operation, maintenance, and removal.
    2. Improve quality of life: Enhance indoor and outdoor comfort (thermal, visual, and acoustic), health, and well-being while carefully controlling the relation between private and public spaces. Also, design and build to meet human needs and happiness. For example, colors, materials, and space can affect everything from emotions and blood pressure to worker productivity and corporate profits. Boyer and Mitgang (1996) sum this up by saying "space affects the way people behave" (p. 38).
    3. Decrease the demands for and consumption of energy: Minimize energy demands during the building's construction and operation for cooling, heating, lighting, ventilation, and use of appliances; decrease consumption of energy due to transport (e.g., issues of density and mixed functions); reduce embodied energy of products; and, whenever possible, promote the utilization of renewable forms of energy.
    4. Optimize the use of materials and other resources: Consider properties and sources of material; contemplate resource availability, favoring use of renewable materials; promote recycling and reuse of products; reduce the use of water; facilitate water recycling; restore water balance; and other measures.

5. Minimize waste: Reduce construction and demolition waste through adequate design strategies, design for disassembly, minimize domestic waste, provide infrastructure for recycling and sorting processes, and other measures.

b) Revitalize and preserve cities. Schools should emphasize design knowledge that preserves and renovates as much as it creates "newness." The goal is to help cities and smaller communities become safer, healthier, and more wholesome.

c) Enable access and urban context: To be green, a building must be close to public transport and other quotidian uses. Achieving a green built environment will involve rethinking not just buildings, but also cities and other forms of human settlement.

In this research, the sorting and categorizing of green architecture criteria will build on the above priorities.

4.1.3 Teaching & Learning Methodologies

Learning theories are often formalized in pedagogical frameworks that emphasize a particular approach. Specific learning theories associated with particular pedagogical perspectives can be used to produce models and frameworks. As already noted in Chapter 2, Figure 4-1 shows how these artifacts mediate between learning theories and actual learning and teaching practice, which itself can be divided into narratives and case studies, tables and matrices, visualizations, and vocabularies (Conole 2014).

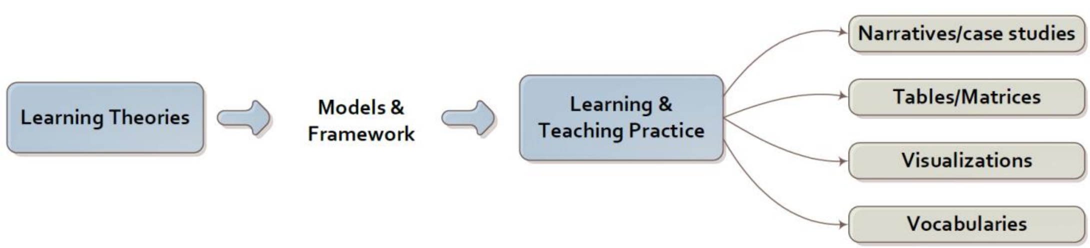

Figure 4-1 the relationship between theory and practice and types of Mediating Artifacts, (adapted from Conole (2014))

The educational literature features many theories and models of learning styles. However, this study will consider the most frequently used learning style models in architectural education, such as experiential learning theory (Kolb's learning cycle), problem-based learning (PBL), and constructivist learning environments (see Chapter 2).

The pedagogical approach should build the knowledge in layers, starting from the first phases of the learning process, including both qualitative and quantitative information, and merging the delivery of knowledge with experiential applications. To facilitate the comprehension of theoretical principles, the knowledge needs to have clear terminology, definitions, and brief explanations, and favour direct experimentation and creative design exploration. Also, lectures, practical workshops, and visits to existing projects should work together to frame physical processes and design concepts relating to basic environmentally responsive issues, such as passive cooling, insulation, solar control, and daylighting, among others (EDUCATE 2012b).

4.2 Data Reduction and Analysis

After the data was collected and understanding, the data needed to be reduced and analyzed. The process of data reduction and analysis was divided into three main stages: data evaluation, data filtration and categorization, and combining and synthesizing the AS-IS knowledge framework. The intent of developing this framework is to then share it with professors and validate its structure and contents so that it can be applied to Saudi Arabia architecture schools as a part of this research. A future goal of this framework is also to apply it in other schools of architecture in other countries (after adding their local context).

4.2.1 Data Evaluation

In the evaluation stage, the researcher measured the value and accuracy of the collected data and its relevance to the research goals and objectives. The researcher photocopied all of the collected data and reviewed the literature in Chapter 2, took notes, and made comments. The volume of the data was reduced into manageable pieces and with this volume, the researcher performed a cluster analysis to determine if any new knowledge was worth either additional development or useful for assessing the quality of knowledge (see Figure 4-2).

To increase reliability and ensure completeness, the researcher repeated the process of data reduction three times. The notes were listed with their references sources (see Figure 4-2 and Table 4-1. From all the literature examined, 126 criteria were collected: forty-eight from “Ten Shades of Green” by Peter Buchanan (2005), thirty-one from “Five

Green Design Strategies" by Ken Yeang (2011), thirty-five from EDUCATE,[21] and twelve from other studies such as Juhani Pallasmaa (2005), and Norberg-Schulz (1980b). Most of the criteria are similar to each other and are frequent in the above-mentioned knowledge sources. The criteria were classified into six topics as illustrated in Figure 4-3.

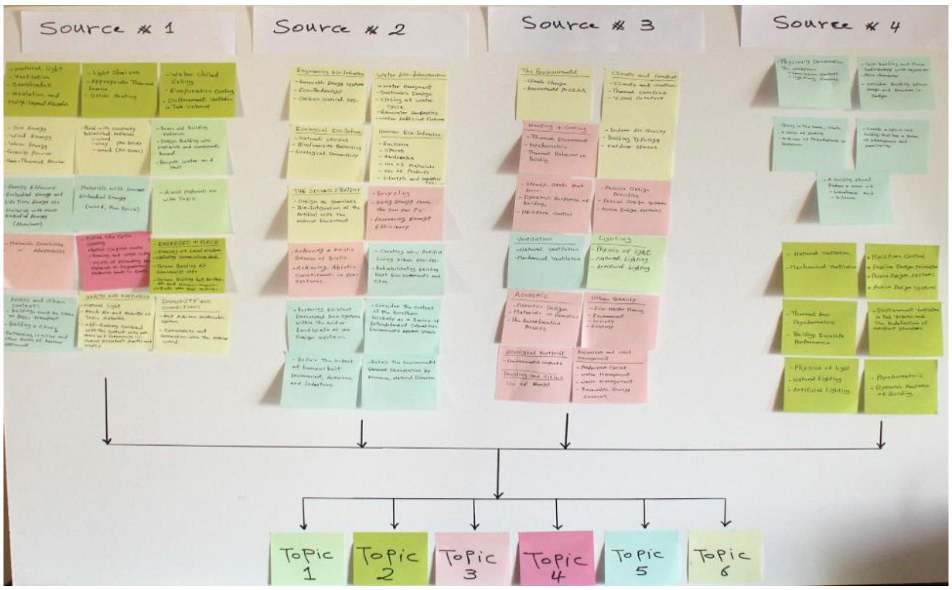

Figure 4-2 Reduction and Analysis of the Volume of the Data into Manageable Pieces

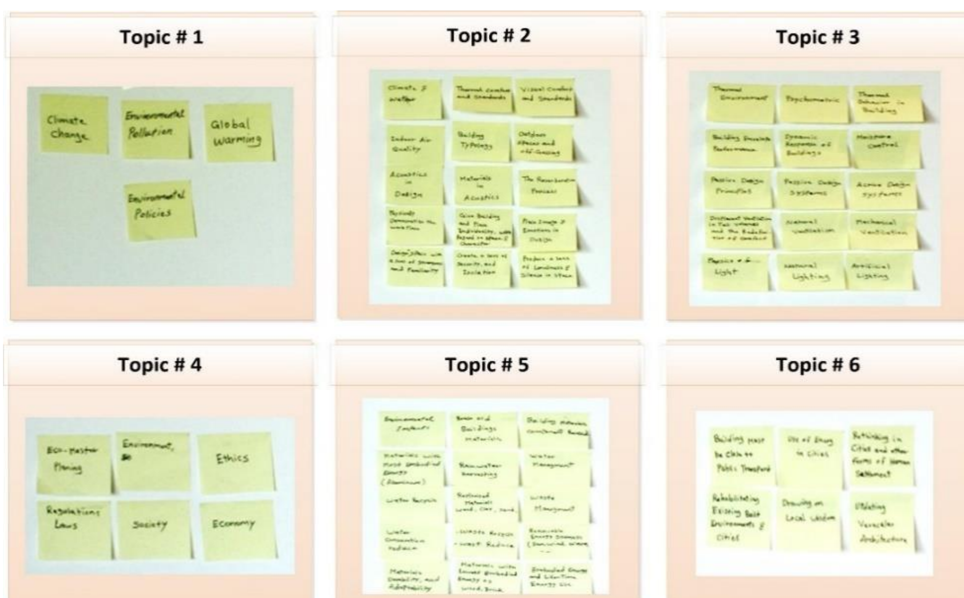

Figure 4-3 Data Classified into Six Topics of Green Architecture Issues

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[21] Environmental Design in University Curricula and Architecture Training in Europe

Table 4-1 Holistic Criteria for Green Architecture Design

The Ten Shades of Green (Source 1)

1- LOW ENERGY/HIGHPERFORMANCE
- Natural Light
- Ventilation
- Sunshades
- Light Shelves
- insulation and Multi-Layered Facades and roofs
- Appropriate Thermal Inertia (High in Temperate Climates, Low in Tropical)
- Solar Heating
- Water Chilled Ceilings
- Evaporative Cooling
- Water Chilled Ceilings
- Displacement Ventilation in Tall Volumes and the Redefinition of Comfort Standards

2- REPLENISHABLE SOURCES
- Sun Energy
- Wind Energy
- Waves Energy
- Gravity Power
- Geo-Thermal Power
- Build with Constantly Replenished Materials, such as:
  - Wood (Near Inexhaustible Ones
  - Clay (For Brick)
  - Sand (For Glass)

3- RECYCLING: ELIMINATING WASTE AND POLLUTION
- Reuse Old Building Materials
- Design Buildings with Materials and Components Reused
- Recycle Water and Heat
- Avoid Materials Use with Toxic

4- EMBODIED ENERGY
- Energy Efficiency
- Embodied Energy and Life-Time Energy Use
- Material with Lowest Embodied Energy (Wood, then Brick)
- Materials with Most Embodied Energy (Aluminum)

5- LONG LIFE, LOOSE FIT
- Durability
- Adaptability

6- TOTAL LIFE CYCLE COSTING
- Initial Capital Costs
- Running and Wage Costs
- Costs of Extracting the Materials to Degradation Materials back to Earth

7- EMBEDDED IN PLACE
- Drawing on Local Wisdom
- Updating Vernacular Architecture
- Green Buildings Fit Seamlessly Into
- Green Buildings Help Reintegrate and Minimize Negative Impacts upon their Settings

8- ACCESS AND URBAN CONTEXT
- A Building Must be Close to Public Transport and other Quotidian Uses
- Rethinking in Cities and Other Forms of Human Settlement

9- HEALTH AND HAPPINESS
- Natural Light
- Fresh Air and Absence of Toxic Materials and Off-Gassing Combined with the Contact with Outdoors and Community Life Makes Occupants Healthy and Happy. Which will Leads to:
  - Diminished Absenteeism
  - Staff Turnover
  - Increased Productivity

10- IMMUNITY AND CONNECTION
- Help Achieve Sustainable Culture
- Community and Connection with the Natural World

Ken Yeang: The Five Green Strategies (Source 2)

1-THE FIRST STRATEGY (FOUR STRANDS OF INFRASTRUCTURE):

The Grey: (Engineering Eco-Infrastructure)
- Renewable Energy Systems
- Eco-Technology
- Carbon Natural Systems

The Blue: (Water Eco-Infrastructure)
- Water Management
- Sustainable Drainage
- Closing of the Water Cycle
- Rainwater Harvesting
- Water Efficient Fixture

The Green: (Ecological Eco-Infrastructure)
- Natural's Utilities
- Biodiversity Balancing
- Ecological Connectivity

The Red: (Human Eco-Infrastructure)
- Enclosure
- Spaces
- Hardscapes
- Use of Materials
- Use of Products
- Lifestyle (Society) and Regulatory Systems

2-THE SECOND STRATEGY:
- Design Building Surfaces as a Seamless (Smooth and Continuous)
- Bio-Integration of the Artificial with the Natural Environment

3-THE THIRD STRATEGY:
- Recycling
- Using Energy from the Sun for Photosynthesis
- Increasing Energy Efficiency
- Achieving a Holistic Balance of Biotic and Abiotic Constituents in the Eco-System.

4-THE FOURTH STRATEGY
- Creating New Artificial Living Urban Eco-Systems
- Rehabilitating Existing Built Environments and Cities
- Restoring Existent Devastated Eco-Systems within the Wider Landscape of our Designed System

5-THE FIFTH STRATEGY
- Consider The Context of The Biosphere Globally as a Series of Interdependent Interactions Environmental Stasis
- Repair The Environmental Devastation by Humans, Natural Disaster.
- Repair The Impact of Human Built Environment, Activities, and Industries

Other Literature Studies (Source 4)

BUILDING AND SPACE
- Physically Democratizes the Workplace (e.g. Ventilation and Lighting Control) (Thom Mayne, San Francisco Federal Building)
- Give Buildings and Place Individuality, with regard to space and character (Norberg-Schulz, 1980)
- Consider Building Space Images and Emotions in Design (Pallasmaa et al., 2005)
- Create a space and building that has a Sense of Strangeness and Familiarity (Pallasmaa et al., 2005)
- Being in the Room, Create a Sense of Security, a Sense of Togetherness or Isolation (Pallasmaa et al., 2005)
- A Building Should Produce a Sense of Loneliness and Silence (Pallasmaa et al., 2005)

EDUCATE (Source 3)
(Environmental Design in University Curricula and Architecture Training in Europe)

THE ENVIRONMENTAL CHALLENGE
- Climate Change
- Environmental Policies

CLIMATE AND COMFORT
- Climate and Weather
- Thermal Comfort
- Visual Comfort
- Indoor Air Quality
- Building Typology
- Outdoor Spaces

HEATING AND COOLING
- Thermal Environment
- Psychometrics
- Thermal Behavior of Buildings
- Steady-State Heat Flow
- Dynamic Response of Buildings
- Moisture Control
- Passive Design Principles
- Passive Design Systems
- Active Design Systems

VENTILATION
- Natural Ventilation
- Mechanical Ventilation

LIGHTING
- Physics of Light
- Natural Lighting
- Artificial Lighting

ACOUSTICS
- Acoustics in Design
- Materials in Acoustics
- The Reverberation Process

URBAN QUALITY
- Eco-Master Planning
- Environment
- Society
- Economy

ECOLOGICAL FOOTPRINT
- Environmental Impacts

RESOURCES AND WASTE MANAGEMENT
- Production Cycles
- Water Management
- Waste Management
- Renewable Energy Sources

BUILDING AND CITIES

Use of Energy

4.2.2 Knowledge Filtration and Categorization

The evaluated knowledge through the previous processes was classified, categorized, and organized. The knowledge was classified according to an index and then linked, combined, and integrated. The criteria were classified into six topics as illustrated in Table 4-2.

4.2.2.1 *Coding*

To reduce the collected data, shown in Figure 4-2, and Table 4-1, and to produce a single list representing green design criteria, a basic system consisting of six topics was designed and used to code the pieces of the data into various categories (see Table 4-2). For example, the categories were fleshed out and made more robust by searching through the data for more and better units of relevant information. The information was classified and categorized into six main topics of green knowledge, as shown in Table 4-2.

Table 4-2 Coding System for the Green Knowledge

Code	Direction	Categories
Topic 1	**Environment**	○ The Environmental Challenge
Topic 2	**Climate, Comfort**	○ Climate ○ Comfort ○ Acoustics ○ Building, and Place, and Space
Topic 3	**Low Energy / High Performance**	○ Heating and Cooling ○ Ventilation ○ Lighting`
Topic 4	**Quality of Life**	○ Urban Quality
Topic 5	**Impacts and Resources**	○ Ecological Footprint ○ Resources and Waste Management ○ Replenishable Sources ○ Embodied Energy
Topic 6	**Architecture and Urban Development**	○ Building and Cities ○ Embedded in Place

These six main topics include environment, climate and comfort, low energy and high performance, quality of life, impacts and resources, and architecture and urban development. Each topic contains categories, and a number of clusters are identified within each category.

4.2.3 Combining and Synthesizing the Western knowledge Framework

The western knowledge framework encompasses two domains: architectural knowledge and green issues and principles. The architecture knowledge domain addresses the main issues in architecture, including design, technology, and science. The green issues and principles domain addresses a combination of a condensed version of the 10 characteristics of green architecture by Buchanan (2005), the five green design strategies by Ken Yeang, green issues and principles that were prepared by EDUCATE (2012b), and other aspects from the case studies and the literature.

Structurally, each of the two domains has its own hierarchy of knowledge: higher-level knowledge builds on or incorporates the abilities acquired at a lower level. In other words, each domain begins with its goal at the top, followed by the objectives from a broad perspective, through the in-between levels, and down to the lowest level, which is usually a set of sub-criteria. To help efficiently prioritize the criteria, each one should have different sub-criteria. For example, green issues and principles in domain-2 started with an environmental as theme that addressed environmental challenges including climate change, global warming, and environmental policies as objectives (see Figure 4-4).

4.2.3.1 *Architecture Knowledge Domain*

The architectural knowledge domain consists of the three main dimensions of design: art, science, and technology. Deeper levels of sub-objectives include design principles, building systems, and building materials. These layers of sub-objectives will be combined with the corresponding layer of the second domain (Figure 4-4).

4.2.3.2 *Green Issues and Principles Domain*

As shown in Figure 4-4, the green issues and principles domain is comparable to the architecture knowledge domain in its structure but different in its content. This domain gathers the main and common green issues that have a strong relationship with architecture: climate and comfort, low energy and high performance, quality of life, impacts and resources, and community and connection. These criteria break down into deeper levels of sub-objectives, including climate, comfort and energy, heating and cooling, ventilation, lighting, health and happiness, access and urban context, environmental impacts, and resources and waste management.

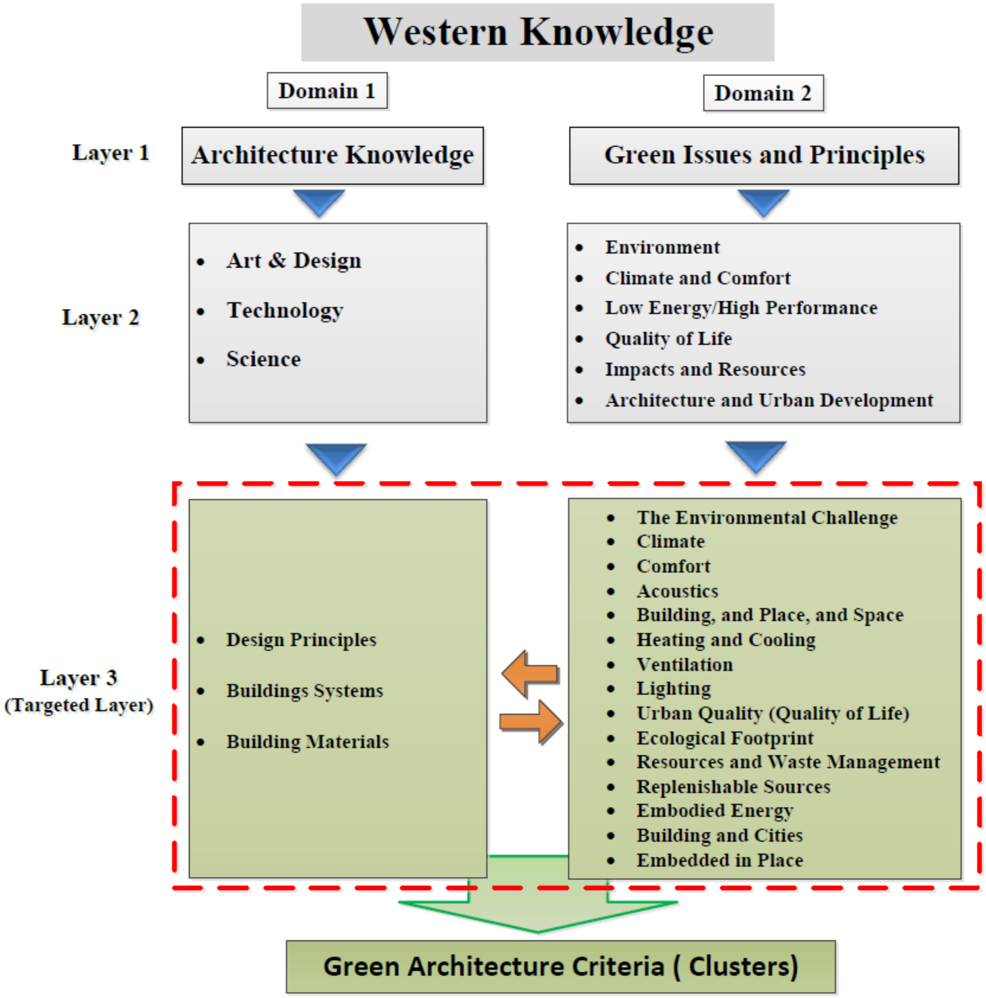


Figure 4-4 Hierarchy of the Western Knowledge Framework Combination

4.2.3.3 *Combining and Synthesizing the Two Domains*

The western knowledge framework was identify the boundary and the relationship between the two knowledge domains at the targeted layer (Figure 4-4). Eventually, the targeted layers of both domains were synthesized into one domain named Green Architecture Knowledge. For example, the new domain was combined architectural knowledge, including building site, space, form, materials, and systems, with green issues such as climate and comfort, health and happiness, air conditioning systems, lighting, water conservation, and air quality and consider them all as part of every design decision. Use of these green architecture criteria would contribute to a high-performance building that saves utility costs and enhances occupancy comfort and satisfaction.

4.2.3.4 *Categories, and Clusters of the Green Architecture Knowledge*

An analysis of the priorities of the knowledge described above and a combination and synthesis of the targeted layers produced green architecture criteria that support the implementation of environmentally responsive design criteria into architecture schools' programs. The researcher defined six main topics in categories approach that illustrated in Table 4-3.

The six main topics include environmental issues, climate and comfort, low energy and high performance, quality of life, impacts and resources, and architecture and urban development. Each topic contains categories, and a number of clusters fall within each category. The number and nature of clusters vary from one category to another according to the category itself and its importance in meeting green criteria (Table 4-3).

These categories and clusters include basic principles and criteria for systems and solutions and address global green challenges and their local expression in architectural and urban development. The knowledge introduced in these topics comes from physical, physiological, and psychological concepts related to the design of green communities that, when realized, can enhance comfort and quality of life for community members. After that, the ontological approach considers the strategies and technologies that assure appropriate management of energy in architecture and urban design while minimizing impacts on the environment and promoting a sustainable utilization of resources.

Table 4-3 the Hierarchy of the Green Architecture Knowledge Framework – Model A

			The Initial Western Knowledge Framework-Model-A	
			Categories	**Clusters**
Green Architecture Knowledge	Topic 1	Environment	The Environmental Challenge	○ Climate Change / Global Warming ○ Environmental Pollution ○ Environmental Policies
	Topic 2	Climate, Comfort	Climate	○ Climate and Weather
			Comfort	○ Thermal Comfort, and Standards ○ Visual Comfort, and Standards ○ Indoor Air Quality (Fresh Air and Absence of Toxic Materials) ○ Building Typology ○ Outdoor Spaces and Off-Gassing
			Acoustics	○ Acoustics in Design ○ Materials in Acoustics ○ The Reverberation Process
			Building, and Place, and Space	○ Physically Democratize the Workplace (e.g. Ventilation, and Lighting control) ○ Give Buildings and Place Individuality, with Regard to Space and Character ○ Place Image and Emotions in Design ○ Create a Space that has a Sense of Strangeness and Familiarity ○ Create a Sense of Security, and Isolation ○ Produce a Sense of Loneliness and Silence in the Space
	Topic 3	Low Energy / High Performance	Heating and Cooling	○ Thermal Environment ○ Psychrometric ○ Thermal Behavior of Building ○ Building Envelope Performance ○ Dynamic Response of Buildings ○ Moisture Control ○ Passive Design Principles ○ Passive Design Systems ○ Active Design Systems
			Ventilation	○ Natural Ventilation ○ Mechanical Ventilation
			Lighting	○ Physics of Light ○ Natural Lighting ○ Artificial Lighting
	Topic 4	Quality of Life	Urban Quality	○ Eco-Master Planning ○ Environment, Society and Economy ○ Laws, Regulations, Ethics
	Topic 5	Impacts and Resources	Ecological Footprint	○ Environmental Impacts
			Resources and Waste Management	○ Reuse old Building Materials and Components ○ Water Management (e.g. Recycle, Reduce, Rainwater Harvesting) ○ Waste Management (e.g. Recycle, Reduce…) ○ Durability, and Adaptability Materials
			Replenishable Sources	○ Renewable Energy Sources (e.g. Sun, Wind, Waves Energy, and Gravity and Geo-Thermal Power…) ○ Replenished Materials (e.g. Wood, or Clay (for Brick) and Sand (for Glass)
			Embodied Energy	○ Embodied Energy and Life-Time Energy Use ○ Material with Lowest Embodied Energy (Wood, then Brick) ○ Materials with Most Embodied Energy (Aluminum)
	Topic 6	Architecture and Urban Development	Buildings and Cities	○ Use of Energy ○ Building Must be Close to Public Transport ○ Rethinking in Cities and other Forms of Human Settlement ○ Rehabilitating Existing Built Environments and Cities
			Embedded in Place	○ Drawing on Local Wisdom ○ Updating Vernacular Architecture

4.3 Interviews

The interviews were the third source of the relevant knowledge in this research (as discussed previously in the research methodology). The information extracted from these interviews were influence the development of the Western knowledge framework. This section includes the findings of the interviews with five professors that represent three schools of architecture. Of the schools selected as case studies, all emphasize climate-responsive design strategies in their programs. The interviewees were helped the researcher achieve and improve the accuracy of the Western knowledge. The interview questions was open-ended and designed to give the interviewees the ability to talk about their experiences with the proposed Western framework (see Appendix A).

4.3.1 The Data Processing of the Interviews

To achieve and improve the validity and accuracy of the initial Western knowledge framework (model-A), a grounded theory approach was used to analyze the collected interview data. The approach contained two stages. The first stage was to identify and highlight the main ideas in each interview, and then to see the common concepts between the different interviewees. The second stage was to give each interviewee a title and illustrate his/her concept in a narrative and graphical way. This was to make the extracted data more workable when updating the final Western green knowledge framework (model-B).

4.3.1 Interviewees' Background and Experience

Participant-A is a professor who has taught at one of the selected schools of architecture (i.e. case studies) for many years. For his/her design studios and seminars, his/her interests are in design solutions that integrate aesthetics and energy awareness. He/she teaches courses related to site and building climatology, daylighting, and energy simulation. His/her topic areas of research are in natural ventilation, daylighting, passive design, building massing, thermal insulation, and energy auditing.

He/she previously participated in a study that focused on curriculum development that was undertaken by his/her institution and twelve additional architectural schools. Based on the results of this study, curriculum resource packages have been developed by these thirteen schools. This curriculum resource package present material for integrating principles of passive solar design and building climatology into architectural education and the studio design process.

Currently, he/she is also working as a director of more than one organization and laboratory. He/she previously worked as an advisor on a project related to the global warming for the U.S. Congress in 1991. Moreover, in 1988, he/she cooperated with a study investigating the impacts of climate change on the energy performance of buildings. He/she is an author of a several books on the practice of sustainable design, sun, wind and light, natural ventilation, and design procedures for passive environmental technologies. He/she has a list of publications that includes more than 100 papers and reports on computing, energy, climate, and housing. He/she also has co-authored software programs to facilitate design, including Energy Scheming, SIP Scheming, Energy Module, and Auto Architect.

He/she is a Fellow of the American Institute of Architects and the American Solar Energy Society. He /she has also received awards for leadership in research from the U.S. Green Building Council and the Architectural Research Centers Consortium. He/she was awarded both the National Award for Energy Innovation from the U.S. Department of Energy and the Governor's Award for Energy Innovation from his/her current institution.

Participant-B is an architecture professor who taught in one of the selected schools of architecture for many years. He/she is one of the top experts in the U.S. and works toward developing curricula for environmentally responsible design and post-occupancy analysis of building performance. He/she teaches design studios, courses in environmental control systems, and seminars in building performance, climatic design, and teaching methods for technical subjects in architecture.

He/she is the author of several books that have contributed to the application of environmental strategies during the schematic design of green buildings for use by design professionals, students, and the public. He/she is a sub-committee member for an ACSA taskforce to integrate sustainability into National Architectural Accrediting Board (NAAB) criteria and conditions. Also, he/she a committee member of some non-profit organizations that focus on green issues and education such as the American Institute of Architects (AIA) and the Society of Building Science Educators (SBSE).

Participant-C is an architecture associate professor interested in architecture that enhances quality of life. His/her research is directed towards high performance building design and evaluation, design for productivity, adaptive reuse, and lighting. He/she has taught at one of the selected schools of architecture for many years. He/she engages students in hands-on research and design explorations in design studios, seminars, and courses in environmental control systems. He/she led research studies on daylighting and productivity in retail, school environments, and designers on sky lighting optimization, lighting controls, and energy efficient multi-family housing.

Participant-D is an architecture professor with expertise in energy-efficient structures and reducing glare from buildings, lighting, natural lighting, design of buildings in response to the thermal, acoustical and radiant environment, and relationships between environment, economics and architectural goals. He/she has been teaching for thirty-eight years, including undergraduate and graduate courses in environmental controls and graduate studios and seminars in lighting and environmentally related courses. He/she has been the director of the building science thesis class for many years. He/she has authored, co-authored or edited six books on topics in environmental controls, published over fifty papers, and consulted on over fifty buildings.

He/she became the vice dean of his/her architecture school and had a very strong impact on the curriculum and school. In this capacity, he/she created some additional exercises to make sure that environmental-control and energy issues taught were in the studios. This was especially important, as the school had nearly failed its NAAB accreditation and he/she had the argument or the reasons that allowed him/her to encourage the professors to address these issues in the classes.

Participant-E is an architect who has taught in one of the selected schools of architecture for five years, focusing on practicing architecture in the community. Within his/her school system, he/she embodied a focus that related to sustainability and energy conservation. He/she has also been interested in educating students about green technology and green thinking. He/she is now working as a faculty advisor for the United States Green Building Council student group at his/her university, which is a group of roughly twenty active students that meet once a week to discuss green design and things that be done to help the community and improve the environment.

His/her knowledge interests include geometry and energy-effective shapes for dwellings. Through his/her scientific journey, he/she taught many classes such as various design studios, environmental technology systems, an integrative graduate studio, an environmental science laboratory, a research studio, and sustainable design and the LEED initiative. He/she worked as project manager for large commercial projects such as hospitals, recreation centers, and hotels. In addition, he/she worked as project designer for several large projects in the U.S. Finally, he/she is a long-standing member of the AIA, the United States Green Building Council (USGBC), the American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE), and is a LEED Accredited Professional (LEED AP BD&C).

4.3.2 Interviews Findings

At the beginning of the interview, a general question about the framework was asked of all of the participants: What do you think about the classification of the six topics of the green knowledge framework? All of the participants agreed on the main thrust of the framework, or that at first look, it seems to be complete, organized, and cover most of the green architecture topics. Some specific additional comments were made by the participants. Participant-A indicated that all topics that were presented in the proposed framework were mentioned in his/her book in a different way, and he/she provided the researcher with a copy of his/her book for more information. Explaining that the framework seems to cover all of the starting points, Participant-C said, “I know nothing is complete but to have a framework that covers a starting point for each of the topic areas is really good.” Participant-D clarified that the topics all look great, but Topic-5 could be switched with Topic-4, or that Topic-5 could be placed before Topic-4 in teaching order. Participant-E said, “I think you covered just about everything I can think of.”

Then, a specific open-ended question was presented to all participants for each topic of the six topics of the framework. The question included: what do you think about the classification of this topic? Should I add/remove any category or cluster? The participants’ responses mentioned the following points.

shows the Western Knowledge Framework-Model-B, including the participants' suggestions.

4.3.2.1 *Topic 1: Environment*

Category 1: The Environmental Challenge

All participants agreed on the validity of this category and its cluster, while suggesting some criteria that need to be added. Participant-A mentioned that all category clusters seem good, but "environmental history" needed to be added to this cluster. Participant-C added to the cluster the idea of "environmental economics," which would talk about the concept of carrying capacity. Participant-D suggest including "water" in this category, because "water" is the way to start talking about other issues (e.g. climate change, global warming, etc.). Participant-E stated that the clusters and the category are fine, but one thing that needed to be part of the education system for teaching this category was to show some images to the students. He/she gave an example of the mountains that were destroyed by using coal mining and some images of the air pollution that comes out of power generation plants. In addition, he/she added that this section should include an understanding of the sources of energy and their associated environmental damage (Topic 2: Climate and Comfort).

Category 1: Climate

All of the participants agreed that this category and its clusters should be included. However, Participant-E suggested changing the teaching order of climate and comfort. More specifically, he/she stated that, at his/her school, he/she usually teaches the topic of comfort first and climate second, "so that [you] can evaluate comfort when you start to teach climate." In addition, he/she added, "When the students understand radiation, conduction, convection, and how that affects the human body … then they will begin to think about climate."

Category 2: Comfort

There are four comments that were made in regards to the clusters of the comfort category mentioned by the participants. Participant-A suggested to remove the word "standards" from the theme "Thermal Comfort and Standards" and from "Visual Comfort and Standards." He/she said, "Standards are quite a bit different to understanding… [a] standard is an exploration of the future of what can be."

Participate-B agreed with including all of the clusters, however he/she suggested transferring “Off Gassing” to Topic-5, Category-3 since, to him/her, “Off Gassing” is more related to “materials” (see Figure 4-5). Participant-C added that the beauty, aesthetics, and the culture of the place are important to the notion of comfort and need to be added to this category, stating, “Comfort is a cultural phenomenon as well.” In addition, he/she suggested adding “ergonomics” to this category and gave an example of the height of a chair, table, etc.—which pertains to muscle comfort.

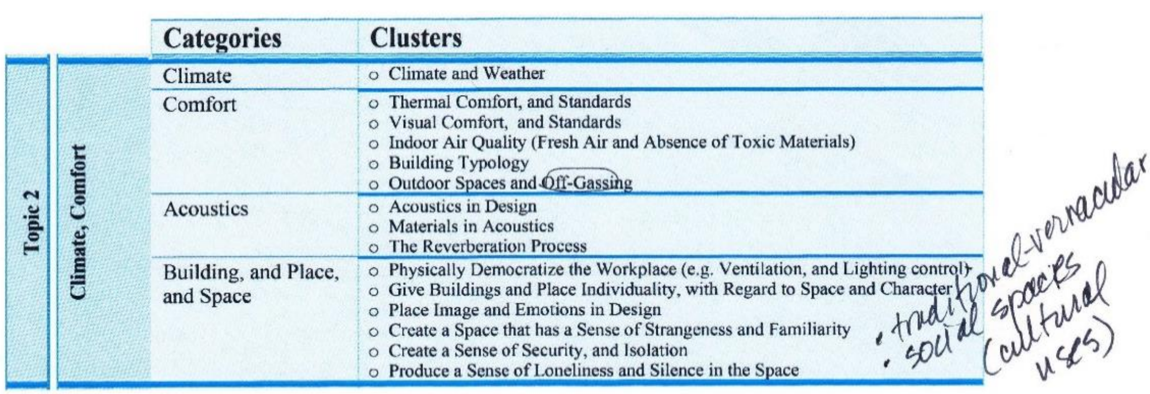
Participate-D stated that a “psychrometric chart” needs to be added to the comfort category as well. According to him/her, an introduction to the comfort zone needs to be taught to the students at this stage of knowledge because, as he/she recommended, it “is better to introduce psychrometrics when you introduce comfort, because that is the first time students think about it.”

Category 3: Acoustics

All of the participants agreed on this topic; however, Participant-C stated that acoustics and lighting are somewhat similar and, thus, it is sometimes useful to teach them back-to-back.

Category 4: Building, and Place, and Space

All the participants agreed on this category and its clusters. However, Participant-B suggested adding “vernacular architecture elements,” like courtyards. He/she also added that vernacular architecture really was about using regional craft and knowledge, and so that could also pertain to climate (see Figure 4-5).



		Categories	Clusters
Topic 2	Climate, Comfort	Climate	o Climate and Weather
		Comfort	o Thermal Comfort, and Standards o Visual Comfort, and Standards o Indoor Air Quality (Fresh Air and Absence of Toxic Materials) o Building Typology o Outdoor Spaces and Off-Gassing
		Acoustics	o Acoustics in Design o Materials in Acoustics o The Reverberation Process
		Building, and Place, and Space	o Physically Democratize the Workplace (e.g. Ventilation, and Lighting control) o Give Buildings and Place Individuality, with Regard to Space and Character o Place Image and Emotions in Design o Create a Space that has a Sense of Strangeness and Familiarity o Create a Sense of Security, and Isolation o Produce a Sense of Loneliness and Silence in the Space

Figure 4-5 Participant-B comments on Topic-2

4.3.2.2 ***Topic 3: Low Energy and High Performance***

Category 1: Heating and Cooling

Participants B, D, and E agreed on this category as it was presented to them. However, while Participants-A, and C both agreed on the category in general, they did so with some additional comments. Participant-A did not naturally see a difference between the ‘passive design principles’ cluster and ‘passive design systems’ cluster. He/she suggested that these could be considered as one and the same unless the principles focus on other aspects of building design.

Participant-C commented that the concept of a ‘building envelope’ is very important to the cluster. He/she stated, “In general, the building envelope or enclosure is related to heating and cooling, but it’s also…related to ventilation and lighting.” He/she suggested that ‘building envelope’ or ‘enclosure’ needs to have its own classification under Topic-3, because it not only pertains to heating and cooling, but also to shading of the building, solar panels, etc. (see Figure 4-6)

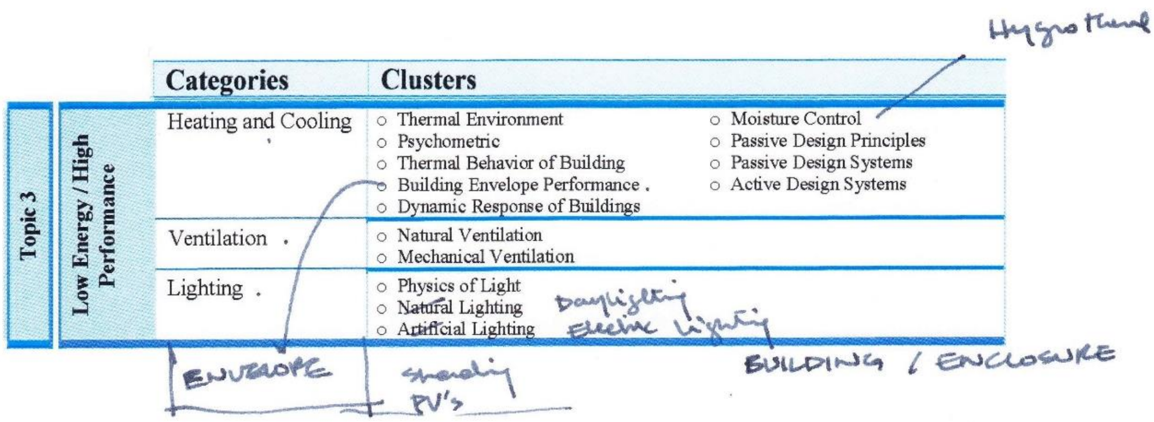


Figure 4-6 Participant-C comments on Topic-3

Category 2: Ventilation

For this category, Participants C, D, and E agreed on this cluster as is. However, Participant-A specified that there is ventilation to cool people and there is ventilation to cool buildings—and that both need to be covered under this category. Participant-B suggested adding one cluster to this category—‘hybrid ventilation’ or ‘mixed mode’—that can combine the two systems of natural ventilation and mechanical ventilation. He/she added that using mixed mode is dependent on the climate conditions of some areas. For example, because the San Francisco climate is cool, it is possible to use that cool air and not have to pre-cool it. Therefore, many commercial buildings in the city began using mixed-mode systems. This helped them save much energy normally used for air conditioning.

Category 3: Lighting

Only Participants D and E agreed on this category as is. Among the other three participants, two additional comments were indicated. Participant B and C suggested using the terms of “daylighting” and “electric lighting” rather than using the terms “natural lighting” and “artificial lighting,” respectively. Their reasons for this is that the former two terms are used more in the education system and in the researchers’ domains (see Figure 4-7).

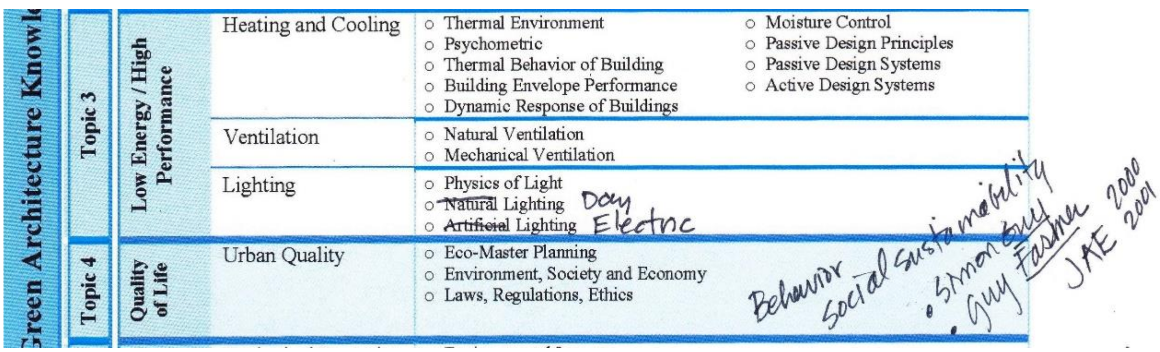


Figure 4-7 Participant-B comments on Topic-3, and 4

Participant-E said, “Everything seems fine,” however, he clarified that when he/she teaches environmental control systems classes, “we include the energy efficiency in the performance of elevators and escalators. [Therefore,] they should be in another category.” In this way, he/she suggested adding a new category under this topic area called “Building Transportation Systems”—which would include covered elevators, escalators, moving walkways, pumps, and fans (see Table-4-4).

4.3.2.3 *Topic 4: Quality of Life*

Category 1: Urban Quality

Participant-A suggested adding “microclimate” and access to sun and light to this category. Participant-B added “behavior” and “social sustainability,” and he/she suggested adding some of Guy and Farmer (2001) knowledge from their paper “Reinterpreting sustainable architecture: the place of technology" in this category (see Figure 4-7). After the researcher looked at this paper, he found that some terms like flexible, decentralized, participatory, environmental sustainability, and social ecology and home could be included in this category. Participant-B also indicated that some knowledge associated with transportation should be covered in this category like "transportation planning" and "walkability." Contrary to Participant-B, Participant-A and Participant-C suggested that transportation knowledge would be much better classified as a separate category in Topic-6 (see Table 4-4).

Participant-E indicated that the major focus of this category is "Urban Quality," which is important to him/her, but he/she also advised adding a new category called "Building Quality or Indoor Quality." He/she stated that the "quality of lives need to be not only urban quality but in and around the building." He/she proposed adding "daylighting" in the newly suggested category (Building Quality or Indoor Quality). He/she noted that daylighting was already included in Topic-2 but needed to be part of this topic as well.

Based on his/her comments, the researcher realized that most of the Participant-E's comments are already covered by Category-4 (Building, and Place, and Space) under Topic-2. This means the clusters that are listed under 'Building, and Place, and Space' can potentially be related to both the "Comfort" theme and to the "Building Quality and Indoor Quality" theme. Therefore, the researcher created a new category under Topic-4 (Quality of Life) called "Building Quality and Indoor Quality" that merges most of the Category-4 (Building, Place, and Space) clusters and includes Participant-E's comments (see Table 4-4).

4.3.2.4 *Topic 5: Impacts and Resources*

Category 1: Ecological Footprint

Participants-B, C, D, and E agreed on this category and its clusters as-is. Participant-A agreed on the category in general with some added comments. He/she mentioned that 'environmental impacts' is a big subject and it is not clear what is covered by this category. He/she suggested to rename it as 'environmental context,' which maybe more useful down the road for environmental considerations because this will include damages and necessary remediation.

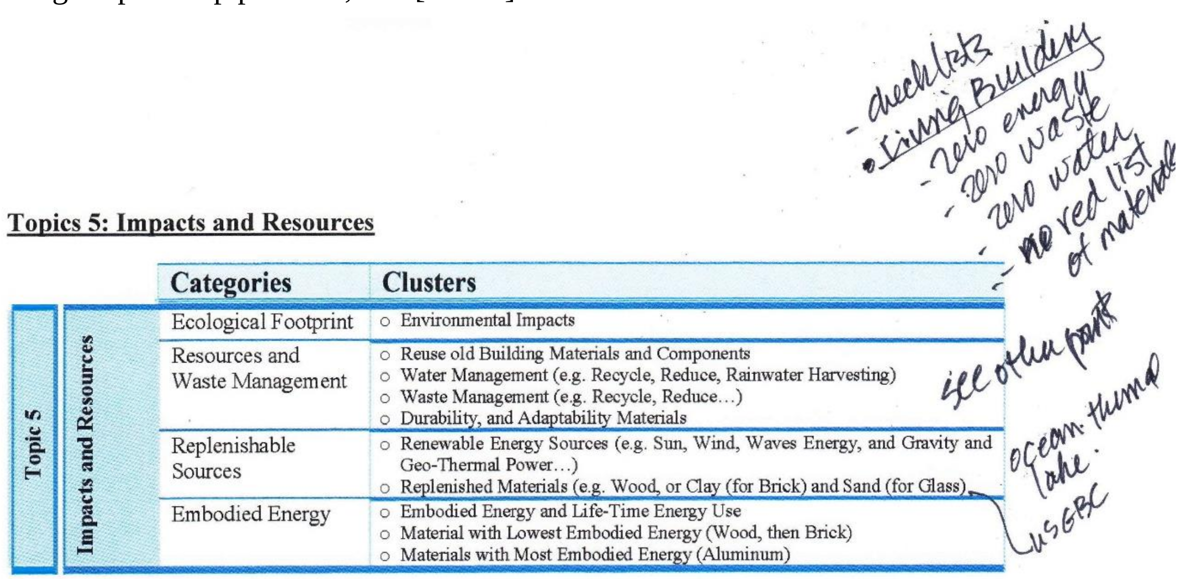
Category 2: Resources and Waste Management

Four of the participants indicated that the category and its clusters "look great." While Participant-B suggested adding both 'carbon analysis' and 'off gassing' of materials. He/she gave an example of some insulation products that use a blowing agent to make the insulation, which is bad for the atmosphere and destroys the ozone. He/she also added that the student learn of how to get zero waste and zero water.

Category 3: Replenishable Sources

Participants A, C, and D accepted this category as it was presented to them. However, Participant-E stated, "most [professors] in our university would call this 'renewable sources'; it means the same thing." Thus, he/she suggested renaming this category.

Participant-B suggested adding some other aspects of renewable energy such as: ocean thermal energy conversion and zero energy (see Figure 4-8). He/she gave the example of Cornell University, which has a huge project employing Lake Source cooling. According to Participant-B, this project "can take cool ocean water from really deep and bring it up to help pre-cool, and [do the] same for the lake."



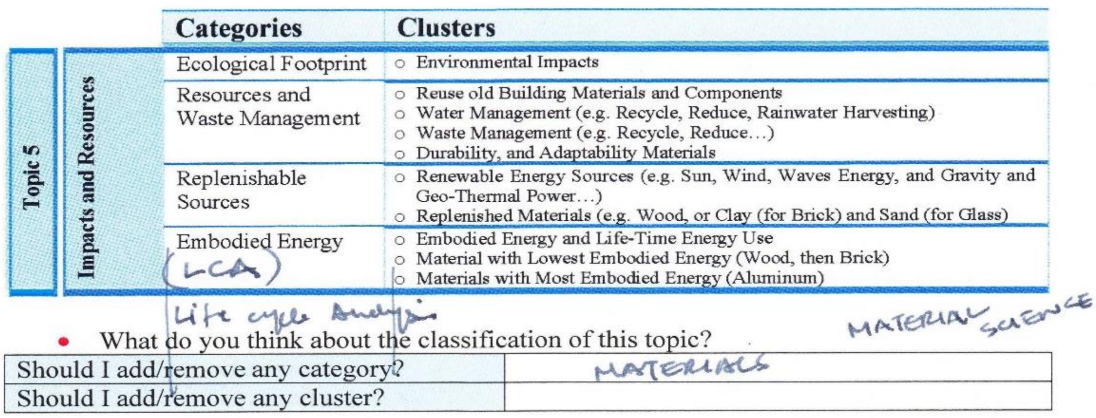
Topics 5: Impacts and Resources

		Categories	Clusters
Topic 5	Impacts and Resources	Ecological Footprint	○ Environmental Impacts
		Resources and Waste Management	○ Reuse old Building Materials and Components ○ Water Management (e.g. Recycle, Reduce, Rainwater Harvesting) ○ Waste Management (e.g. Recycle, Reduce…) ○ Durability, and Adaptability Materials
		Replenishable Sources	○ Renewable Energy Sources (e.g. Sun, Wind, Waves Energy, and Gravity and Geo-Thermal Power…) ○ Replenished Materials (e.g. Wood, or Clay (for Brick) and Sand (for Glass)
		Embodied Energy	○ Embodied Energy and Life-Time Energy Use ○ Material with Lowest Embodied Energy (Wood, then Brick) ○ Materials with Most Embodied Energy (Aluminum)

Figure 4-8 Participant-B comments on Topic-5

__Category 4: Embodied Energy__

All the interviewees accepted the category with its clusters as-is, with the exception of Participant-C and E adding some comments. Participant-C suggested adding one more category, ‘life cycle analysis’, that needs to have its own classification under Topic-5. This would include more knowledge of new developed materials and materials science like ‘phase change materials’ (PCM) and ‘plastic products’ (see Figure 4-9).



Topic 5	Impacts and Resources	Categories	Clusters
		Ecological Footprint	o Environmental Impacts
		Resources and Waste Management	o Reuse old Building Materials and Components o Water Management (e.g. Recycle, Reduce, Rainwater Harvesting) o Waste Management (e.g. Recycle, Reduce…) o Durability, and Adaptability Materials
		Replenishable Sources	o Renewable Energy Sources (e.g. Sun, Wind, Waves Energy, and Gravity and Geo-Thermal Power…) o Replenished Materials (e.g. Wood, or Clay (for Brick) and Sand (for Glass)
		Embodied Energy	o Embodied Energy and Life-Time Energy Use o Material with Lowest Embodied Energy (Wood, then Brick) o Materials with Most Embodied Energy (Aluminum)

• What do you think about the classification of this topic?

Should I add/remove any category?	
Should I add/remove any cluster?	

Figure 4-9 Participant-C comments on Topic-5

Participant-E offered one comment to increase the knowledge covered by this category. He/she said, “Embodied energy is really important. One of the things we were talking about with some of the educators here today was going beyond understanding what embodied energy is, but what it means to choose something relative to its embodied energy.”

He/she continued by giving an example of concrete that has a very high-embodied energy. He/she said,

> *“Because, for example, concrete, which has very high embodied energy because of the heating process and pulverization of the cement, could be preferred environmental choice over another material, because concrete will lasts for several centuries. If you can build a building that last several centuries that has higher embodied energy, maybe that is better than having a building that gets torn down every sixty years that has less embodied energy.”*

Therefore, Participant-E suggested that embodied energy should be part of this subject matter as well. The researcher will discuss this aspect in more detail in Chapter 6 as part of the future knowledge that is suggested in the proposed framework (see Table 4-4).

4.3.2.5 *Topic 6: Architecture and Urban Development*

Category 1: Buildings and Cities

All the participants accepted the category, with all but Participant-B offering some comments regarding its clusters. Participant-A, C, and D suggested classifying transportation in a separate category under this topic. According to Participant-C, the new category should include knowledge like transportation planning, alternative transportation, city connectivity, accessibility, walkability, and bike-ability. Moreover, Participant-E suggested adding 'urban densities' here as well, which was already mentioned in Topic-5, Category-1.

Category 2: Embedded in Place

All the participants accepted this category as is.

Table 4-4 Western Knowledge Framework – Model-B

Western Knowledge Framework (Model-B)

Green Architecture Knowledge

Topic	Theme	Categories	Clusters
Topic 1	Environment	The Environmental Challenge	○ Environmental History ○ Climate Change ○ Global-Warming Potential ○ Water and Environmental ○ Energy Sources and Associated Damage ○ Environmental Economics ○ Environmental Pollution ○ Environmental Policies
Topic 2	Comfort, and Climate	Comfort	○ Psychrometrics (more general, and applies) ○ Thermal Comfort ○ Visual Comfort ○ Indoor Air Quality ○ Building Typology ○ Outdoor Spaces Design ○ Beauty and Aesthetic of a Place ○ Culture of a Place ○ Ergonomics (e.g. Special Comfort)
		Climate	○ Climate and Weather
		Acoustics	○ Acoustics in Design ○ Materials in Acoustics ○ The Reverberation Process
Topic 3	Low Energy / High Performance	Heating and Cooling	○ Thermal Environment ○ Psychrometrics Chart ○ Thermal Behavior of Building ○ Building Envelope Performance ○ Dynamic Response of Buildings ○ Moisture Control (Hygrothermal) ○ Passive Design Systems ○ Active Design Systems
		Ventilation	○ Natural Ventilation ○ Mechanical Ventilation ○ Hybrid Ventilation / Mixed Mode
		Lighting	○ Physics of Light ○ Daylighting ○ Electric Lighting
		Enclosure	○ Double-Façade Curtain Wall ○ Green Roofs ○ Solar Panels and PV's Integration ○ Infiltration and Airtightness ○ Solar Control ○ Thermal Insulation ○ Orientations ○ Design for Durability ○ Design for Simplicity and Aesthetic
		Building Transportation Systems	○ Energy Efficiency and Performance of: ○ Elevators, Escalators, and Moving walkways ○ Pumps, and Fans
Topic 4	Impacts and Resources	Ecological Footprint	○ Environmental Context
		Resources and Waste Management	○ Reuse old Building Materials and Components ○ Water Management (e.g. Recycle, Reduce, Rainwater Harvesting) ○ Zero Water ○ Waste Management (e.g. Recycle, Reduce…) ○ Zero Waste ○ Durability, and Adaptability Materials ○ Carbon Analysis, and Off-Gassing of materials
		Renewable Sources	○ Renewable Energy Sources (e.g. Sun, Wind, Waves Energy, and Gravity and Geothermal Power…) ○ Ocean Thermal Lakes ○ Zero Energy ○ Replenished Materials (e.g. Wood, or Clay (for Brick) and Sand (for Glass)
		Embodied Energy	○ Embodied Energy and Life-Time Energy Use ○ Material with Lowest Embodied Energy (Wood, then Brick) ○ Materials with Most Embodied Energy (Aluminum)
		Life Cycle Analysis	○ Materials Science (e.g. phase change materials (PCM)) ○ Building Life-Cycle Analysis (e.g. Material Manufacturing, Construction, Use & Maintenance, and End of Life)
Topic5	Quality of Life	Urban Quality	○ Eco-Master Planning ○ Health and well-being ○ Behavior - Social Sustainability ○ Urban Densities ○ Decentralized ,and Participatory ○ Microclimate and Sun Access ○ Environment, Society and Economy ○ Laws, Regulations, Ethics
		Building Quality and Indoor Quality	○ Quality of Daylighting ○ Social Places (e.g. Courtyard) ○ Physically Democratize the Workplace (e.g. Ventilation, and Lighting control) ○ Give Buildings and Place Individuality, with Regard to Space and Character ○ Place Image and Emotions in Design ○ Create a Space that has a Sense of Strangeness and Familiarity ○ Create a Sense of Security, and Isolation ○ Produce a Sense of Loneliness and Silence in the Space
Topic 6	Architecture and Urban Development	Buildings and Cities	○ Use of Energy ○ Rethinking in Cities and other Forms of Human Settlement ○ Rehabilitating Existing Built Environments and Cities
		Transportation	○ Transportation Planning ○ Alternative Transportation ○ City and Connectivity ○ Accessibility ○ Walkability ○ Bike-ability
		Embedded in Place	○ Drawing on Local Wisdom ○ Updating Vernacular Architecture

5. SAUDI ARABIAN CONTEXT FRAMEWORK

5.1 Architecture Schools and Local Context

As already noted in Chapter 2, six schools in Saudi Arabia have architecture programs. The first five of these were established between 1967 and 1983 (Salama and Amir 2005). In 1967, King Saud University (KSU) was the first university to establish a department of architecture. The University of Dammam (UOD) followed in 1975, with King Abdul-Aziz University (KAU) in 1976, King Fahd University of Petroleum and Minerals (KFUPM) in 1980, and Umm Al Qura University (UAU) in 1983 (Salama and Amir 2005, Akbar 1985). More recently, Qassim University (QU) established its college of architecture and design in 2008 and accepted its first students during the 2008-2009 academic year (QU 2013). The relatively short period in which architecture emerged as a discipline in Saudi Arabia makes it an excellent case study for making a comparative study. Therefore, this chapter seeks to answer two questions: what are the similarities and differences amongst the six schools of architecture in terms of four dimensions—historical, environmental, economic, and socio-cultural? Are these schools all similar enough to allow one framework to be implemented laterally, or does each school have its own characteristics that requires different frameworks for each? In answering these questions, the goal of the proposed framework of this study is to integrate green design knowledge into Saudi architectural programs, but in a way that is culturally sensitive.

To answer the first question, the research reviewed the goals, objectives, curricula, course syllabi, and course slides of these six schools in order to determine their degree of similarities and differences. These materials will be compared with literature from some professors and scholars in Saudi Arabia to answer the two questions that serve as the basis of this part of the research. This will help the researcher to see if the all schools of architecture in Saudi Arabia exhibit similar characteristics or if each school has its own characteristics in terms of the four context dimensions. According to the schools' course syllabi and contents, a curriculum review, and a literature review, these programs are different in curricular structures, class names, and length of study, but similar in context. This means that the topics and the contents are almost identical among these six schools and the classes discuss the same cultural, environmental, historical, and economic issues. For example, the syllabi for and contents of classes in all of the schools' programs cover Islamic cultural aspects and privacy, neighborhood relationships, vernacular and Islamic architecture characteristics, and environmental conditions and human behavior issues. Moreover, sustainability issues like energy saving issues, efficient use of non-renewable resources, climate and design, water management and recycling, and materials recycling and reuse are all covered by all of the programs.

However, to answer the second question, it is important to understand the reasons for these similarities and differences. One reason for the similarities between these programs is because of the nature of Saudi Arabia as a country. Saudi Arabia is not a federation of states, each with its own economic, historical, and environmental issues, like the United States of America. It is a Kingdom controlled by a King, one government, and one economy—or a "is a monarchy based on Islam…headed by the King" (DC 2015). The King governs with the help of twenty-two government ministries. Each ministry specializes in a different part of the government, such as education and finance. In addition, Saudi Arabia has thirteen provinces, each governed by a governor, who advises the King and deals with the development of the province (DC 2015). Though the six schools are located in different regions, they address the same economic issues and fall under the same economic umbrella. The economy is totally controlled by the government; the King and the structure of the government itself are the most influential factors in economic investment. For example, the cost of building materials such as concrete, cement, and steel are almost the same in all regions of Saudi Arabia. The cement sector is highly regulated by the government in Saudi Arabia, which gives the government relatively high control of cement prices (Edwards 2012). Consequently, the historical, environmental, economic, and social and cultural dimensions of the six schools are considered the same, and they are taken as a group, one school representing all. Moreover, the most important reason for the similarities between the programs is that higher education in Saudi Arabia is totally under the control of the government (i.e. absolute monarchy) and the state religion of Islam. All of the six schools report to the Ministry of Higher Education, which recently merged with the Ministry of Education (SUSRIS 2015). The higher education system and its knowledge-base is grounded on the foundation of religious Sharia law, so religion is also a big part of the structure of each architecture school. Therefore, Islamic social and cultural values are inherent in the schools' programs, and all schools are grounded on the same principles. For example, teaching Islamic cultures and Sharia law or Islamic law are mandatory and required courses in all Saudi architecture schools. Therefore, Islamic values are rooted in each individual in the society and have a big influence on design studio.

Another reason for the program's similarities is due to the influence of the structure of international architectural programs. This has led to the similarities between architecture schools in Saudi Arabia and the schools from which they were derived. For instance, the curriculum at the University of Dammam (previously King Faisal University) was revised in the autumn of 1985 with the cooperation and advice of Rice University; the architecture curriculum at King Saud University was developed in 1967 by the United Nations Educational Scientific and Cultural Organization (UNESCO); and the curriculum at King Abdul Aziz University was developed by Harvard University (Abu-Ghazzeh 1997). Abu-Ghazzeh formerly taught at the College of Architecture and Planning at King Saud University in Riyadh, Saudi Arabia. In his paper, "Vernacular architecture education in the Islamic society of Saudi Arabia," Abu-Ghazzeh (1997) looks for the influence of international schools on the local context of architecture programs by incorporating the literature review with the current local issues in the schools' curriculum to build a strong base of knowledge that covered most of the local issues. Based on his findings, the author suggests that the curricula of architecture schools have been developed to reflect international standards, although often at the cost of being insensitive to local issues.

Despite the many similarities in the programs, there are also some differences that need to be considered before determining if these six programs are similar enough to allow one to represent all. Jamel Akbar (1985) states in his paper "Architectural education in the Kingdom of Saudi Arabia" that launching four schools of architecture within ten years by different organizations should lead to diversity of programs and curriculum structures. However, though these programs differ in length of study, distribution of courses, and other factors, they are very similar in content. He adds, "All curricula have the same theoretical underpinnings. As a graduate of King Saud University and a member of the Faculty of King Faisal University, and having examined the course descriptions of other schools, I would say that the doctrine is a very noble one." The fact that the six schools are located in different regions helps explain the difference in curricular structures, class names, and length of study. However, because the historical, environmental, economic, social and cultural dimensions of the six schools can be considered the same, the researcher has concluded that they can be interpreted as a homogenous group, and therefore a single Saudi Arabia knowledge framework could be implemented in all six schools.

5.2 The Initial Saudi Arabia Knowledge Framework (Model-A)

The Saudi Arabian context framework focuses on the country's historical, environmental, economic, social, and cultural perspectives. These four perspectives or dimensions were extracted from the literature review, documents from the Saudi architecture schools, and interviews with Saudi Ph.D. students in architecture and allied fields (see Table 5-1). Examples of selected types of documents include curricular content structures, course content explanations, course syllabi, and some lecture slides. The students selected for the study all graduated from different schools of architecture in Saudi Arabia and have experience and knowledge of the four Saudi perspectives.

Structurally, as shown in Figure 5-1, the initial Saudi Arabia knowledge framework contains three layers of knowledge content, beginning at the surface level with the main goal (Saudi Arabian context) and progressing to the deeper objectives. The Saudi Arabian context is the main goal of the Saudi knowledge category, followed by broad criteria including Saudi historical, economic, environmental, and socio-cultural dimensions. The framework then progresses to the deepest level, which is a set of targeted sub-criteria related to place and culture, vernacular architecture, religious and privacy issues, and economic issues.

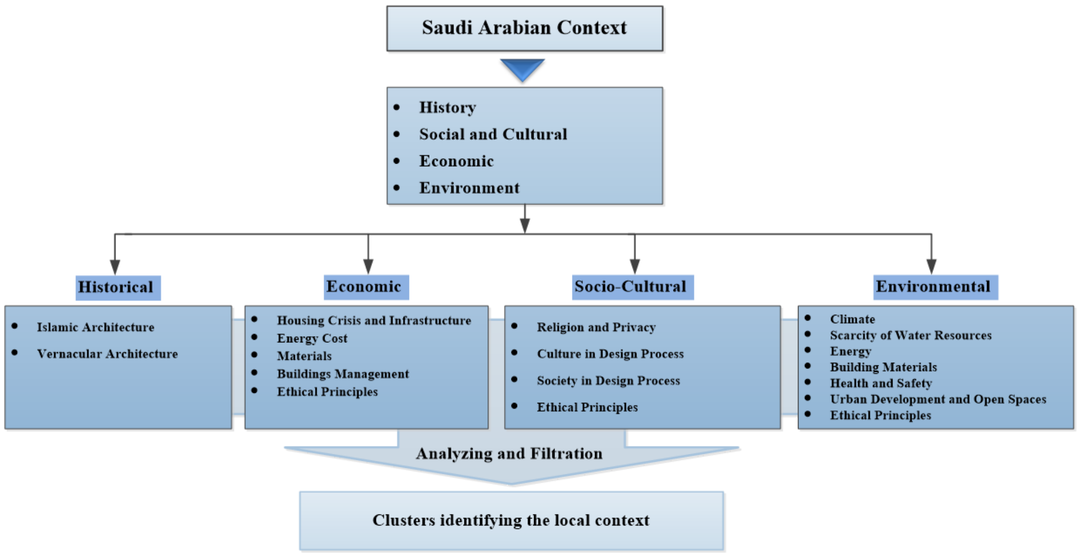


Figure 5-1 the Saudi Arabian Context Framework Structure

5.2.1 Knowledge Analysis and Reduction

The researcher reviewed the curricula of the Saudi architecture schools to understand the incorporation of local context in their current program criteria. The review of course descriptions, syllabi, and some lecture slides showed that they captured local issues, including Saudi historical, social and cultural, economic, and environmental dimensions (see Table 5-1). For example, syllabus contents of the architecture programs include Islamic cultural aspects and privacy, vernacular and Islamic architecture characteristics, and environmental conditions and human behavior issues. Also, the syllabi discuss issues of sustainability like energy saving issues, efficient use of non-renewable resources, climate and design, water management and recycling, and materials recycling and reuse are all covered by all of the schools' programs. In addition, the local issues captured in the schools' documents were also supported by other local issues found in the literature review. The researcher used these documents and the literature review to extract, analyze, and filter the local context of the four dimensions and determine the criteria most representing the Saudi context. The researcher photocopied all the schools' documents, took notes, made comments, and gathered all information related to the above four dimensions. The volume of the data was reduced into manageable pieces, after which the researcher performed a cluster analysis (see Table 5-1) to determine that all knowledge related to Saudi Arabian issues was covered and to see if it was worthwhile to undertake additional development and assessment of the quality of knowledge. The extracted knowledge from the schools documents was triangulated and merged with other issues from the literature review to create the initial Saudi Arabia knowledge framework. For example, in the last three decades, several scholars, writers and thinkers have written about the current problems and the future of the Kingdom in term of shortage of water resources, dependence on the oil as the sole source income of the country, rationalization of energy use, and encourage people to avoid negative habits in the use of resources (see Section 2.8.4, Chapter-2). All these issues and other issues related must be included in the new Saudi Arabia educational framework.

All of the information that was gathered was classified and categorized under four dimensions. A basic coding system was designed to sort the documents' data and the literature into four categories: history, environment, economy, and society and culture. Historical aspects include Islamic architectural characteristics, vernacular architecture characteristics, conventions, customs, laws, and decision-making processes. Social aspects include comfort, health, indoor environment quality, access to facilities, participation, control, education, safety, and other factors. Economic aspects can be defined by efficiency of use, ongoing costs, capital costs, operation costs, durability, adaptability, maintenance, and other factors. Finally, environmental aspects include climate, scarcity of water resources, energy issues, buildings materials, health and safety, urban development, and other factors.

5.2.1.1 *Categories, and Clusters of Saudi Aspects*

The review of the Saudi schools' documents, the literature, and related previous studies revealed ninety-one criteria. These three sources of criteria were triangulated with each other to be sure that they all gathered information cover all Saudi context. Then, the researcher analyzed and classified the collected criteria into four dimensions: historical, environmental, economic, and socio-cultural dimensions. A number of categories identify each dimension, and a number of criteria identify each category. The number and nature of the criteria vary from one category to the next according to the category itself and its importance in matching the local context (see Table 5-1).

Table 5-1 the Initial Saudi Arabia Context – Model A

		Saudi Arabian Knowledge Framework (Model-A)	
		Categories	**Clusters**
Saudi Arabia Context	Historical	**Historical Criteria**	○ Islamic Architecture Characteristics ○ Vernacular Architecture Characteristics ○ Create Awareness Among Designers ○ Conventions, Customs, Laws, and Decision-Making Processes ○ Technical Durability, Simplicity, Adaptability
	Economic	**Housing Crisis and Infrastructure**	○ More Demand for Single-Family Houses ○ Increase Single-Family Villa's Cost ○ Limited Lands ○ A Huge Bill for Servicing Land for Housing ○ Provide Public Services and Infrastructure
		Energy Cost	○ High Cost of Energy Usage ○ Efficiency of Use (Water, Energy, and Materials Use) ○ Apply Energy Technical Standards
		Materials	○ Local/Regional Materials ○ Ensure Durability of Materials ○ Enable Adaptability of Materials ○ Ensure Quality of Materials
		Buildings Management	○ Life Cycle Cost and Profit ○ Buildings Maintenance Cost ○ Project Management ○ Construction Management ○ Marketing and Sales Skills
		Ethical Issues	○ Legal and Ethical Issues
	Socio-Cultural	**Religion and Privacy**	○ Respect Islamic Laws and Users Privacy ○ Consider Neighborhood Relationships and Privacy ○ Residential Visual Privacy ○ Consider the Separation Issues between Women and Men in Design
		Cultural Issues	○ Respect Culture Issues ○ Preserving Heritage Value ○ Preserving Social and Cultural Character
		Society and Design	○ Innovation and Design Process ○ Usability and Aesthetic Aspects in Design ○ Functionality (the purpose of the building) ○ Consider Environmental Conditions and Human Behavior Issues ○ Provide Public Amenities ○ Satisfy Privacy ○ Consider Earthquake, Geotechnical and Weather Aspects in Design ○ Provide Evacuation Area ○ Eliminate Toxicity and Sick Buildings ○ Prevent Crime ○ Respect Disabled and Satisfy Their Requirements and Needs ○ Increase Single-Family Villa's Cost ○ Limited Lands ○ Involve Society in Decision-Making
	Environmental	**Climate**	○ Emphasis on Cooling Systems in Design ○ Prevent Dust Penetration ○ Reduce Unwanted Sun Penetration ○ Consider Microclimate in Design ○ Climatic Treatments (e.g. Courtyard, Wind Catcher)
		Scarcity of Water Resources	○ Water Management ○ Recycle and Reuse Water ○ Minimize Water Consumption ○ Soil Water Content

		Energy	○ Problems of Dependence on Oil as the Only Source of Energy
			  ○ Minimize Electricity Consumption
			  ○ Daily Energy Saving
			  ○ Maximize Efficient Use of Non-Renewable Resources
			  ○ Encourage Renewable Resources (Solar Energy)

		Buildings Materials	○ Recycle and Reuse Materials ○ Reduce Material Waste in Construction Use
		Health and Safety	○ Carbon Dioxide Emission Reduction ○ Good Indoor and Outdoor Environment ○ Public Area Pollution ○ Materials Pollution ○ Water Pollution ○ Light Pollution ○ Sewage and Garbage Issues ○ Precaution Against Earthquake
		Urban Development	○ Prevalent Transport Problems ○ Housing Density Problems ○ Housing and Accessible Routes ○ Maximize Efficient Use of Land ○ Protect Biodiversity, and Flora and Fauna ○ Enhance and Preserve Open Green Spaces

5.3 Interviews

The interviews are the third source of the relevant knowledge in this research, as discussed previously in the research methodology. The information extracted from these interviews was influence the development of the Saudi Arabian Context framework (Model-B). This section includes the findings from the interviews with four Saudi doctoral students at Virginia Tech. The interviewees were mainly architects and designers in the field—who had an understanding of the Saudi Arabian context and educated in Saudi Arabia. Most of these students are Ph.D. candidates, and they will be future professors in Saudi architectural schools (Table 5-2). Their expertise helped achieve and improve the accuracy of the Saudi Arabia knowledge framework (model-B). The interview questions (see Appendix A) were open-ended and designed to give the interviewees the ability to talk about their experiences within Saudi local context.

5.3.1 The Interview Goals and Processing

To achieve and improve the validity and accuracy of the proposed Saudi context knowledge framework-A, two stages were used to analyze the collected interview data. The first stage was to identify and highlight the main ideas in each interview, and see the common concepts between the different interviewees. The second stage was to give each interviewee a code number and illustrate his/her concepts in a tabular format; this was done to make the extracted data more workable when updating the final Saudi Arabia framework-model-B.

5.3.2 Interviewees' Background and Experience

Interviewee No. 1 is an architect and a Saudi Ph.D. candidate studying in the United States. He was graduated from King Saud University (KSU) in Saudi Arabia. His bachelor's degree in architecture and building science. He worked on the design of a number of research buildings. He also worked at a scientific organization in Saudi Arabia as a head of planning and design projects. He has a background in architectural design knowledge and issues related to Saudi context.

Interviewee No. 2 is an architect graduated from King Saud University (KSU) in Saudi Arabia. He has a bachelors degree in architecture and building science. He has been practicing architecture for more than seven years. He is a faculty member teaching design courses in KSU. He is now a Saudi Ph.D. student studying in the United States.

Interviewee No. 3 is an architect who has been practicing architecture for more than six years. He graduated from King Saud University (KSU) in Saudi Arabia. His bachelors degree is in architecture and building science. He is a faculty member who has taught design courses at a Saudi university. He is now a Saudi Ph.D. student studying in the United States.

Interviewee No. 4 is an architect and a Saudi Ph.D. candidate studying in the United States. He graduated from King Abdulaziz University (KAU) in Saudi Arabia. His bachelors degree is in architecture science. He worked in construction companies in Saudi Arabia and has a background in architectural knowledge.

Table 5-2 Interviewees' Characteristics

Interviewee code	University' Name	Positions	Graduate Degree
Interviewee No. 1	King Saud University, Bachelor's degree in architecture and building science.	Architect	Ph.D. candidate
Interviewee No. 2	King Saud University, Bachelor's degree in architecture and building science	Lecturer	Ph.D. Student
Interviewee No. 3	King Saud University, Bachelor's degree in architecture and building science	Lecturer	Ph.D. Student
Interviewee No. 4	King Abdulaziz University, Bachelor's degree in science in architecture	Architect	Ph.D. Graduated from Virginia Tech

5.3.3 Interview Findings

After the Saudi Arabia knowledge framework was presented to the Saudi interviewees, all interviewees agreed on the definition and classification of the four main aspects of the Saudi Arabian context. Table 5-3 shows the interviewees' feedback and suggestions for the Saudi Arabia knowledge framework's categories and clusters.

Table 5-3 Interviewees' Feedback and Suggestions (Finding)

Interviewees		Historical Aspect	Economic Aspect	Socio-Cultural Aspect	Environmental Aspect
No.1	Add		Suggested "Materials" as new category.		In "Climate" category, suggested some notes regarding criteria names.
	Remove			Removed "Satisfy Privacy" criterion.	Under Water category, removed one criterion: "Soil Water Content."
No.2	Add	Suggested considering "Islamic Architecture" and "Vernacular Architecture" as two separate categories.	Added two criteria to the Materials category: (1) Materials cost and (2) Labor Cost.		Added "Material Properties and Climate" as a new criterion under the Building Materials Category. Suggested adding "Respect Lands' Topography" as new criterion under Urban Development and Open Spaces category.
	Remove				
No.3	Add				
	Remove		Suggested removing "Marketing and sales skills" criterion from the Buildings Management clusters.		
No.4	Add		Suggested adding "Vacant Lands" as new criterion under the Housing Crisis and Infrastructure Category. Suggested adding "Quality Assurance" under the Buildings Management Category. Suggested adding "Ethical Principles" as new category.	Suggested adding "Social Norms" as new criterion under Culture in Design Process Category.	Suggested adding "Ethical Principles" as new Category.
	Remove			Removed "Preserving Heritage Value" criterion from the Culture in Design Process category.	Suggested adding "Treat Waste Land (Leftover-Lands)" as new criterion under the Urban Development and Open Spaces Category.

Table 5-4 shows the Saudi Arabian context, including the interviewees' suggestions presented in Table 5-3:

Table 5-4 the Saudi Arabian Context –Model B

		Saudi Arabian Knowledge – Model B	
		Categories	**Clusters**
Saudi Arabian Context	Historical	Islamic Architecture	o Islamic Architecture Values and their Influence on Design o Conventions, Customs, Laws, and Decision-Making Processes o Technical Durability, Simplicity, Adaptability
		Vernacular Architecture	o Vernacular Architecture Characteristics o Technical durability, Simplicity, and Adaptability
	Economic	Housing Crisis and Infrastructure	o More Demand for Houses o Reduce Housing's Cost o Limited Lands within the Cities, and Vacant Lands o Residential Land Development Cost o Provide Public Services and Infrastructure
		Energy Cost	o High Cost of Energy Usage o Efficiency of Use (Water, Energy, and Materials Use) o Apply Energy Technical Standards
		Materials	o Local/Regional Materials o Ensure Durability, Adaptability, and Quality of Materials o Reduce Materials and Labors Cost
		Buildings Management	o Life Cycle Cost and Profit o Buildings Operation and Maintenance Cost o Project and Construction Management o Quality Assurance
		Ethical Principles	o Legal and Ethical Issues
	Socio-Cultural	Religion and Privacy	o Respect Islamic Laws and Users Privacy o Consider Neighborhood Forms and Privacy o Residential Visual Privacy o Consider Genders Separation in Design
		Culture in Design Process	o Respect Social Norms o Preserving Cultural Characteristics
		Society in Design Process	o Innovation and Design Process o Usability and Aesthetic Aspects in Design o Functionality (the Purpose of the Building) o Consider Environmental Conditions and Human Behaviors Issues o Provide Public Amenities o Consider Earthquake, Geotechnical and Weather Aspects in Design o Provide Evacuation Area o Eliminate Toxicity and Sick Buildings o Build a Sense of Safety o Respect Disabled and Satisfy their Requirements and Needs o Involve Society in Decision-Making and in Design Process
		Ethical Principles	o Legal and Ethical Issues
	Environmental	Climate	o Emphasis on Cooling Systems in Design o Prevent Dust Penetrations o Reduce Unwanted Sun Penetrations o Consider Microclimate Between Buildings o Climatic Treatments (e.g. Courtyard, Wind Catcher)
		Scarcity of Water Resources	o Water Management o Water Treatments (Recycle and Reuse) o Reduce Water Consumption

		Energy	o Problems of Dependence on Oil as the Only Source of Energy
			    o Minimize Electricity Consumption
			    o Daily Energy Saving
			    o Reduce Efficient Use of Non-Renewable Resources
			    o Encourage Renewable Resources (Solar Energy)

		Building Materials	o Recycle and Reuse Materials o Reduce Material Waste in Construction Use o Material Properties and Climate
		Health and Safety	o Carbon Dioxide Emission Reduction o Good Indoor and Outdoor Environment o Public Area Pollution o Materials Pollution o Water Pollution o Light Pollution o Sewage and Garbage Treatment o Precaution Against Earthquake
		Urban Development and Open Spaces	o Prevalent Transport Problems in Big Cities o Housing Density Problems o Housing and Accessible Routes o Housing and Connected Sidewalks o Maximize Efficient Use of Land o Protect Biodiversity, and Flora and Fauna o Enhance and Preserve Open Green Spaces o Treat Waste Land (Leftover-Lands) o Rainwater Drainage Within the Streets and the Cities o Respect Lands' Topography
		Ethical Principles	o Legal and Ethical Issues

5.4 Important Issues of the Saudi Arabia Context

The next task was to merge the list of 18 categories of Saudi Arabian issues in Table 5-4 into the five important issues to be reviewed in the study. The goal was to gain a deeper understanding of the intricacies of designing and implementing green architecture criteria in the five most critical issues of the Saudi context. It would not be feasible, due to time limitations, to gain the same depth of inquiry into all 18 categories and their clusters. Figure 5-2 shows the filter for narrowing the categories. In other words, the intention is to study those big issues that most significantly impact building form in Saudi Arabia.

Figure 5-2 Narrowing the Saudi Arabian Context into Five Critical Issues that Affect Architectural Form in Saudi Arabia

Table 5-5 shows the five most critical issues of the Saudi Arabian context, including religion and privacy, climate and comfort, water and water conservation, materials, and energy conservation. Each category is identified by a number of criteria. The number and nature of criteria vary from one category to another according to the category itself and its importance in addressing the local context. These five issues were selected based on the literature review, interviews, and the researcher's experience. Every building in Saudi Arabia has to deal with these five issues. They branch into different areas, including religious, socio-cultural, economic, and environmental criteria. For example, the local material criterion shows up in the other dimensions (Table 5-5).

Table 5-5 The Important Issues of the Saudi Arabian Context

No	Issues	Clusters
1	**Religion, Culture, and Privacy**	○ Respect Islamic Laws and Users Privacy ○ Consider Neighborhood Forms and Privacy ○ Residential Visual Privacy ○ Consider Genders Separation in Design
2	**Climate and Comfort**	○ Emphasis on Cooling Systems in Design ○ Prevent Dust Penetrations (Sandstorm) ○ Reduce Unwanted Sun Penetrations ○ Consider Microclimate between Buildings ○ Climatic Treatments (e.g. Courtyard, Wind Catcher)

3	**Water and Water Conservation**	○ Scarcity of Water Resources
		  ○ Water Management
		  ○ Water Treatments (Recycle and Reuse)
		  ○ Reduce water consumption

4	**Materials**	○ Recycle and Reuse Materials ○ Reduce Material Waste in Construction Use ○ Material Properties and Climate ○ Local/Regional Materials ○ Ensure Durability, Adaptability, and Quality of Materials ○ Reduce Material and Labors Costs

5	**Energy Conservation**	○ Problems of Dependence on Oil as the Only Source of Energy
		  ○ Minimize Electricity consumption
		  ○ Daily Energy Saving
		  ○ Reduce Efficient Use of Non-Renewable Resources
		  ○ Encourage Renewable Resources (Solar Energy)
		○ High Cost of Energy Usage
		○ Efficiency of Use (Water, Energy, and Materials Use)
		○ Apply Energy Technical Standards

Chapter six discusses how these five issues connect and interact with green architecture issues. It also discusses the knowledge that needs to come from green architecture to influence Saudi issues. These five major issues are the priority for this study.

6. ADAPTING THE WESTERN KNOWLEDGE FRAMEWORK TO THE FINAL PROPOSED FRAMEWORK

The Western Knowledge Framework-Model-B as demonstrated in chapter four (see Table 4-4) is merged with the five important issues for Saudi Arabia as demonstrated in chapter five (see Table 5-5) to produce a new green knowledge framework for Saudi Arabia. This green knowledge framework was triangulated with empirical applications and analytic tools to create a comprehensive knowledge framework. The process of merging the knowledge to the proposed framework occurred in three main stages: Adapting the Western green knowledge to the Saudi Arabian context, triangulating the empirical applications and analytic tools with the Saudi green knowledge framework, and eventually developing the final knowledge framework.

6.1 First Stage: Adapting the Western Green knowledge to the Saudi Arabian Context

6.1.1 Interdiction

Table 5-5 in chapter five shows the five most critical issues for the Saudi Arabian context, including religion and privacy, climate and comfort, water and water conservation, materials, and energy conservation. Each category is identified by a number of criteria. The number and nature of criteria vary from one category to another according to the category itself and its importance in matching the local context. These five issues were merged with the Western Knowledge Framework. Presently every building in Saudi Arabia must deal with these five issues.

This chapter discusses how these five issues connect and interact with green architecture issues. It also discusses the knowledge that needs to come from green architecture that may influence the Saudi issues. These five major issues are important for this study (see Table 6-1).

The following is a brief discussion of each of the five major issues and how well they match the green criteria in western knowledge:

6.1.1.1 *Religion, Culture, and Privacy*

In part because of religious considerations, privacy must be included in the basic design. Architectural elements and local regulations should work together to provide users with suitable privacy that respects religious issues.

As stated in Chapter two, Islamic culture has an influence on the design of private property in Islamic countries. In this way, the freestanding villa can be interpreted not only as a symbol of social prestige, but also to the desire for privacy. For example, the private and cool inner courtyards found in many traditional houses fifty years ago have been replaced by narrow, two-meter setback spaces that surround the villa with concrete walls approximately three meters high, which provides daylight and ventilation to the villa's interior, while at the same time maintains the owner's privacy from neighbors and adjoining streets.

Another issue of religious and cultural privacy that specifically affects architectural design in Saudi society is the separation of male and female domains, based on the legal status of women that is quite different from the Western concept. Abu-Gazzeh (1995) says, "In Saudi Arabia, the most valuable, and the only un-compromisable, cultural heritage is religion, Islam. It structures all aspects of human life and endeavours." Moreover, he states, "Culture, as influenced by Islam and the related differentiation of gender, is an important spatial organizing device in this society" (p. 96). The effects of this issue can be seen obviously in the increased use of boundaries and partitioned spaces. This can also be seen in the floor plans for single-family houses, school buildings, government buildings, and private buildings that have dedicated spaces for men and women.

The single-family house (villa) is designed based on different spatial functions and gendered spaces. In other words, the house space is designed into multiple rooms that serve both males and females in separate functions. Walls and partitions serve as significant physical boundaries inside the house. Gender-specific spaces for guests are also present in every house built in Saudi Arabia. For example, the villa ground floor is designed to have two separate sitting spaces—one for female guests and the second for unrelated male guests. Also, gender specific entrances are preferred (see Figure 6-1). Other buildings like schools are designed based on gender-specific spaces. Gender separation can be seen also in other places such as mosques, work places, and waiting areas in hospitals (Abu-Gazzeh 1995). All Islamic and government institutions in Saudi Arabia reinforce this separation.

Figure 6-1 Ground Floor Plan for a Single Family Villa in Saudi Arabia (Pinterest 2016)

Although the primary objective of green architecture should be about designing a good place and resource preservation can contribute to this objective, doing so in a way that is culturally sensitive should also be taken into consideration. In the case of Saudi Arabia, green architecture must meet the requirements of these societally dominant issues of privacy and religion, which demand a certain degree of separation between men and women. For example, designs must deal with elements such as floors plans, window opening size and orientation, window placement and height, building orientation, setback spaces, and privacy from neighbors and adjoining streets to provide adequate user privacy and comfort. At the same time, these elements need to be integrated with green architecture elements such as daylighting, ventilation, inward orientation instead of outward, etc.

For example, a courtyard can be part of natural ventilation, daylighting, and privacy strategies. Concepts related to these green elements need to be taught in Saudi Arabian architecture schools. However, non-Islamic architects should also know more about religion and privacy issues and their significance to architecture practice, including respect for Islamic laws and users' privacy, consideration for privacy at a neighbourhood scale, residential visual privacy, and gender separation.

6.1.1.2 ***Climate and Comfort***

The climate in Saudi Arabia is harsh, with desert conditions and extreme temperature differences ranging from 52°F to 122°F (Piccolo 2014). Consequently, buildings in Saudi Arabia depend on cooling more than heating systems. The issues of cooling need to be reconciled with the issues of green architecture. For example, criteria for green architecture, such as passive and active design systems, thermal behavior of buildings, building envelope performance, natural and mechanical ventilation, and all issues related to HVAC systems, must be considered early in the design process. This will produce new buildings that have a high performance with minimum energy consumption and provide thermal comfort and well-being for their occupants.

Another issue is dust storms. Dust storms frequently and periodically occur from February to July, with strong winds blowing the dust from the dry deserts into the cities. Solutions might include minimizing dust penetrations considering window opening size and orientation, and designing tight building envelopes. This may conflict with green building criteria. Implementing suitable bioclimatic strategies can contribute to comfort and well-being of users. For example, site analysis, building geometry, glazing size and properties, material selection, and the incorporation of natural cooling and ventilation techniques should be a significant part of the green design process. These strategies also can be supported by adequate services and systems (e.g., HVAC).

6.1.1.3 ***Water Resources and Water Conservation***

Because of the desert climate, Saudi Arabia is facing a water crisis. Despite the government making "massive investments in desalination plants, demand is growing at a rate that threatens to outstrip supply, leading to the formulation of ambitious plans for the expansion of its desalination plants at a cost of tens of billions of dollars, amid calls from experts for urgent reforms of subsidies and water use" (Al-Suhaimy 2013). The buildings and construction sector is one of the largest users of water and, at the same time, is a major source of water waste (Al-Swat 2004). Therefore, building design should apply green building strategies that minimize water consumption through water recycling and reuse.

6.1.1.4 ***Building Materials***

This part of the study will focus on the principles, fundamentals, and thermo-physical properties of local building materials.

Concrete is the most common material available for building in Saudi Arabia. How does use of concrete meet issues of green building? The climate in Saudi Arabia has large temperature swings; it is hot during the day and cool at night. Concrete is a good material because it delays and dampens the effect of temperature cycles. An important property for improving energy efficiency is thermal inertia (also known as thermal mass), which represents the capacity of a material to store heat captured from the sun. Walls with high thermal inertia can improve indoor comfort, without necessarily having good insulation properties, by delaying and reducing the impact of outdoor temperature changes on conditioned indoor environments (Taleb and Sharples 2011). For instance, walls that are constructed from materials with a high-density concrete mix, used to produce a concrete masonry unit (block), will reduce heat from entering the building's interior by storing it during the day and releasing it during the night when the temperature cools down. The use of high-thermal-inertia walls, along with thermal insulation, should reduce energy requirements for both cooling and heating (Aste, Angelotti, and Buzzetti 2009).

In addition, materials with the lowest embodied energy, such as concrete and bricks can be justified if they contribute to lower operational energy over the life of the building (Geoff Milne 2013). For example, in climates with greater cooling requirements and significant day/night temperature variations (like Saudi Arabia), large amounts of thermal mass, high in embodied energy, can significantly reduce cooling needs in well-designed passive cool buildings.

Architecture students need to focus on green building criteria that optimize the use of materials, such as by minimizing construction waste and recycling and reusing construction materials. Architectural education should also develop the students' ability to choose the best, healthiest, and safest building materials available that are most commonly adopted for the local climate conditions.

6.1.1.5 ***Energy Conservation***

Energy consumption attributed to residential buildings in Saudi Arabia has become a problem. The rate of power used in residential buildings is about 70% of the total production, which is a very high rate when compared to some developed countries (Al-Swat 2004, Alulayet et al. 2012). Taleb and Sharples (2011) stated that cooling systems alone use about 80% of the total electrical energy consumed by residential buildings in Saudi Arabia and that natural systems can be used to meet most of demand.

With immense solar resources, photovoltaics can play a central role in providing more electrical power throughout Saudi Arabia. Utilizing the sun to generate power for cooling can be done in two ways: use photovoltaic panels to provide electrical power or use cooling systems like solar-assisted absorption chillers. Absorption chillers are the most distributed thermally driven chillers worldwide. Thermal compression of the refrigerant is achieved by using a liquid refrigerant/sorbent solution and a heat source, which replaces the electric power consumption of a mechanical compressor (Solair 2009).

In addition, Building Integrated Photovoltaics (BIPV) is a new building technology that should be taught in architecture schools. BIPV integrates PV modules into the building envelope in conventional building products, such as the roof, windows, or walls. PV panels can be integrated with the building envelope. PV panels need to be effectively integrated into the building envelope in a way that is functional and is aesthetically pleasing, not just tagged on. Architecture students need to understand the aesthetic as well as performance issues associated with PV systems.

Dependence on oil as the primary source of energy is tenuous for the country's future. Applying green architecture practices to reduce the use of electricity in buildings and encouraging the use of renewable energy strategies can lead to reductions in power use in residential buildings and thus will achieve significant economic savings for the Saudi community.

6.1.2 Merging the Five Important Issues for the Saudi Arabian Context to the Western Green Knowledge Framework

Table 6-1 shows the interaction between the Western framework and the five important issues for the Saudi context. The five important issues were merged into the Western framework as demonstrated in red in the table below. Each issue or cluster of the five issues was merged into its related topic or category from the Western knowledge framework. For example, scarcity of water resources in Saudi Arabia went under the environment challenge category. Moreover, religion and privacy, which are some of the important issues in Saudi Arabia, became a category after being merged with the Western knowledge framework. The category has its own classification under the Quality of Life topic (Topic-5), because this is an important topic and it has many issues that needed to be included in the new framework. Other Saudi issues were merged via the same approach in order to create the Saudi green knowledge framework (see Table 6-1

Table 6-1 Merging the Western Knowledge into the Saudi Knowledge

Merging the Western Knowledge into the Saudi Arabian Context				
			Categories	**Clusters**
Green Architecture Knowledge	Topic 1	Environment	**The Environmental Challenge**	○ Climate Change ○ Global-Warming Potential ○ Water and Environmental ○ Scarcity of Water Resources ○ Energy Sources and Associated Damage ○ Environmental History ○ Environmental Economic ○ Environmental Pollution ○ Environmental Policies
	Topic 2	Comfort, and Climate	**Comfort**	○ Psychrometric (more general, and applies) ○ Thermal Comfort ○ Visual Comfort ○ Prevent Dust Penetrations (Sandstorm) ○ Reduce Unwanted Sun Penetrations ○ Indoor Air Quality ○ Building Typology ○ Outdoor Spaces Design ○ Beauty and Aesthetic of a Place ○ Culture of a Place ○ Ergonomics (e.g. Special Comfort)
			Climate	○ Climate and Weather ○ Climatic Treatments in Saudi Arabia
			Acoustics	○ Acoustics in Design ○ Materials in Acoustics ○ The Reverberation Process
	Topic 3	Low Energy / High Performance	**Heating and Cooling**	○ Thermal Environment ○ Psychrometric Chart ○ Thermal Behavior of Building ○ Building Envelope Performance ○ Emphasis on Cooling Systems in Design ○ Dynamic Response of Buildings ○ Moisture Control (Hygrothermal) ○ Passive Design Systems ○ Active Design Systems
			Ventilation	○ Natural Ventilation ○ Mechanical Ventilation ○ Hybrid Ventilation / Mixed Mode
			Lighting	○ Physics of Light ○ Daylighting ○ Electric Lighting
			Enclosure	○ Double-Façade Curtain Wall ○ Green Roofs ○ Solar Panels and PV's Integration ○ Orientations ○ Design for Durability ○ Thermal Insulation ○ Design for Simplicity and Aesthetic ○ Infiltration and Airtightness ○ Solar Control
			Building Transportation Systems	○ Energy Efficiency and Performance of: ○ Elevators, Escalators, and Moving walkways ○ Pumps, and Fans
			Local Energy Issues	○ Reduce Dependence on Oil as the Only Source of Energy ○ Daily Energy Saving ○ Reduce Efficient Use of Non-Renewable Resources ○ Apply Energy Technical Standards
	Topic 4	Impacts and Resources	**Ecological Footprint**	○ Environmental Context
			Resources and Waste Management	○ Reuse old Building Materials and Components ○ Water Management (e.g. Recycle, Reduce, Rainwater Harvesting) ○ Zero Water ○ Waste Management (e.g. Recycle, Reduce…) ○ Zero Waste ○ Local/Regional Materials ○ Reduce Materials and Labors Cost ○ Durability, Adaptability, and Quality of Materials ○ Carbon Analysis, and Off-Gassing of Materials
			Renewable Sources	○ Renewable Energy Sources (e.g. Sun, Wind, Waves Energy, and Gravity and Geothermal Power…) ○ Ocean Thermal Lakes ○ Zero Energy ○ Replenished Materials (e.g. Wood, or Clay (for Brick) and Sand (for Glass)
			Embodied Energy	○ Embodied Energy and Life-Time Energy Use ○ Material with Lowest Embodied Energy (Wood, then Brick) ○ Materials with Most Embodied Energy (Aluminum)
			Life Cycle Analysis	○ Materials Science (e.g. phase change materials (PCM)) ○ Building Life-Cycle Analysis (e.g. Material Manufacturing, Construction, Use & Maintenance, and End of Life)
	Topic5	Quality of Life	**Urban Quality**	○ Eco-Master Planning ○ Health and well-being ○ Behavior - Social Sustainability ○ Urban Densities ○ Decentralized ,and Participatory ○ Microclimate and Sun Access ○ Environment, Society and Economy ○ Laws, Regulations, and Ethics
			Building Quality and Indoor Quality	○ Quality of Daylighting ○ Social Places (e.g. Courtyard, and Wind Catcher) ○ Physically Democratize the Workplace (e.g. Ventilation, and Lighting Control) ○ Give Buildings and Place Individuality, with Regard to Space and Character ○ Place Image and Emotions in Design ○ Create a Space that has a Sense of Strangeness and Familiarity ○ Create a Sense of Security, and Isolation ○ Produce a Sense of Loneliness and Silence in the Space
			Religion, Culture, and Privacy	○ Respect Islamic Laws and Users Privacy ○ Consider Neighborhood Forms and Privacy ○ Residential Visual Privacy ○ Consider Genders Separation in Design
	Topic 6	Architecture and Urban Development	**Buildings and Cities**	○ Use of Energy ○ Rethinking in Cities and other Forms of Human Settlement ○ Rehabilitating Existing Built Environments and Cities
			Transportation	○ Transportation Planning ○ Alternative Transportation ○ Connectivity City ○ Accessibility ○ Walkability ○ Bike-ability
			Embedded in Place	○ Drawing on Local Wisdom ○ Updating Vernacular Architecture

6.2 Second Stage: Triangulating the Empirical Applications and Analytic Tools with Saudi Green Knowledge Framework

Before the Saudi green knowledge can be transferred into the new framework, the comprehensiveness of the knowledge related to green building and its implementation needs to be assessed. To do so, Yannas (2014) proposes a cognitive framework (the Knowledge Triangle[22]) to systematize and organize knowledge so that it can be delivered transversely in an architectural education program. EDUCATE (2012b) also uses this knowledge triangle in their study "Framework for Curriculum Development" to foster integrating knowledge and skills in sustainable environmental design at all stages of architectural education in European schools. This cognitive framework categorizes the knowledge associated with environmentally responsive design into three domains: theoretical topics, empirical applications, and simulation and analytic tools (see Figure 6-2).

Each of the three domains has its own character and function, but each is an essential contributor to the other two. Case studies, simulation techniques and analytic tools can support the translation of the knowledge into a good design, and reveal how different principles can be applied in practice. The EDUCATE report (2012b) stated that these domains also facilitate the testing and evaluation of different hypotheses and make performance predictions from the early stages of design. Though the pedagogical methodologies applied and the level of competence acquired at each phase of the curriculum may vary, all three domains of the framework should be relevant throughout the curriculum (EDUCATE 2012b).

6.2.1 Empirical Applications

As shown in Figure 6-2 and Table 6-2, the analysis of empirical applications (or case studies) covered different types of buildings, including examples from vernacular and contemporary architecture practice. The EDUCATE report (2012a) stated that, "Coherent comparisons between scenarios can lead to critical understanding, whilst contributing to

[22] The "Knowledge Triangle" is modeled on the cognitive structure of the curriculum developed by Simos Yannas for the Architectural Association's MSc and MArch courses in sustainable environmental design (Yannas 2014).

possible [differences] between the results [from] design predictions and onsite measurements” (p. 22). This implies that on-site observations, performance investigations, post-occupancy evaluations (POE), and presentations of case studies by visiting professionals should be incorporated and encouraged in architectural education programs.

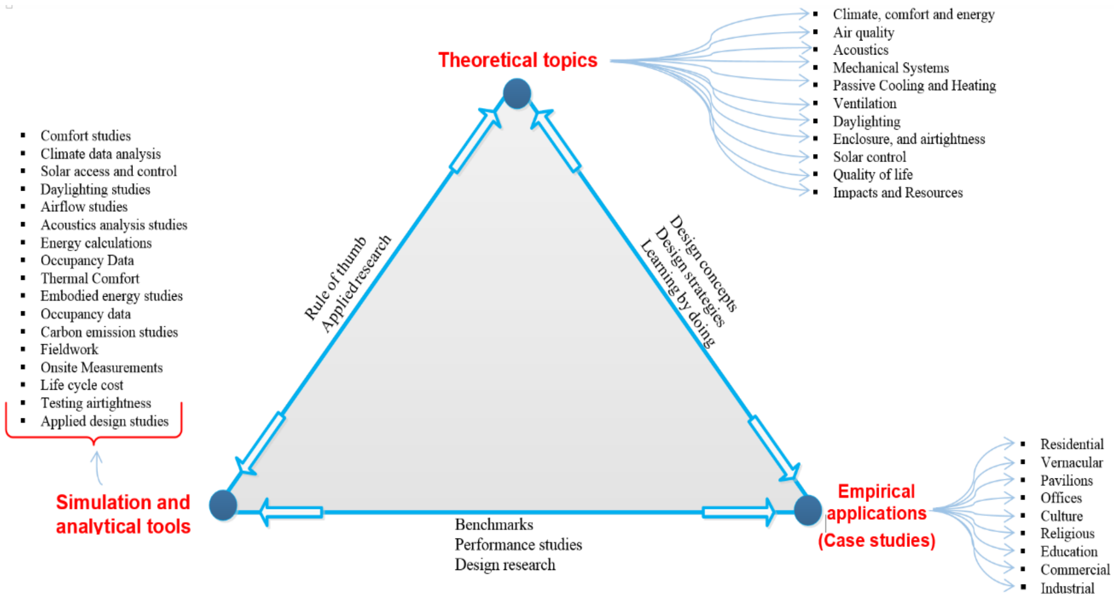


Figure 6-2 The Knowledge Triangle as an integrated cognitive framework (adapted from Yannas (2014) and EDUCATE (2012b))

6.2.2 Simulation and Analytical Tools

The analytical tool domain covered learning resources that support design decision-making, including energy simulation software, occupancy data analysis, climate data analysis, and equipment performance. The EDUCATE report (2012a) stated that, “The use of tools is fundamental in order to test, compare and evaluate applications and case studies against measured data and benchmarks, fine tune design proposals and inform decisions, as well as consolidate the acquisition of issues and principles of sustainable environmental design and provide tangible verification to intuitive design solutions” (p. 22). Therefore, these tools are encouraged to be used to assess comfort of occupants as well as daylighting, ventilation, solar access and control, acoustic, etc. (see Figure 6-2 and Table 6-2).

6.2.3 Theoretical Topics

As shown in Figure 6-2 and Table 6-2, the domain of green issues was organized into topics and cateogories of environmentally responsive design issues that include basic principles and examples of systems and solutions. The EDUCATE report (2012) stated that the delivered knowledge should be introduced to students "with clear terminology and definitions, brief explanations, and it should support direct experimentation and creative design exploration to complement the acquisition of theoretical principles" (p. 21). In addition, the report added, "Lectures should be combined with practical workshops and visits to contextualise physical processes and design concepts relating to basic principles such as passive heating, heat storage, insulation, solar control, daylighting, etc. Seminars on current environmental challenges should also promote discussion and debate" (p. 21). The implication is that these cateogories should start from the primary stages of the learning process, including both qualitative and quantitative information and benchmarks. Eventually, the delivery of content needs to be combined with empirical applications and analytical tools.

Table 6-2 The Interaction between Tools and Case Studies with the Green Theory of Saudi Arabia

Topics	Categories	Simulation and Analytical Tools	Empirical Applications (Case Studies)
Comfort, and Climate	Comfort	- Comfort Studies - Embodied Energy - Daylighting Studies - Climate Analysis - Solar Studies - Fieldwork	- Vernacular - Offices (Workplaces) - Pavilions - Religious - Residential
	Climate	- Embodied Energy Studies - Climate Analysis	- Offices (Workplaces) - Cultural - Commercial - Residential
	Air quality	- Carbon Emission - Climate Analysis - Airflow Studies - Fieldwork	
	Acoustics	- Acoustics Analysis Studies - Fieldwork	- Rooms - Offices (Workplaces) - Educational - Pavilions - Religious - Onsite Measurements
Low Energy / High Performance	Mechanical Systems	- Energy Calculations - Daylighting Studies - Solar Studies - Fieldwork - Occupancy Data	- Educational - Pavilions - Offices (Workplaces)
	Passive Heating	- Daylighting Studies	- Residential - Vernacular - Cultural - Industrial - Religious - Educational
	Passive Cooling	- Airflow Studies	- Offices (Workplaces) - Vernacular - Commercial
	Ventilation	- Embodied Energy	- Vernacular - Offices (Workplaces)
	Daylighting	- Embodied Energy	- Offices (Workplaces) - Educational - Pavilions
	Enclosure and Thermal Insulation,	- Embodied Energy - Life Cycle Cost - Solar Studies	- Residential - Offices (Workplaces) - Cultural - Commercial - Industrial
	Infiltration and Airtightness	- Diagnostic Tools (Testing Airtightness)	- Educational - Residential - Industrial - Pavilions
	Solar Control	- Energy Calculations - Carbon Emission - Comfort Studies - Airflow Studies - Fieldwork	- Vernacular - Educational - Cultural - Pavilions - Religious - Residential
Impacts and Resources	Materials	- Energy and CO2	- Educational - Residential - Industrial - Commercial
	Life Cycle Analysis	- Life Cycle Cost	
Quality of Life	Applied Design	- Applied Design Studies	- Vernacular - Cultural

6.3 Third Stage: Developing the Final Framework

The purpose of this final stage is to present information to educators in the form of a new framework that enables them to apply the knowledge structure to architecture education systems. As shown in Table 6-3, the new knowledge framework was developed to merge the Saudi Arabian and Western green knowledge that was presented in Table 6-1, and the associated analytical tools and empirical applications that were presented in Table 6-2. For each of the six topics, the knowledge was transferred into a logical, sequential structure that presents the knowledge in terms of teaching order and knowledge path. The knowledge path is not represented in a sequential structure of years per se; rather, it is represented to be more general so that it can be applied across all of architecture schools in Saudi Arabia.

The knowledge path was designed according to four stages: early/foundational knowledge, intermediate knowledge, advanced/expert knowledge, and future knowledge. Each stage addresses how acquired knowledge layers start to interact and how these interactions start to relate to each of the six topics of the proposed framework. These layers are then translated into a knowledge sequence. For example, there are certain issues concerning energy efficiency that need to be identified as early, intermediate, or advanced knowledge, and as knowledge for the future. This path is meant to infer a sequence of growth in the education of architects. Moreover, the final framework shows how the knowledge of the six topics interacts with its empirical applications (or case studies) and the simulation and analytical tools, which form the final framework of the Saudi Arabia knowledge base.

Table 6-3 The Final Saudi Arabia Knowledge Framework

Final Saudi Arabian Knowledge Framework

Topic	Categories	Clusters and Learning Path			
Topic 1 Environment	**The Environmental Challenge**	▪ Climate Change ▪ Global-Warming Potential ▪ Water and Environmental	▪ Environmental History ▪ Scarcity of Water Resources ▪ Energy Sources and Associated Damage	▪ Environmental Economic ▪ Environmental Pollution ▪ Environmental Policies	
		Early/Foundational Knowledge	**Intermediate Knowledge**	**Advanced/Expert Knowledge**	**Future Knowledge**
Learning Path		▪ Environmental History ▪ Climate Change ▪ Global-Warming Potential ▪ Energy Sources and Associated Damage	▪ Water and Environmental ▪ Scarcity of Water Resources ▪ Environmental Economic	▪ Environmental Pollution ▪ Environmental Policies	▪ Exploration for New Sources ▪ Development of New Technologies to Better Obtain Resources
Topic 2 Comfort, and Climate	**Comfort**	▪ Psychrometrics (more general, and applies) ▪ Thermal Comfort ▪ Visual Comfort	▪ Indoor Air Quality ▪ Reduce Unwanted Sun Penetrations ▪ Prevent Dust Penetrations (Sandstorm)	▪ Building Typology ▪ Outdoor Spaces Design ▪ Beauty and Aesthetic of a Place	▪ Culture of a Place ▪ Ergonomics (e.g. Special Comfort)
	Analytical Tools	- Comfort Studies - Daylighting studies - Solar Studies - Airflow Studies - Embodied Energy - Climate Analysis - Fieldwork - Carbon Emission			
	Case Studies	- Vernacular - Pavilions - Residential - Offices (Workplaces) - Religious			
	Climate	▪ Climate and Weather ▪ Climatic Treatments in Saudi Arabia			
	Analytical Tools	- Embodied Energy Studies - Climate Analysis (Climate Consultant Software)			
	Case Studies	- Offices (workplaces) - Cultural - Commercial - Residential			
	Acoustics	▪ Acoustics in Design ▪ Materials in Acoustics ▪ The Reverberation Process			
	Analytical Tools	- Acoustics Analysis Studies - Fieldwork			
	Case Studies	- Rooms - Educational - Religious - Offices (Workplaces) - Pavilions - Onsite Measurements			
		Early/Foundational Knowledge	**Intermediate Knowledge**	**Advanced/Expert Knowledge**	**Future Knowledge**
Learning Path		▪ Thermal Comfort ▪ Psychrometrics Chart ▪ Climate and Weather Analysis ▪ Site and Climate ▪ Wind Study ▪ Sun Path and Orientation ▪ Visual Comfort	▪ Indoor Air Quality ▪ Sun Control ▪ Dust Control ▪ Outdoor Spaces Design ▪ Ergonomics ▪ Beauty and Aesthetic of a Place ▪ Building Typology	▪ Climatic Treatments in Saudi Arabia ▪ Culture of a Place ▪ Acoustics in Design ▪ Materials in Acoustics ▪ The Reverberation Process	▪ Improve Architecture and Health ▪ More Connection Between Design and Health
Topic 3 Low Energy / High Performance	**Heating and Cooling**	▪ Thermal Environment ▪ Psychrometric Chart ▪ Thermal Behavior of Building	▪ Emphasis on Cooling Systems in Design ▪ Building Envelope Performance ▪ Dynamic Response of Buildings	▪ Moisture Control ▪ Passive Design Systems ▪ Active Design Systems	
	Analytical Tools	**Mechanical Systems:** - Energy Calculations - Solar Studies - Occupancy Data - Daylighting Studies - Fieldwork	**Passive Heating:** - Daylighting Studies	**Passive Cooling:** - Airflow Studies	
	Case Studies	- Educational - Offices (Workplaces) - Pavilions	- Residential - Religious - Industrial - Vernacular - Cultural - Educational	- Offices - Commercial - Vernacular	
	Ventilation	▪ Natural Ventilation ▪ Mechanical Ventilation ▪ Hybrid Ventilation / Mixed Mode			
	Analytical Tools	- Embodied Energy			
	Case Studies	- Vernacular - Offices (Workplaces)			
	Lighting	▪ Physics of Light ▪ Daylighting ▪ Electric Lighting			
	Analytical Tools	**Daylighting:** - Embodied Energy			
	Case Studies	**Daylighting:** - Offices (Workplaces) – Educational - Pavilions			
	Enclosure	▪ Double-Façade Curtain Wall ▪ Green Roofs ▪ Thermal Insulation	▪ Solar Panels and PV's Integration ▪ Orientations ▪ Solar Control	▪ Design for Durability ▪ Design for Simplicity and Aesthetic ▪ Infiltration and Airtightness	
	Analytical Tools	**Enclosure and Thermal Insulation:** - Embodied Energy - Solar Studies	**Infestation and Airtightness:** - Diagnostic Tools - Testing Airtightness	**Solar Control:** - Energy Calculations - Carbon Emission - Comfort Studies - Airflow Studies - Fieldwork	
	Case Studies	- Residential - Offices (Workplaces) - Cultural - Commercial - Industrial	- Educational - Pavilions - Residential - Industrial	- Vernacular - Educational - Cultural - Pavilions - Religious - Residential	
	Building Transportation Systems	▪ Energy Efficiency and Performance of: ▪ Elevators, Escalators, and Moving walkway ▪ Pumps, and Fans			
	Local Energy Issues	▪ Reduce Dependence on Oil as the Only Source of Energy ▪ Daily Energy Saving	▪ Reduce Efficient Use of Non-Renewable Resources ▪ Energy Technical Standards		
		Early/Foundational Knowledge	**Intermediate Knowledge**	**Advanced/Expert Knowledge**	**Future Knowledge**
Learning Path		▪ Thermal Environment ▪ Psychrometric Chart ▪ Thermal Behavior of Building ▪ Solar Radiation, Convection, and Conduction ▪ Sun Altitude and Azimuth Angles ▪ Site Selection and Orientation ▪ Sun Path Diagrams ▪ Design Shading Devices Angles ▪ Thermal Insulation	▪ Physics of Light ▪ Daylighting ▪ Electric Lighting ▪ Introduction of HVAC design ▪ Natural and Mechanical Ventilation ▪ Introduction of Passive Heating and Cooling Design Systems ▪ Moisture Control ▪ Infiltration and Airtightness ▪ Building Transportation Systems and Equipment	▪ Cooling and Heating Systems in Design ▪ Passive Design Systems ▪ Active Design Systems ▪ Energy Efficiency Systems ▪ Building Envelope Performance ▪ Dynamic Response of Buildings ▪ Double-Façade Curtain Wall ▪ Building Modeling and Simulating ▪ Green Roofs ▪ Solar Panels Integration ▪ Design for Simplicity and Aesthetic	▪ New Aspects of Passive Cooling Design ▪ Development of New Technologies to Better Obtain Energy Resources ▪ Daylighting Studies ▪ Optimization Strategies for Building Systems

Table 6-3 Continued

Topic	Categories	Clusters and Learning Path			
Topic 4 Impacts and Resources	**Ecological Footprint**	▪ Environmental Context			
	Resources and Waste Management	▪ Reuse old Building Materials and Components ▪ Water Management (e.g. Recycle, Reduce, Rainwater Harvesting) ▪ Zero Water ▪ Waste Management (e.g. Recycle, Reduce…) ▪ Zero Waste ▪ Local/Regional Materials ▪ Reduce Materials and Labors Cost ▪ Durability, Adaptability, and Quality of Materials ▪ Carbon Analysis, and Off-Gassing of Materials			
	Analytical Tools	**Materials:** - Energy and CO2			
	Case Studies	**Materials:** - Educational - Residential - Industrial - Commercial			
	Renewable Sources	▪ Renewable Energy Sources (e.g. Sun, Wind, Waves Energy, and Gravity and Geothermal Power…) ▪ Ocean Thermal Lake ▪ Zero Energy ▪ Replenished Materials (e.g. Wood, or Clay (for Brick) and Sand (for Glass)			
	Embodied Energy	▪ Embodied Energy and Life-Time Energy Use ▪ Material with Lowest Embodied Energy (Wood, then Brick) ▪ Materials with Most Embodied Energy (Aluminum)			
	Life Cycle Analysis	▪ Materials Science (e.g. Phase Change Materials (PCM)) ▪ Building Life-Cycle Analysis (e.g. Material Manufacturing, Construction, Use & Maintenance, and End of Life)			
	Analytical Tools	- Life Cycle Cost			
	Case Studies	- Educational - Residential - Industrial - Commercial			
Learning Path		**Early/Foundational Knowledge**	**Intermediate Knowledge**	**Advanced/Expert Knowledge**	**Future Knowledge**
		▪ Ecological Footprint and Environmental Context ▪ Materials Science ▪ Durability, Adaptability, and Quality of Materials ▪ Carbon Analysis, and Off-Gassing of Materials ▪ Water Management ▪ Waste Management	▪ Renewable Energy Sources and Systems ▪ Embodied Energy and Life-Time Energy Use ▪ Material with Lowest Embodied Energy (Wood, then Brick) ▪ Materials with Most Embodied Energy (Aluminum)	▪ Carbon Calculation ▪ Local/Regional Materials ▪ Water Budget and Features ▪ Replenished Materials ▪ Reuse old Building Materials and Components ▪ Materials and Labors Cost ▪ Phase Change Materials (PCM) ▪ Building Life-Cycle Analysis	▪ Net Zero Energy Building ▪ Net Zero Water Building ▪ Net Zero Waste Building ▪ Zero Carbon Emissions ▪ Exploration for New PCM ▪ Exploration for New Materials with Most, and Lowest Embodied Energy
Topic5 Quality of Life	**Urban Quality**	▪ Eco-Master Planning ▪ Health and well-being ▪ Behavior - Social Sustainability ▪ Decentralized ,and Participatory ▪ Microclimate and Sun Access ▪ Urban Densities ▪ Environment, Society and Economy ▪ Laws, Regulations, Ethics			
	Building Quality and Indoor Quality	▪ Quality of Daylighting ▪ Social Places (e.g. Courtyard, and Wind Catcher) ▪ Physically Democratize the Workplace (e.g. Ventilation, and Lighting Control) ▪ Give Buildings and Place Individuality, with Regard to Space and Character ▪ Place Image and Emotions in Design ▪ Create a Space that has a Sense of Strangeness and Familiarity ▪ Create a Sense of Security, and Isolation ▪ Produce a Sense of Loneliness and Silence in the Space			
	Analytical Tools	- Applied Design Studies			
	Case Studies	- Vernacular - Cultural			
	Religion, Culture, and Privacy	▪ Respect Islamic Laws and Users Privacy ▪ Consider Neighborhood Forms and Privacy ▪ Residential Visual Privacy ▪ Consider Genders Separation in Design			
Learning Path		**Early/Foundational Knowledge**	**Intermediate Knowledge**	**Advanced/Expert Knowledge**	**Future Knowledge**
		▪ Eco-Master Planning ▪ Health and well-being ▪ Behavior - Social Sustainability ▪ Microclimate and Sun Access ▪ Quality of Daylighting ▪ Social Places (e.g. Courtyard, and Wind Catcher) ▪ Islamic Laws and Users Privacy ▪ Genders Separation in Design ▪ Neighborhood Forms and Privacy	▪ Community and Urban Issues ▪ Residential Visual Privacy ▪ Decentralized ,and Participatory ▪ Urban Densities ▪ Place Image and Emotions in Design ▪ Space Strangeness and Familiarity ▪ Space Security, Isolation, Loneliness and Silence	▪ Environment, Society and Economy ▪ Laws, Regulations, Ethics ▪ Physically Democratize the Workplace (e.g. Ventilation, and Lighting Control) ▪ Buildings and Place Individuality ▪ Space Character	▪ New Aspects of Design Innovation ▪ 3D Printer House
Topic 6 Architecture and Urban	**Buildings and Cities**	▪ Use of Energy ▪ Rethinking in Cities and other Forms of Human Settlement ▪ Rehabilitating Existing Built Environments and Cities			
	Transportation	▪ Transportation Planning ▪ Alternative Transportation ▪ Connectivity City ▪ Accessibility ▪ Walkability ▪ Bike-ability			
	Embedded in Place	▪ Drawing on Local Wisdom ▪ Updating Vernacular Architecture			
Learning Path		**Early/Foundational Knowledge**	**Intermediate Knowledge**	**Advanced/Expert Knowledge**	**Future Knowledge**
		▪ Transportation Planning ▪ Alternative Transportation ▪ Connectivity City ▪ Accessibility, Walkability, and Bike-ability	▪ Use of Energy within Buildings and Cities ▪ Rethinking in Cities and other Forms of Human Settlement ▪ Rehabilitating Existing Built Environments and Cities	▪ Drawing on Local Wisdom ▪ Updating Vernacular Architecture	▪ New Studies on Updating Vernacular Architecture

6.3.1 Knowledge/Learning Path

This part of the research discusses how the six topics in the proposed framework (see Table 6-3) are incorporated into the four stages of the knowledge path. In other words, it presents the learning process that a student might go through in terms of early/foundational knowledge, intermediate knowledge, advanced/expert knowledge, and future knowledge. These four stages will help to develop and foster the integration of technical and practical knowledge of design work if well implemented in architectural design education systems.

The knowledge path was designed to look like an inverted pyramid or a reverse triangle that is used to show proportional, interconnected, or hierarchical relationships—with the largest component at the top and narrowing down to more advance components at the bottom (see Figure 6-3). In other words, students need to know the basis and the principles of a knowledge domain that will serve as the foundation for the intermediate and advanced knowledge stages. In addition, knowledge starts as more comprehensive and broad in its early and intermediate stages, and becomes more in-depth and concentrated in its advance stage. The role of the advanced stage is to introduce in-depth knowledge and manage all of the knowledge together in a final product.

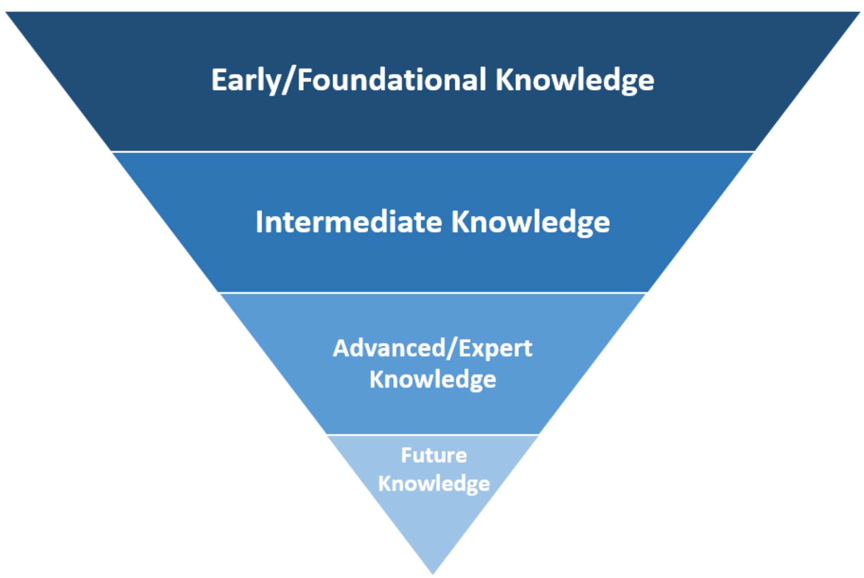


Figure 6-3 An Inverted Pyramid Shows Proportional, Interconnected, and Hierarchical Relationships of the Stages of the Knowledge Path

Interviews were conducted with professors from the three selected case study: University of Oregon, Arizona State University, and University of Southern California. At the end of each interview, a question was asked about this part of the framework: "what green issues do you feel are well incorporated in the early/foundational knowledge stage, intermediate knowledge stage, advanced knowledge stage, and future knowledge stage?"

In other words, in a studio sequence in an architecture school, what might a student go through in terms of the four stages? Their responses were incorporated in the following explanations of the four knowledge stages (see Table 6-4):

6.3.1.1 *Early/Foundational Knowledge Stage*

In the early stage, students are expected to be aware of methods, show an understanding of the positive and negative impacts of ecological aspects on buildings and their occupants, comprehend basic principles of the two-dimensional and three-dimensional design elements, and understand basic principles of lighting, acoustics, environmental control, and other building systems.

Participants A and E stated that the early stage should cover "wind, sun, light, microclimate and buildings," in addition to "the relationships between human comfort and convection, radiation, and conduction." Participant-B indicated that "site and climate, comfort, orientation, materials, and passive design are all fundamental knowledge" and need to be taught in the early stages of the architecture program. Participant-C mentioned that in the early stages, students should know about where the "sun rises, where the sun sets, the sun's altitude and azimuth, and heating and cooling degrees during the days." In addition, he/she added that the early stage should cover "the very basics of climatic design, site selection and building orientation, the design for shading devices, geometry, climatic, and understanding the climate and being able to analyze the climate of the city or the site" for the proposed building. Participants D and E said that students should "understand the climate, cold, temperate, hot-humid, hot-arid…, and their impact on human comfort" (see Table 6-4).

6.3.1.2 *Intermediate Knowledge Stage*

Participant-C stated that in the intermediate stage, students should start "looking a little bit deeper into issues of daylighting, passive heating and passive cooling design." He/she added that professors should start introducing supplemental systems such as "HVAC, electric lighting, and mechanical ventilation." In addition, he/she added that the students should know how to "create water budgets and their features," what the water requirements of a building will be, and what water resources are available. Participant-B stated that the intermediate stage should cover "community and urban issues" and focus more on "energy calculation and simulation, carbon calculations, and hand calculation principles and concepts." Participant-E added that this stage should incorporate the study of "building passive design [strategies], placement of windows relative to the sun path, and [the use of] thermal mass to produce buildings that perform well without using mechanical systems." He/she added that the students should also understand "energy systems, lighting (e.g. florescent and LED lighting), and be knowledgeable of mechanical equipment, lighting systems, plumbing systems, etc.—including how it works, what the best performing systems are, and what the newest systems are" (see Table 6-4).

6.3.1.3 *Advanced/Expert Knowledge Stage*

Participant-B indicated that the advance stage should focus more on design that includes energy efficient "active systems," "mechanical systems," "local materials," and "the most efficient use of resources." He/she also added that the students should start calculating the carbon footprint for materials and the building (see Figure 6-4). Participant-C stated that the role of the advance stage is to introduce knowledge that is more in-depth and builds upon the previous knowledge. For example, he/she stated that the student should acquire more in-depth knowledge of how to design "water tanks" and "piping systems." In addition, he/she added that more use of building energy simulations and modeling could show students how to best optimize the systems. Participant-E included "renewable energy systems" and an understanding of the fundamentals of "photovoltaic panels," "fossil fuels," and "large thermal heat capacity storage systems" in this stage (see Table 6-4).

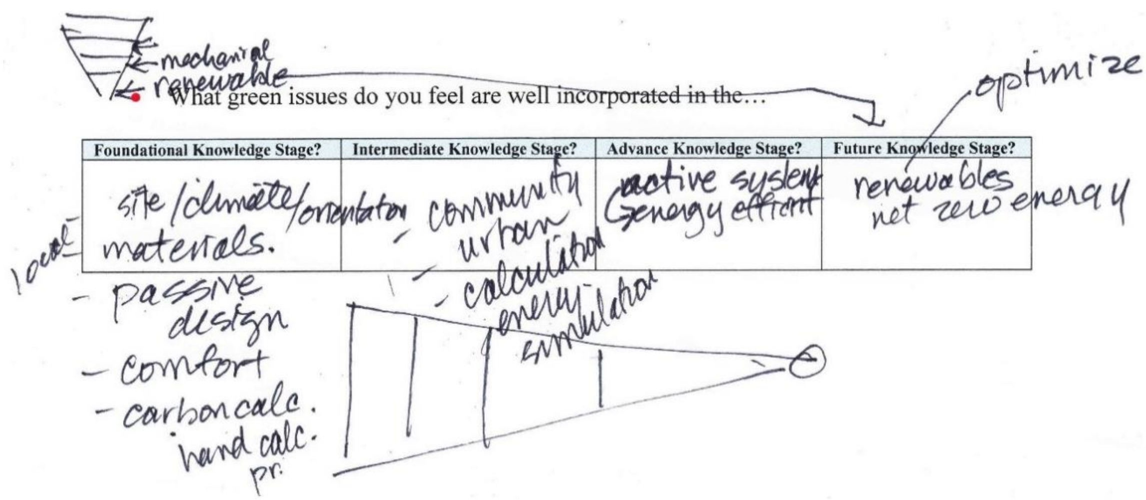


Figure 6-4 Participant-B comments

6.3.1.4 ***Future Knowledge Stage***

In the future stage, Participant-B believes that students should be encouraged to undertake more research on applying "renewable energy" sources "to create net zero energy and zero carbon emissions" designs (see Figure 6-4). Participant-C suggested that in the future, students do more studies on "architecture and health," such as: "how buildings affect the users' health, how daylighting in building can impact the sleep cycle, how the way a city is designed can impact users' health in terms of obesity rate." He/she added that students should be encouraged to do research that includes "new materials technology," such as "self-assembly and self-filling materials found in nature." Finally, Participant-E stated that at this stage, students should take the knowledge that they already studied and learned, and be more creative and discover things that have not yet been discovered (see Table 6-4).

Table 6-4 Knowledge/Learning Path Contents

	Knowledge/Learning Path Contents		
Early/Foundational Knowledge Stage	▪ Environmental History, ▪ Environmental Pollution ▪ Environmental Policies ▪ Climate Change ▪ Global-Warming Potential ▪ Climatic Treatments in Saudi Arabia ▪ Energy Sources and Associated Damage ▪ Water and Environmental ▪ Scarcity of Water Resources ▪ Environmental Economic ▪ Human Thermal Comfort	▪ Psychrometrics Chart Principles ▪ Climate and Weather Analysis (Cold, Hot Human, and Hot-Aired Climate). ▪ Site and Climate ▪ Site Selection and Building Orientation ▪ Wind Studies ▪ Sun Path Diagrams ▪ Sun Altitude and Azimuth Angles ▪ Design Shading Devices Angles ▪ Solar Radiation, Convection, and Conduction ▪ Visual Comfort ▪ Thermal Environment	▪ Thermal Behavior of Building ▪ Thermal Insulation ▪ Passive Design Principles ▪ Ecological Footprint and Environmental Context ▪ Materials Science ▪ Acoustics in Design ▪ Materials in Acoustics ▪ The Reverberation Process ▪ Durability, Adaptability, and Quality of Materials ▪ Carbon Analysis, and Off-Gassing of Materials ▪ Behavior - Social Sustainability ▪ Microclimate and Sun Access
Intermediate Knowledge Stage	▪ Indoor Air Quality ▪ Sun, and Dust Control ▪ Outdoor Spaces Design ▪ Ergonomics ▪ Beauty and Aesthetic of a Place ▪ Building Typology ▪ Physics of Light ▪ Daylighting Quality ▪ Electric Lighting ▪ HVAC Design Principles ▪ Natural and Mechanical Ventilation ▪ Passive Heating Design Systems ▪ Passive Cooling Design Systems ▪ Moisture Control ▪ Infiltration and Airtightness	▪ Energy, and Carbone Calculation Principles ▪ Water Management ▪ Water Budget and Features ▪ Building Transportation Systems and Equipment ▪ Embodied Energy and Life-Time Energy Use ▪ Material with Lowest Embodied Energy (Wood, then Brick) ▪ Materials with Most Embodied Energy (Aluminum) ▪ Community and Urban Issues ▪ Residential Visual Privacy ▪ Decentralized ,and Participatory ▪ Urban Densities ▪ Culture of a Place ▪ Social Places (e.g. Courtyard, and Wind Catcher) ▪ Islamic Laws and Users Privacy	▪ Genders Separation in Design ▪ Neighborhood Forms and Privacy ▪ Transportation Planning ▪ Alternative Transportation ▪ Connectivity City ▪ Accessibility, Walkability, and Bike-ability ▪ Place Image and Emotions in Design ▪ Space Strangeness and Familiarity ▪ Space Security, Isolation, Loneliness and Silence ▪ Use of Energy within Buildings and Cities ▪ Rethinking in Cities and other Forms of Human Settlement ▪ Rehabilitating Existing Built Environments and Cities
Advanced/Expert Knowledge Stage	▪ Cooling and Heating Design Systems ▪ Passive Design Systems ▪ Active Design Systems ▪ Energy Efficiency Systems ▪ Building Envelope Performance ▪ Dynamic Response of Buildings ▪ Double-Façade Curtain Wall ▪ Building Modeling and Simulating ▪ Green Roofs	▪ Renewable Energy Sources and Systems ▪ Solar Panels Integration ▪ Energy Simulation and Modeling ▪ Buildings Optimizations ▪ Carbon Calculation for Materials ▪ Local/Regional Materials ▪ Use Resources Most Efficient ▪ Water Systems Design (Tanks, Piping…) ▪ Waste Management ▪ Replenished Materials ▪ Reuse old Building Materials and Components	▪ Materials and Labors Cost ▪ Phase Change Materials (PCM) ▪ Building Life-Cycle Analysis ▪ Physically Democratize the Workplace (e.g. Ventilation, and Lighting Control) ▪ Buildings and Place Individuality ▪ Space Character ▪ Drawing on Local Wisdom ▪ Updating Vernacular Architecture ▪ Design for Simplicity and Aesthetic ▪ Health and well-being
Future Knowledge Stage	▪ Exploration for New Sources ▪ Development of New Technologies to Better Obtain Resources ▪ Improve Architecture and Health ▪ More Connection Between Design and Health ▪ New Aspects of Passive Cooling Design	▪ Development of New Technologies to Better Obtain Energy Resources ▪ More Daylighting Studies ▪ Optimization Strategies for Building Systems ▪ Exploration for New PCM ▪ Exploration for New Materials with Most, and Lowest Embodied Energy	▪ Net Zero Energy Building ▪ Zero Carbon Emissions ▪ Net Zero Water Building ▪ Net Zero Waste Building ▪ New Aspects of Design Innovation

7. NARRATIVE

7.1 Introduction

The purpose of the narrative approach presented in this chapter is to investigate the sequence of integrating green knowledge into the final Saudi Arabian Framework and describe how this knowledge can be systematically applied and understood in the architecture design studio. The researcher argues that the narrative approach most effectively communicates how Western green knowledge can be adapted in response to the case of Saudi Arabia.

Therefore, this chapter is about translating the environmental responsive design strategies that are demonstrated in the final Saudi Arabian Knowledge Framework (see Table 6-3) into practice in Saudi Arabian architectural schools. The purpose of the previous stage (see Chapter 6) was to map out the general interaction of the framework after being informed by Western green knowledge and Saudi context. However, the current stage presented in this chapter is primarily about giving examples of how this knowledge would interact with and be applied in studios in Saudi Arabia. This stage will also identify the meaning of these interactions and translate them into the Saudi Arabian architectural design pedagogy.

In this part of the research, the researcher took one important topic of the six previous topics of the final green Knowledge Framework (see Table 6-3) and presented a scenario of how the contents of that topic can be implemented into architectural design studio in a hypothetical school in Saudi Arabia. From the final Saudi Arabian Knowledge Framework (see Table 6-3), the “Low Energy/High Performance” (Topic-3) was selected to be the main subject of this part of the study. The other five topics remain outside of the scope of the current research, but could be discussed in future research studies using a similar approach.

7.1.1 Low Energy and High Performance (Selected Topic)

As discussed in Chapter-6, Western green knowledge is comprised of several topics, which include “Environment,” “Comfort and Climate,” “Low Energy/High Performance,” “Impacts and Resources,” and “Quality of Life.” Of these, Topic-3 (Low Energy/High Performance) was chosen to be the subject of this narrative for several important reasons. First, its green contents represent a big part of the framework, including mechanical systems, passive heating and cooling, and daylighting among other topics. Second, this topic is perhaps the most important to buildings—as it is known that the largest proportion of the world's total energy consumption is spent on heating, cooling and lighting (Edwards 1999). In today's world of shrinking available resources and huge population growth, green building design strategies that emphasize low energy consumption and high performance should be a part of any architectural program. Naturally, the architect is the first and most important factor in determining the energy consumption in buildings. Thus, there is a need to create a green and sustainable architectural awareness among students who will be the next generation of architects.

The design studio in architecture schools is the first and primary place where students become experienced with architectural problems, and start designing buildings according to their local climate and site conditions. In his call for the "2030 Challenge," Edward Mazria (2007) states, "In our professional architecture and planning schools, we should require the establishment of a mandatory, full-year, innovative, studio-based program which promotes creative problem-solving relevant to climate change." As the school is the place where students explore their ideas, and evaluate alternative design options, it is therefore the best environment to educate students on green building design strategies within an "ecological studio." Saudi Arabian architectural schools like other schools worldwide should follow the developments of green knowledge and apply it.

As previously mentioned, "Low Energy and High Performance" (Topic-3) and its categories include heating and cooling, ventilation, lighting, enclosure, building transportation systems, and local energy issues (see Table 7-1). In addition to the table, these categories are further explained in a narrative scenario in order to fully demonstrate how Western green knowledge could interact with students in a hypothetical design studio. This study assumes an architectural design studio in a hypothetical school in Saudi Arabia. The suggested design studio will present a design problem (i.e. project/s) that deal with green building design strategies that emphasize low energy consumption and high performance along with an understanding of the social, cultural and functional relations within a multidisciplinary perspective of green architecture. In addition, this study suggests how these strategies can be implemented in architectural schools in Saudi Arabia. The suggested design studio that is presented here will concentrate on green building design strategies from an early, intermediate, and advanced stage—which will then lead to a future knowledge stage. The future knowledge stage represents how students can discover new issues and solutions that have not been discovered yet, and encourages students to determine new studies of designing buildings that consume less energy while maintaining high performance. This knowledge path may also help students to increase their creativity during the design studio.

Table 7-1 Design Requirements Regarding Low Energy and High Performance in Architectural Design Studio

Topic	Categories	Clusters and Learning Path
Topic 3 Low Energy / High Performance	**Heating and Cooling**	▪ Thermal Environment ▪ Psychrometric Chart ▪ Thermal Behavior of Building ▪ Emphasis on Cooling Systems in Design ▪ Building Envelope Performance ▪ Dynamic Response of Buildings ▪ Moisture Control ▪ Passive Design Systems ▪ Active Design Systems
	Analytical Tools	**Mechanical Systems:** - Energy Calculations - Solar Studies - Occupancy Data - Daylighting Studies - Fieldwork **Passive Heating:** - Daylighting Studies **Passive Cooling:** - Airflow Studies
	Case Studies	- Educational - Offices (Workplaces) - Pavilions - Residential - Religious - Industrial - Vernacular - Cultural - Educational - Offices - Commercial - Vernacular
	Ventilation	▪ Natural Ventilation ▪ Mechanical Ventilation ▪ Hybrid Ventilation / Mixed Mode
	Analytical Tools	- Embodied Energy
	Case Studies	- Vernacular - Offices (Workplaces)
	Lighting	▪ Physics of Light ▪ Daylighting ▪ Electric Lighting
	Analytical Tools	**Daylighting:** - Embodied Energy
	Case Studies	**Daylighting:** - Offices (Workplaces) – Educational - Pavilions
	Enclosure	▪ Double-Façade Curtain Wall ▪ Green Roofs ▪ Thermal Insulation ▪ Solar Panels and PV's Integration ▪ Orientations ▪ Solar Control ▪ Design for Durability ▪ Design for Simplicity and Aesthetic ▪ Infiltration and Airtightness
	Analytical Tools	**Enclosure and Thermal Insulation:** - Embodied Energy - Solar Studies **Infestation and Airtightness:** - Diagnostic Tools - Testing Airtightness **Solar Control:** - Energy Calculations - Carbon Emission - Comfort Studies - Airflow Studies - Fieldwork
	Case Studies	- Residential - Offices (Workplaces) - Cultural - Commercial - Industrial - Educational - Pavilions - Residential - Industrial - Vernacular - Educational - Cultural - Pavilions - Religious - Residential
	Building Transportation Systems	▪ Energy Efficiency and Performance of: ▪ Elevators, Escalators, and Moving walkway ▪ Pumps, and Fans
	Local Energy Issues	▪ Reduce Dependence on Oil as the Only Source of Energy ▪ Daily Energy Saving ▪ Reduce Efficient Use of Non-Renewable Resources ▪ Energy Technical Standards

Learning Path	Early/Foundational Knowledge	Intermediate Knowledge	Advanced/Expert Knowledge	Future Knowledge
Learning Path	▪ Thermal Environment ▪ Psychrometric Chart ▪ Thermal Behavior of Building ▪ Solar Radiation, Convection, and Conduction ▪ Sun Altitude and Azimuth Angles ▪ Site Selection and Orientation ▪ Sun Path Diagrams ▪ Design Shading Devices Angles ▪ Thermal Insulation	▪ Physics of Light ▪ Daylighting ▪ Electric Lighting ▪ Introduction of HVAC design ▪ Natural and Mechanical Ventilation ▪ Introduction of Passive Heating and Cooling Design Systems ▪ Moisture Control ▪ Infiltration and Airtightness ▪ Building Transportation Systems and Equipment	▪ Cooling and Heating Systems in Design ▪ Passive Design Systems ▪ Active Design Systems ▪ Energy Efficiency Systems ▪ Building Envelope Performance ▪ Dynamic Response of Buildings ▪ Double-Façade Curtain Wall ▪ Building Modeling and Simulating ▪ Green Roofs ▪ Solar Panels Integration ▪ Design for Simplicity and Aesthetic	▪ New Aspects of Passive Cooling Design ▪ Development of New Technologies to Better Obtain Energy Resources ▪ Daylighting Studies ▪ Optimization Strategies for Building Systems

7.1.2 A Design Problem Dealing with the Green Building Strategies

Before the proposed design studio can be implemented, prerequisite classes that teach the fundamental knowledge of environmental issues should be taken. The prerequisite classes should cover environmental control systems, heating and cooling, ventilation, lighting, building enclosure, local energy issues, building transportation systems, and other issues presented in Table 7-1. In other words, a student is assumed to come to the suggested design studio already with fundamental knowledge of site selection and orientation, sun path diagrams, sun altitude and azimuth angles, optimum shading device angles, solar radiation/convection/conduction, the psychrometric chart, passive and active design principles, and other required knowledge. This means that the main aim of the design studio can be to provide an understanding of these issues and then teach the most well-known aspects of the green building strategies. Moreover, the purpose of the suggested studio can be to teach students how green building strategies can be translated and applied to a real local site in certain design processes.

As part of basic design requirements based on a common perspective regarding green design strategies, students should be asked to read sources such as Mazria (1979), Grondzik et al. (2011), Kwok and Grondzik (2011), Cofaigh et al. (1999), Yeang (1995), and other sources that summarize the main aims of green architecture criteria (shown in Table 7-1). Following this, a design problem will be posed to students in the third or fourth year[23] of architectural design studio. The subject of the design studio is to create a building that fits its site and is compatible with its climatic conditions with regard to green design issues. In order to focus on the site, this study will use an experimental educational design problem dealing with the issue of green design for specific local site(s) at Riyadh. As this study represents only a hypothetical architecture school, other cities could be substituted for Riyadh during the actual implementation stage depending on where the school is located (see Section 7.3.2).

7.1.3 Teamwork

In the design studio, students will be distributed among a number of groups. Working as a team is one of the most important components in architectural design and is even more important in designing green buildings. Establishing a team approach during the pre-design phase will allow a multidisciplinary team to share their expertise and organize a single design effort to achieve a well-functioning and integrated building. However, this approach can only work if the design students' teams commit themselves to design a project based on green building strategies (Council 1996). Therefore, students should be required to work in pairs rather than working in isolation on only their own areas of

[23] Depends on the school's curriculum

expertise. To increase collaboration, students can select their team according to their preferences.

7.1.4 Project and Site Selection

The instructor should give the students an authentic, complex and significant problem that will allow students to examine the real forces that surround the problem. As Honebein (1996) states, “the aim of an authentic activity is not just to simulate or replicate the physical environment…[but] is to design an environment in which learners use their minds and bodies as they would if they were practitioners in a domain” (p. 20). As the example used in this study, students will be asked to solve a design problem for a project in a specific site(s) in Riyadh in Saudi Arabia.

In general, building type selection depends more on the design aims for the specific level of the studio in implementing green design strategies. However, the design project should not be limited in size or function, and can be a large mixed usage development, residential complex, office building, industrial building, or commercial building project. Yet, the project site must be chosen to be surrounded by negative and positive environmental challenges, which can create a competitive spirit among students in order to find appropriate design solutions for that design problem. For example, noise sources or traffic from a highway, existing trees, parks, slopes, high-rise buildings, and/or other physical considerations should be found within the selected site(s) in order to challenge the students to find appropriate design solutions.

After the site is selected, a brief summary of the proposed project and its site should be given to the students—with the idea that the students should focus on energy efficiency and the climatic condition of that site. Information that can be provided includes site location, project type, program, occupant load, and other required design information.

7.1.5 Teaching and Learning Methodology

The knowledge and skills of environmental design that aim to achieve low energy and high performance in buildings must be reinforced by principles of environmentally responsive architecture design in education (see Chapter-2, Section 2.9.1). In addition, all stages of the architectural design studio must promote a culturally, economically, and socially viable design process. In the suggested studio, environmentally responsive design knowledge must be seen as a priority (shown in Table 7-1).

As described in a previous chapter (see Section 2.9.2 in Chapter-2), there are multiple pedagogical methodologies of how knowledge can be delivered in an architectural design studio. However, the problem-based learning (PBL) method is considered one of the most effective learning methods in teaching design studio (see Chapter-2, Section 2.9.2.3). The PBL method can be best approached by meeting a set of pedagogic criteria. In this regard, Savery and Duffy (1995) explain eight instructional principles that were derived from constructivism. The eight critical principles that can enhance the design studio are as follows:

1. Anchor all learning activities to a larger problem.
2. Support the learner in developing ownership of the overall problem.
3. Design an authentic task.
4. Design the task and the learning environment to reflect the complexity of the environment they should be able to function in at the end of learning.
5. Give the learner ownership of the process used to develop a solution.
6. Design the learning environment to support and challenge the learner's thinking.
7. Encourage testing ideas against alternative views and alternative context.
8. Provide opportunity for and support reflection on both the content learned and the learning process. (p. 137-140)

Overall, the instructor needs to ensure that the studio meets the eight critical criteria listed above. Admittedly, the first four criteria may be a little difficult to implement in a studio. However, the latter four criteria that emphasize the use of self-regulated learning and creative thinking are often a studio instructor's main challenge in implementing effective PBL in a design studio. In other words, without adhering to the eight criteria, the studio instructor cannot completely direct or regulate the students' problem solving efforts. Because professional problem solving is largely individualized, as suggested by Schön (1987), the contribution of the instructor must involve demonstration and critique rather than collaborating in the doing.

Table 7-2 and Figure 7-1 show the teaching method of how green building knowledge can be taught in the suggested design studio. Green knowledge in the design studio will go through three stages including early/foundational knowledge, intermediate knowledge, and advanced knowledge stage. As shown below, each stage has its own goals and presentation method. Eventually, evaluation procedures of the students' work should be applied during the studio stages as well.

Table 7-2 Teaching/Learning Method for Green architecture in Architectural Design Studio

Stages		Goals	Presentation	
1	Early/Foundational Knowledge	Warm-up to the Project(s)	PowerPoint Presentations	
2	Intermediate Knowledge	Primary Design Concept(s)	Poster Concepts Mood Boards	
3	Advanced and Future Knowledge	Design Process:	1st Phase:	Site Plans Drawings and Models
			2nd Phase:	Project Plans Drawings and Models
			3rd Phase:	Project Details Drawings and Models

Evaluation Procedures			
1	2	3	4
First Jury	Second Jury	Third Jury	Class Work Evaluation

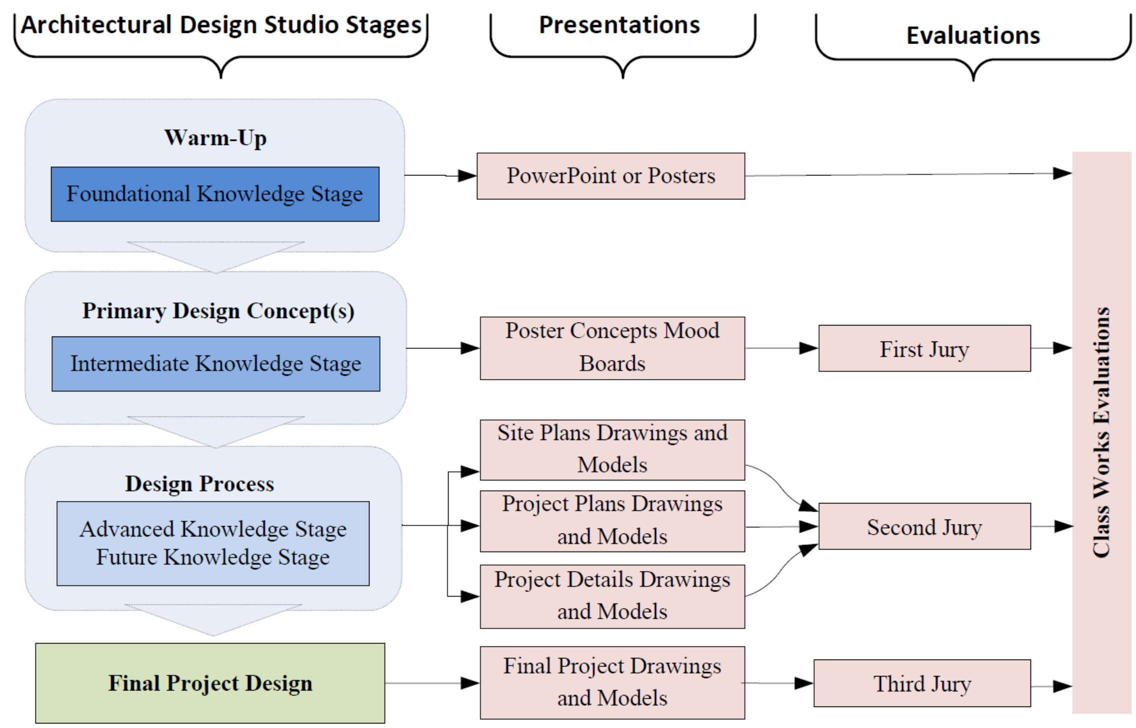


Figure 7-1 Shows the design processes in architecture education

7.2 Scenario for the Design Studio

7.2.1 Introduction

The purpose of any design process is to gather information that will lead the design to generate ideas for the project and then represent the project in different ways in order to create a better understanding, where the representation can be both quantitative and qualitative. Therefore, the design process in architecture education in Saudi Arabia should also be based on qualitative and quantitative aspects. Qualitative aspects of Saudi Arabia to consider include its culture, society, and religious principles. Quantitative aspects of Saudi Arabia have more to do with performance indicators like energy modeling, daylighting analysis, life cycle cost analysis, embodied energy, etc. In other words, in order to be implemented in green architecture design education, projects must meet the requirements of Saudi society like privacy and religion (which demand a certain degree of separation between men and women) while at the same time addressing green architecture knowledge such as daylighting and ventilation, etc. The boundaries between quantitative and qualitative aspects should inform the early, intermediate, and advanced knowledge of the design studio (see Figure 7-2).

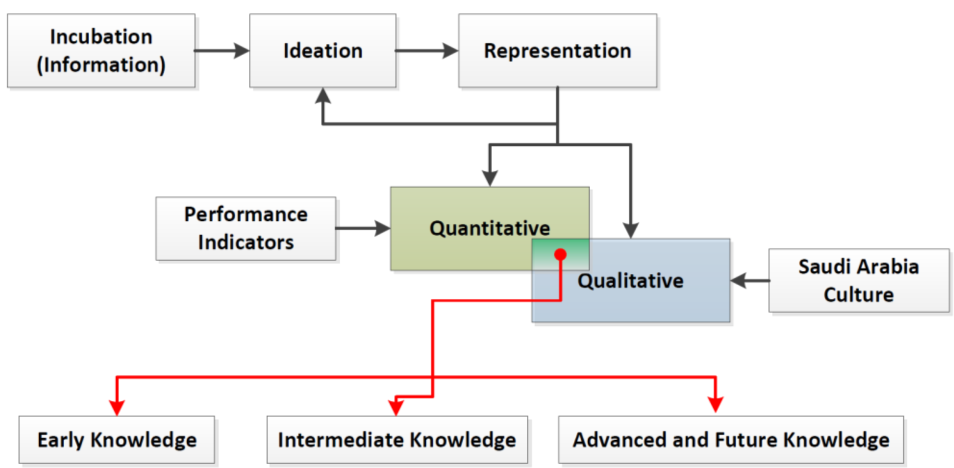


Figure 7-2 The design processes in the proposed studio

This part of the narrative is discussed two parts. The first part is a philosophical discussion about how the students can link green architectural elements (including elements like "Mashrabiya" and "courtyard" that emphasize low energy and high performance in buildings) and Islamic cultural aspects (including culture and privacy). This issue is essential and imperative for the design studio to succeed in Saudi Arabia. The second part discusses the design studio procedures from an early, intermediate, and advanced stage—which will then lead to a future knowledge stage.

7.2.2 Linking Between Green Architecture Elements and Islamic Cultural Aspects

Today's architects must understand how socio-religious and cultural complexities can affect the structuring of spatial and architectural domains in the present society of Saudi Arabia (Abu-Gazzeh 1995). This understanding should involve translating green building concepts into architectural design practice. More importantly, the cultural complexity and its appearance in space design must be studied and understood completely before the design stage. Future architects in Saudi Arabia must study the cultural schemata of the people in addition to the more usual studies of their activities and ecology. In this way, the suggested studio must provide built environment knowledge that will most closely fit the group's spatial and cultural needs.

Two issues are essential and important in the Muslims' houses: "culture" and "privacy." Saudi culture is defined and governed by Islamic principles, and the edicts of the religion's two primary texts (the Quran and the Hadith). These principles provide guidance for all Muslims in every aspect of their daily life. Therefore, it is imperative that these principles be covered and reflected in the design of Muslim houses.

Therefore, the design studio should discuss issues of how students can find a compromise between green design elements that can reduce energy consumption and provide comfort, and Islamic cultural aspects. In other words, when green architecture is an objective, this should be achieved in a way that is culturally sensitive. In the case of Saudi Arabia, green architecture must meet the requirements of these societally dominant issues of privacy and religious culture, which demand a certain degree of separation between men and women. Ipswich (2011) discusses the three main aspects of privacy that need to be considered: "Privacy between neighbors as well as between the individual dwelling and the street. Privacy between the sexes and privacy between individual family members of a dwelling." As an example of this, designs must deal with elements such as floor plans, window opening size and orientation, window placement and height, building orientation, setback spaces, and privacy from neighbors and adjoining streets to provide adequate user privacy and comfort. At the same time, these elements need to be integrated with green architecture elements such as daylighting, ventilation, etc.

Students should be encouraged to learn green strategies from the traditional and vernacular architecture in Saudi Arabia instead of being influenced by contemporary architecture including the western-styled villa and multiple story apartments. Western styles are not particularly responsive to the local climatic conditions of Saudi Arabia and can lead to excessive energy demands. However, of value may be procedural knowledge from Western architecture, green design strategies, and new green technologies that may be suitable to the Saudi house. In the studio, students and instructors should discuss the benefits of some older, vernacular architectural elements that have not been in use for several decades—such as the use of the Mashrabiya and the courtyard. These two elements can be developed and incorporated into the current design of a Saudi house to achieve practical energy reduction strategies and needed privacy. In the following paragraphs, some examples of the use of the Mashrabiya and the courtyard, and cultural and Islamic aspects like privacy in building design that need to be taught prior to the early stage of the studio, are discussed.

The Mashrabiya is a traditional wooden mesh that is installed over a window (see Figure 7-3), which adds a good amount of privacy while providing a view of the street. At the same time, the wooden mesh gives shade and protection from the hot summer sun while allowing the cool night air to flow through. Because of the high price of making a Mashrabiya in the old-style and the time needed to build one, Mashrabiyas are no longer in wide spread use in Saudi Arabia (Samuels 2011). However, in light of new shading technologies and the increasing collaboration between architects and stakeholders of housing development, the high cost of the Mashrabiya can be reduced by exploring new design and manufacturing strategies (Al Surf, Susilawati, and Trigunarsyah 2012).

Figure 7-3 Mashrabiya style (Productions 2000)

The courtyard is another traditional architectural concept in Saudi Arabia. The courtyard concept was common among Muslims mainly because it satisfied their social and religious needs, especially the need for privacy. For example, privacy can be achieved by facing all the house's windows to the inner courtyard rather than to the street. Besides providing privacy, the courtyard can be part of natural ventilation and daylighting strategies. This is especially true if the courtyard is designed to enhance thermal comfort and facilitate passive cooling through natural air circulation (see Figure 7-4 and Figure 7-5). With this in mind, the design and use of materials in Western architecture can be adapted to hot local climate conditions (Numan et al. 2000). Numan states, "This requires careful scrutiny and rationalization of development and impact of cultural changes on building design and determinants of external heat loads." Therefore, in a studio, students should learn and explore design concepts that include courtyards that can achieve high-energy performance and merge with conservative Saudi Islamic culture.

In conclusion, socio-cultural factors have determined the formation of places, conditions within them, and consequently, social relations. In addition, architectural elements and local regulations work together to provide users with privacy that respects religious issues. Elements such as the courtyard, Mashrabiya, and windows, must be merged with socio-cultural and Islamic considerations such as gender segregation, building height, privacy from neighbors and adjoining streets, etc. Students should be aware of socio-cultural and religious issues and their significance to architecture practice, including the historical role that social and cultural factors have played in shaping the current context within which architectural work takes place. Students should also discuss the integration of passive strategies such as airflow and natural lighting. Most importantly, students need to critically examine how theories and practices shape the field of architecture and impact society.

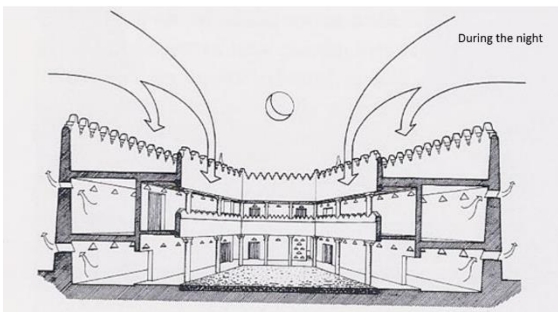


Figure 7-4 the courtyard and roof act as a cool air sink (Facey 1997)

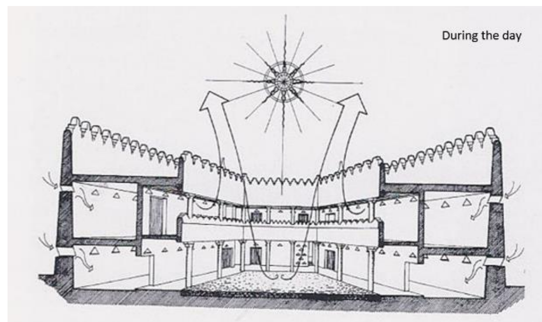


Figure 7-5 the sun heats the courtyard (Facey 1997)

7.2.3 Design Studio Procedures

This section discusses the studio procedures that must be implemented in the early, intermediate, and advanced stages in order to lead to a future knowledge stage. All the knowledge and examples that were outlined above in Section 7.2.1 of how to link architectural elements with cultural and Islamic aspects like privacy should be discussed and encouraged in the every stages of the design studio. Also, students must understand the use of natural strategies such as natural ventilation and daylighting, and how to integrate them into the design. The following discusses procedures for how the studio would work. In other words, what might a student go through in terms of early, intermediate, and advanced stage knowledge development in an architecture school studio?

7.2.3.1 *Foundational Knowledge Stage (Warm-Up)*

Prior to the early stage of the studio, students must take prerequisite lecture courses that cover fundamental and background knowledge of the criteria listed in Table 7-1. At the beginning of the early stage, the instructor should focus on developing the creative thinking skills of the students, while also summarizing the targeted knowledge that was acquired in all previous courses. Students will be asked to focus on the green criteria listed in Table 7-1 through readings, discussions, and analyzing reliable examples. The studio instructors should guide the students to further master the criteria and strategies related to energy and environment, forms of energy, and how buildings use energy by utilizing the sun, wind, light, and site. In addition, professionals and expert guests in ecological architecture should be invited to the studio to give seminars and presentations concerning past buildings that are known or considered to be green buildings.

In the studio, the instructor should present a design problem(s) (i.e. project/s) to students that deals with green building design strategies and emphasizes low energy consumption and high performance with an understanding of the social, cultural, Islamic context (including gender segregation and privacy) (see Section 7.2.1), and functional relations. In addition, the studio instructor should prepare site visits and let students become familiar with the proposed site(s). The site visits will allow students to discover and examine the real forces that surround the project site that must be considered during the early design stage. Thus, students will be able to define the positive and negative environmental issues and try to determine how a climate-conditioned approach might be undertaken. For example, in 2009, an Eco-Friendly House[24] was posed to senior students in Riyadh College of Technology in Saudi Arabia (Aloshan et al. 2009). The purpose of the project was to design an eco-friendly house appropriate for Saudi family culture and for Riyadh's environment and surroundings. During its early stage, the students were asked to prepare and develop site plan drawings after they visited and understood the proposed site. As a team, students surveyed the site, built models of the site, and presented a site analysis. During this phase, the students gained a better understanding of the site conditions in terms of energy and environmental opportunities, forms of energy that could be utilized, and how the proposed building type uses energy and issues related to sun access and orientation, daylight, wind, noise, traffic, existing trees, parks and good views, slopes, and other physical conditions. The site analysis should synthesize these conditions with cultural context such as privacy and gender segregation (see Figure 7-6).

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[24] In 2009, the researcher worked as a lecturer in the Riyadh College of Technology. He had been involved in the twinning project between Riyadh College of Technology (SA) and Derby College (UK) as coordinator of the Saudi team for the competition to design an eco-friendly house.

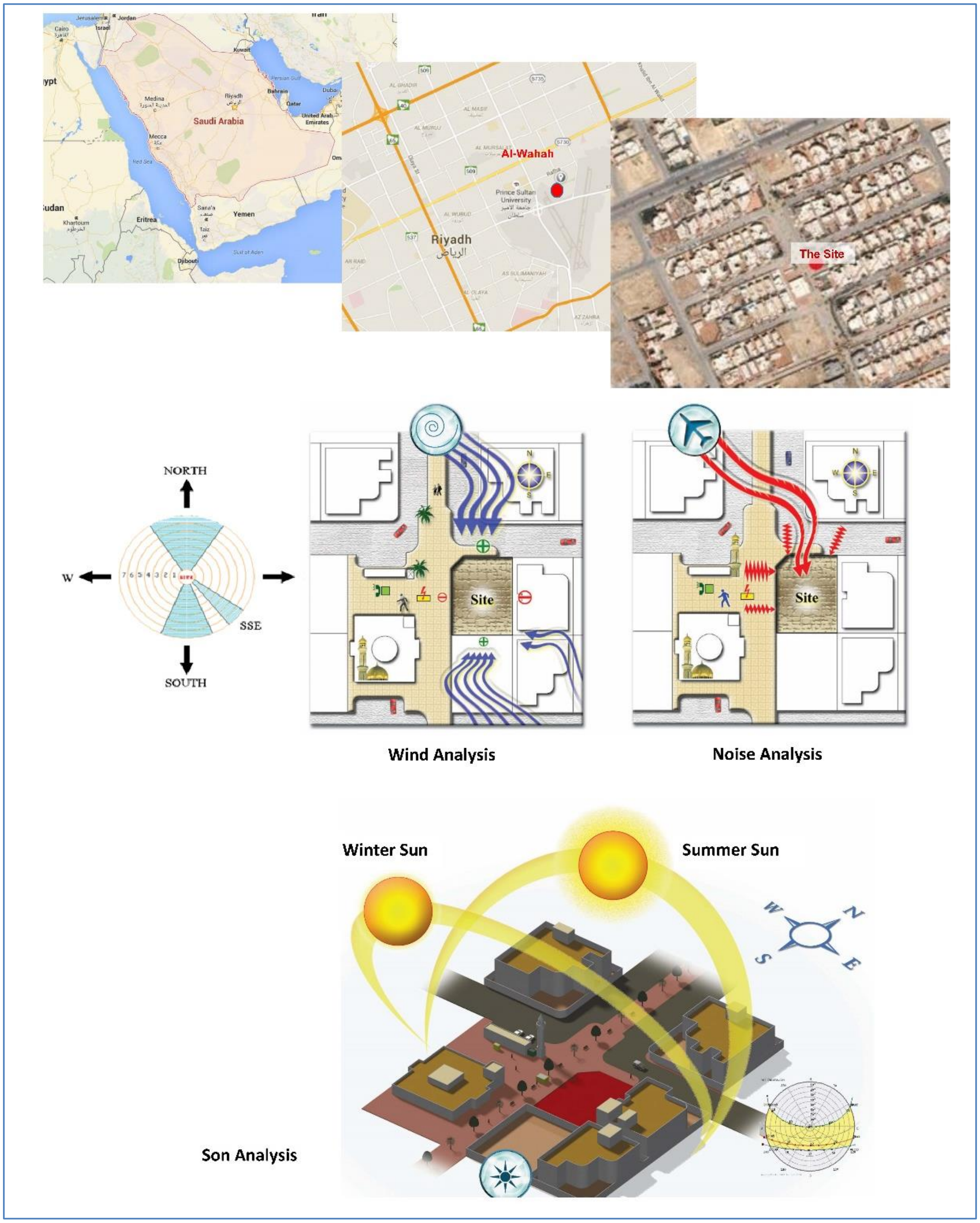


Figure 7-6 Site analysis including wind, sun, and noise analysis for the Eco-Friendly House in Saudi Arabia (Aloshan et al. 2009)

Before the site visit, students will be asked to select one of their studio colleagues as a partner to work with during the project. Instructors may elect to choose a site within the same city in which their university is located, or any other suitable location nearby. For example, an instructor at a university in Riyadh may select a project within the Financial District or a residential district near the university.

During the first stage, students will be asked to prepare and develop site plan drawing(s) after they visit. As a team, students should survey the site, build, models of the site, and present a site analysis.

One example of a project could be a complex of single-family villas in a Riyadh suburb. For this project, students could design the site to benefit from the cool breezes and natural air circulation. In addition, students could consider utilizing the sun during the winter. In order to design active and passive green solutions, students would decide the best building orientation, building mass and open spaces between buildings. In general, the orientation should be designed in a way that will allow cool breezes to flow inside during summertime and corresponds to the weather conditions of Riyadh. However, all of the green design elements that can save energy and provide comfort need to be designed while understanding and respecting aspects of Islamic cultural identity including privacy that were discussed in Section 7.2.1. Other site issues such as the accessibility of the site for pedestrians, bicycles, and public transport should be analyzed as well. At the end of the site analysis, students will be asked to present and show their work as sketches, posters, two- and three-dimensional drawings and site models. Initial site plan drawings and physical models also need to be completed at the appropriate scales.

In the case of multiple sites, students should discuss the similarities and the differences of these sites in terms of the above-mentioned criteria. Students should obtain and analyze all of the necessary information about not only the physical conditions of the site but also the lifestyles of the occupants and the cultural context of the site(s).

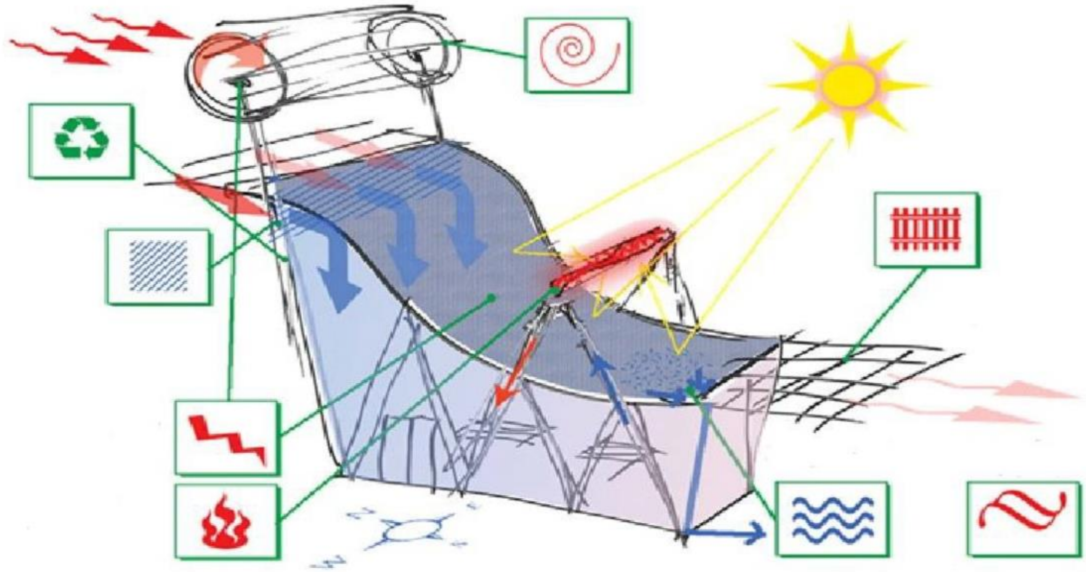
Above all, the instructor and students should discuss the needs and expectations of the project users. All of these discussions should be based on a project summary that is given to students early in the process. At the end of this stage, students will be asked to prepare PowerPoint presentations or posters summarizing their findings.

7.2.3.2 *Intermediate Knowledge Stage (Primary Design Concept/s)*

After the warm-up period, the students should start to create parti diagrams showing their concepts while considering the criteria seen in Table 7-1. The general form and direction of the building mass should be derived from the site properties and surrounding environment including sun, wind, light, and view. When the students start to create a conceptual structure for the project, they should think of new ways to make connections to the contextual conditions (see Figure 7-7).

Moreover, instructors and students should discuss green design strategies that can reduce energy load and provide comfort such as daylighting, natural and mechanical ventilation, passive cooling and heating design systems listed in Table 7-1 (see Figure 7-7) as they relate to the parti diagram and concept. For example, students should be encouraged to think of new ways to integrate culturally sensitive green design elements such as the courtyard and Mashrabiya that can reduce energy consumption and provide comfort. This will help the students to discover and respond to the users' needs, desires, wants, moods, and feelings.

At the end of this stage, students will have considered various elements of the program and then contributed to the brief. This will provide the students with opportunities to reformulate social, Islamic cultural requirements (see Section 7.2.1) and functional relations within the context of green architecture. For the first jury, it is therefore expected that students develop their own ideas and present their work as a poster and models that explain their approach and represent their design concepts.



The conceptual structure for the Eco-Friendly House

The design concept and the existing physical objectives

Figure 7-7 the conceptual structure for the Eco-Friendly House in Saudi Arabia (Aloshan et al. 2009)

7.2.3.3 *Advanced and Future Knowledge Stage (Design Process)*

In this stage, the required knowledge becomes more comprehensive and concentrated in comparison to the early and intermediate stages. The role of the advanced stage is to introduce and coalesce all of the required knowledge into a final product, for example, the collected information that will have been processed and discussed in the early and intermediate stages. This stage is the longest stage; if the early and intermediate stages took 5 weeks, this stage may take about 10 weeks from the semester.

After the students complete the initial site design(s) and the conceptual structure that reflects the local climate-sensitive building criteria for Riyadh, students should think about functionality and technical issues. Now, students should start to think about the required spaces and the relationship between these spaces. For example, in designing a residential building, students could be asked to design and solve three different types of housing situations in the city or suburbs of Riyadh: a studio for a single person, a unit for a married family without children, and a unit for married family with two children. Moreover, the project could be for a high-rise building with a mixture of three types of units or a complex of single-family houses. In this example, the three types of units would have different design requirements (including spaces and equipment) that would make the project more complex and pose challenges. The population of this settlement should be identified by the studio instructor and be based on the design requirements. All necessary social requirements for the site should also be provided, including exterior spaces like common gardens, balconies or terraces. During this phase of the studio, students should discuss the users' needs and comfort issues, and energy efficiency through a balance between operational and aesthetic issues, and Islamic context and environmental solutions.

Figure 7-8 shows the floor plans for the Eco-Friendly House in Saudi Arabia. This house was designed based on different functions and gendered separation. In other words, the house is designed into multiple rooms that serve both males and females in separate areas. Walls and partitions serve as significant physical boundaries inside the house. Gender-specific spaces for guests are also present in every house built in Saudi Arabia. For example, the villa ground floor is designed to have two separate sitting spaces—one for female guests and the second for unrelated male guests. Also, gender specific entrances are preferred.

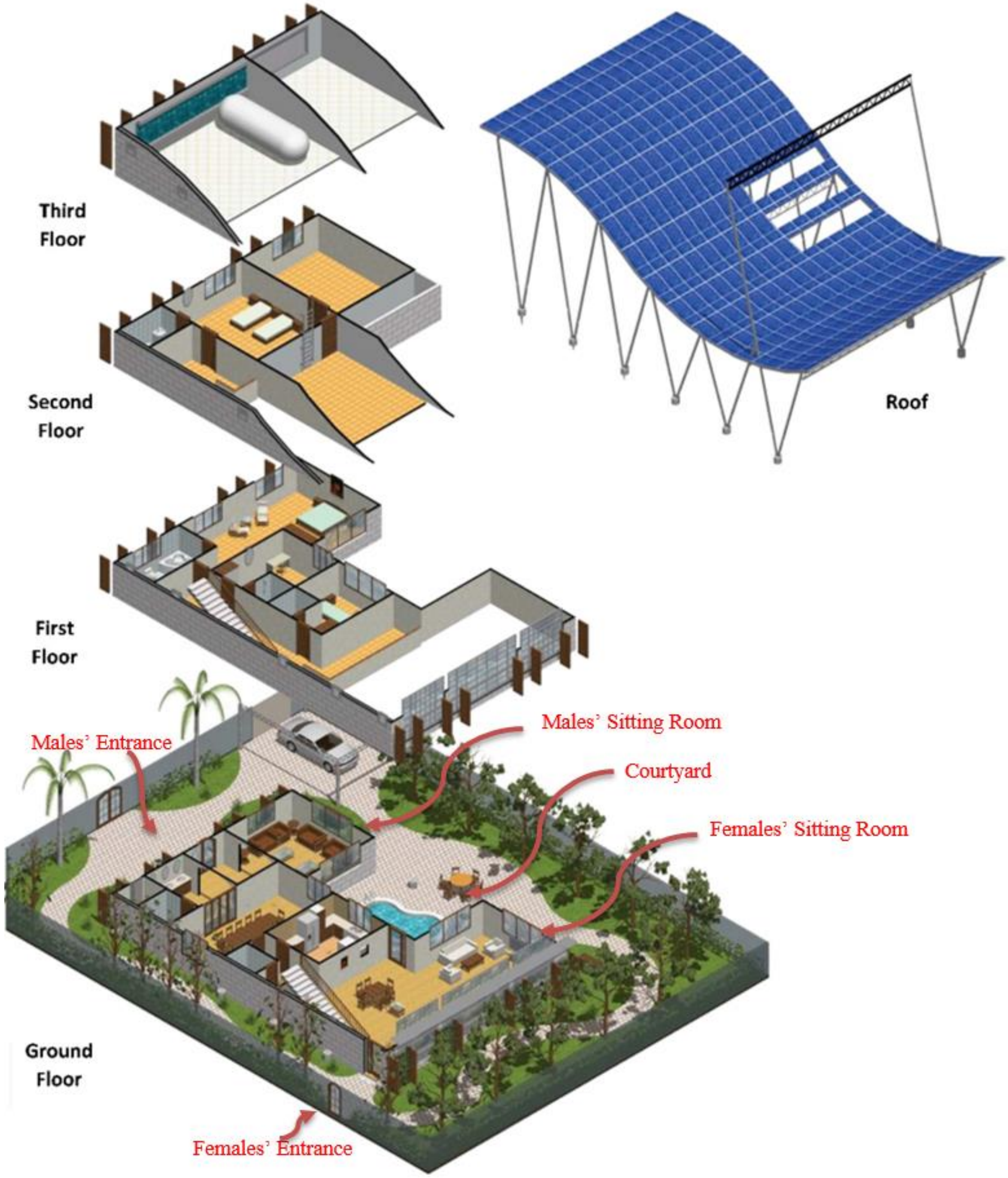


Figure 7-8 Floors plans for the Eco-Friendly House in Saudi Arabia (Aloshan et al. 2009)

Although the primary objective of green architecture should be about designing a good place and resource preservation can contribute to this objective, doing so in a way that is culturally sensitive should also be taken into consideration. In the case of Saudi Arabia, green architecture must meet the requirements of these societally dominant issues of privacy and religion, which demand a certain degree of separation between men and women. Also, the courtyard can be part of natural ventilation, daylighting, and privacy strategies (Aloshan et al. 2009). These elements need to be integrated within the building and need to be taught in the studio. Moreover, students should enhance and strengthen the interactions between exterior and interior spaces. In a similar way, students should design for good daylighting (see Figure 7-9). In addition, students should be encouraged to think of new ways of design that satisfy green design elements and Islamic cultural sensitivities.

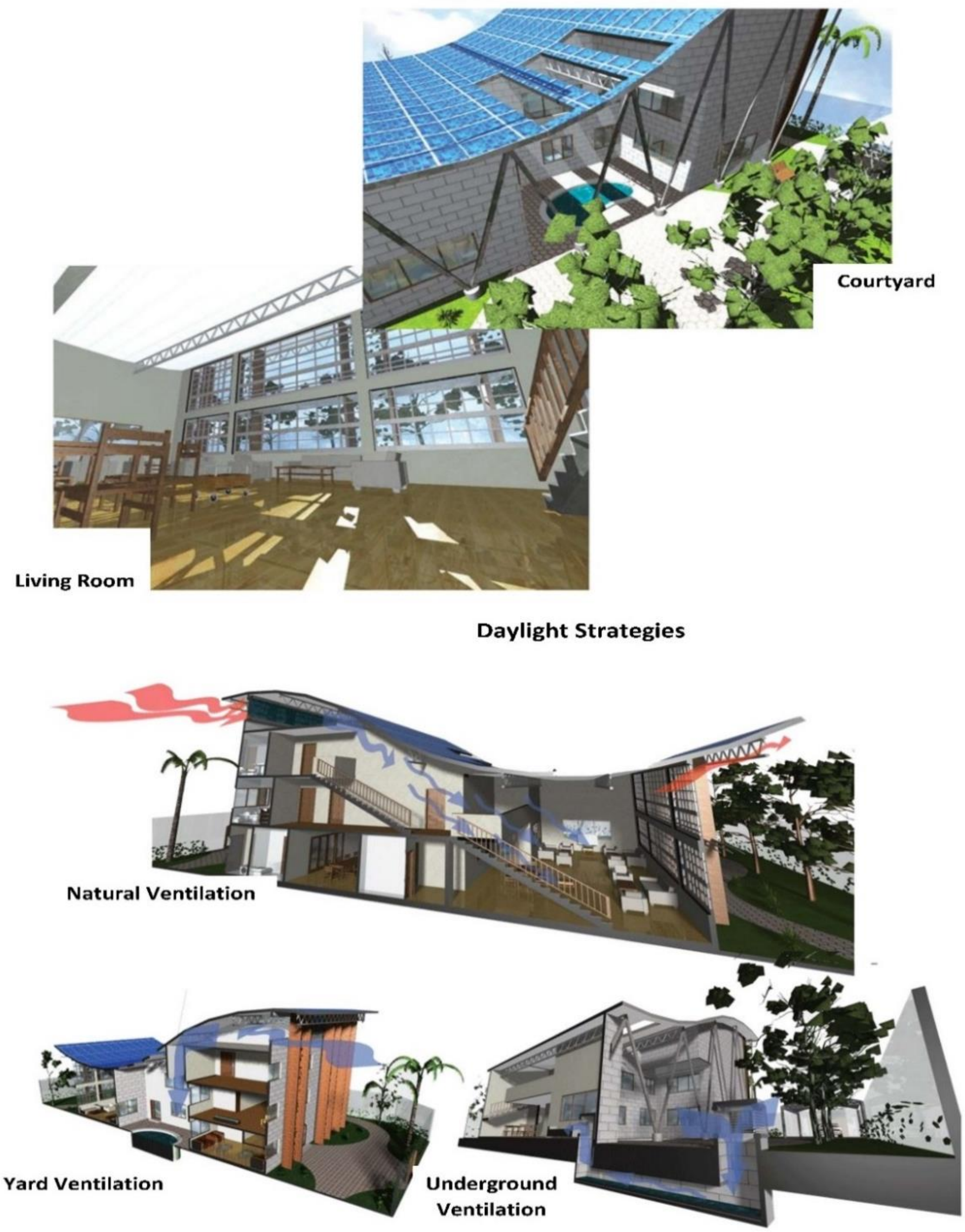


Figure 7-9 Shows the Eco-Friendly House Sections including daylighting and ventilation strategies (Aloshan et al. 2009)

In the final phase, instructors should ask students to develop technical knowledge including building envelope design and performance, double walls, and solar panel integration (see Figure 7-10). The building envelope system should be designed while considering performance, aesthetics, durability, and energy and material resources. Designing the building façade should be done in accordance to the mass/space ratio for the best energy efficiency. In addition, understanding the climate condition of Riyadh will help students to decide the appropriate shading devices and design the façade accordingly. For example, any large windows facing south that are used for winter solar heating may cause overheating in the summer. Therefore, horizontal shading devices are required to prevent overheating, while allowing winter sun to enter. If overheating still occurs in the summer, ventilation could then dissipate the unwanted heat.

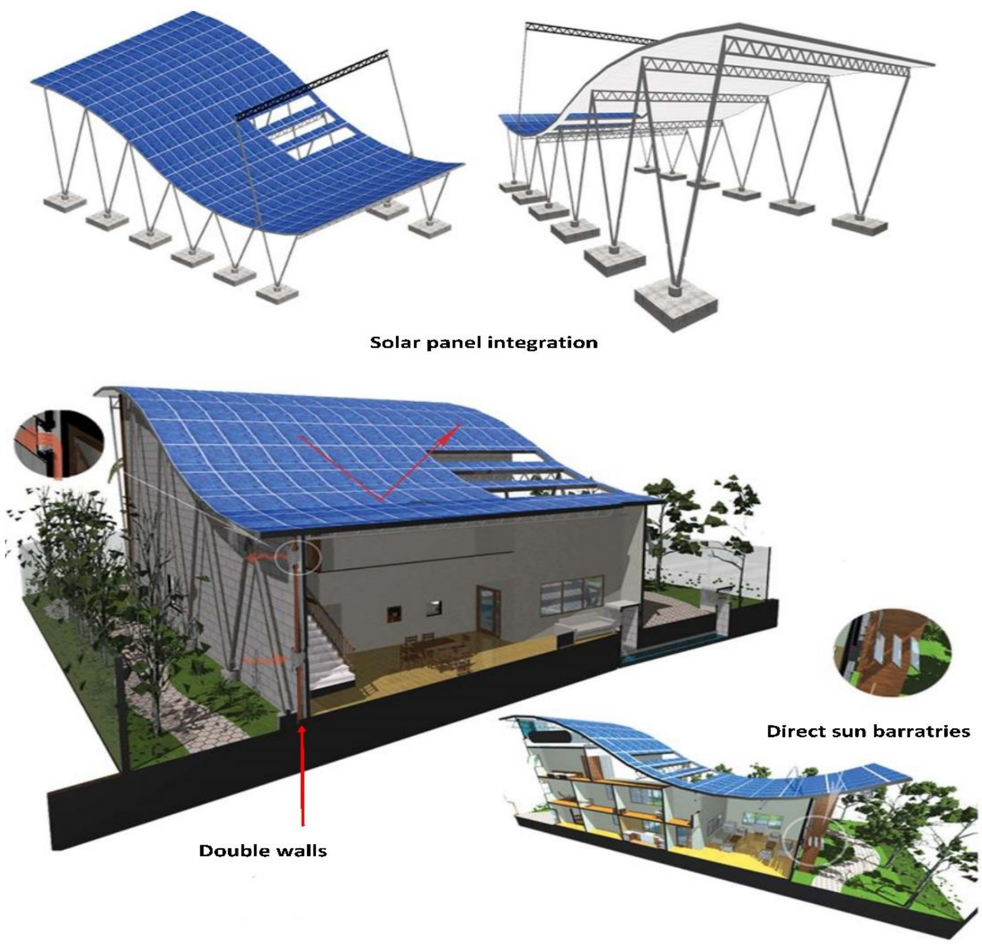


Figure 7-10 Shows the Eco-Friendly House structure and sections including solar panel integration and the house envelope (Aloshan et al. 2009)

During the design studio, instructors could extend the discussion to cover some future knowledge. Students should be encouraged to develop their design to consider some new future issues including the development of new aspects of passive cooling design, new technologies to better utilize scarce energy resources, daylighting studies, and optimization strategies for building systems.

At the pre-final jury, students will be asked to present their work with fully detailed drawings at an appropriate scale. The work should cover site and floor plans, sections, elevations, technical details, and models. Instructors must give the students important comments and feedback about their work. This second jury presentation will help students to make decisions according to their instructor's suggested changes. After the students have taken into consideration the important comments from the pre-final jury, students should focus their attention on the functional, technical and architectural complexity and technical solutions of their proposals to prepare for the final design presentation. At this point, students will be asked to present all of their completed work in the final jury of the evaluation stage (see Figure 7-11).

In conclusion, it is expected that the students will leave the studio with a clearer vision of the relationship between buildings and the environment; a broader understanding of what green architecture is within the Saudi context.

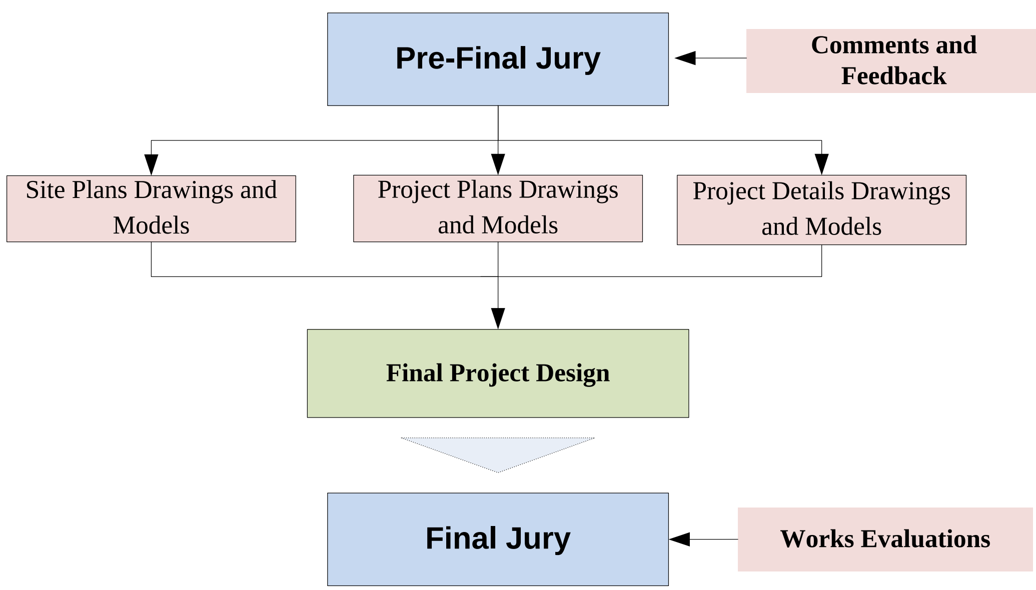


Figure 7-11 The evaluations processes for the proposed design studio

8. CONCLUSION

8.1 Introduction

Architecture creates the framework around our lives, as it protects us from the external environment and it gives us a place to relax, to live, and to work. However, the practice of architecture can be very complicated because of the still growing complexities that characterize our time and our society. Today, owners and users have different requirements than before. They are asking architects to design for lower operational costs, good daylighting and views, and higher indoor air quality (IAQ). At present, the design process depends more than ever on a large number of different disciplines outside of architecture to achieve these goals. Integrating all of these issues in building design is a dynamic process, which looks holistically at all architectural dimensions. Moreover, developments in knowledge, technology, and science are incorporated with art and materials to make architecture multifarious. However, present barriers of integrating green and sustainable strategies in the design process are mostly associated with deficiencies in both the architect's education and understanding of the fundamental knowledge of the dynamics between the building and the local environmental conditions. These are the areas of study and methods that should be encouraged by teachers and architectural program decision-makers during the course of one's professional education.

For this to transpire, it is important for Saudi Arabia—where resource conservation has typically not been an issue to architects—to redefine the architectural education model to cover new knowledge bases related to resource conservation. As a response, the framework presented in this research was designed for interested faculty members and school program directors in Saudi Arabia who are exploring ways to provide substantial, holistic information to students about green and sustainable architecture design.

This study developed a new knowledge-based educational framework for green building design in Saudi Arabia (see Chapter-6, Table 6-3). This framework was created based on the examination of the knowledge domains, knowledge structuring and sequencing, and learning theory through the three following stages. First, it identified the knowledge domains associated with green architecture knowledge, architecture design, and education through literature review, case studies, and interviews with experts in Western universities. Second, it determined the educational framework in Western universities in addition to identifying the barriers to and constraints of incorporating green architecture knowledge into architectural education in those universities (see Chapter-4). The Western framework was developed and evaluated by professors from three schools of architecture (University of Oregon, Arizona State University, and University of Southern California), all of who emphasize climate-responsive design strategies in their programs. The professors helped the researcher achieve and improve the accuracy of the Western knowledge. Third, this research established the Saudi Arabian framework, including the historical, environmental, economic, social, and cultural dimensions to understanding the nature, needs, and priorities of Saudi Arabia (see Chapter-5). This framework was shared and further developed by four Saudi architectural doctoral students at Virginia Tech. Their expertise helped achieve and improve the accuracy of the Saudi knowledge framework.

Based on the above three stages, the green architecture issues of the Western framework were merged with Saudi context in order to inform and develop the new Saudi Arabian educational framework (see Chapter-6). This process allowed the new framework to benefit from the expertise and knowledge of Western countries in terms of the acquisition and implementation of the environmentally responsive strategies in architectural education, while at the same time work on keeping the environmental, economic, social, and cultural conditions of Saudi Arabia in mind. Moreover, to foster integrating knowledge and skills in a sustainable environmental design at all stages of architectural education, the topics of the new framework were merged with empirical applications, simulation, and analytical tools (see Section 6.2, Chapter-6). Finally, the study presented a narrative approach for one topic of the new framework (see Chapter-7) and described how the knowledge of that topic could be systematically applied and understood in a hypothetical architecture design studio within the context of Saudi Arabia. More specifically, this narrative approach communicated how Western green knowledge could be adapted in response to the case of Saudi Arabia.

The final new framework revealed how knowledge related to green building can be structured and strategically implemented into architectural design education in Saudi Arabia. Also, this framework presented the opportunity for future architects to attain the required knowledge domains, knowledge structuring and sequencing, and learning paths for environmentally friendly architecture.

8.2 Expected Outcomes and Contributions

8.2.1 Meeting the Objectives of the Research

The expected outcomes and contributions to the body of knowledge can be summarized as the following points:

1. This study will better enable educators to prepare future generations of architects in Saudi Arabia, who can make successful contributions to the world they inhabit as professionals.
2. This study provides insight into how green building can be productively and strategically integrated into formal architectural curricula throughout the Kingdom.
3. This framework presents a workable model for green design education in the context of existing Saudi Arabian educational practices, thus improving the overall architectural educational system.
4. Presently, there is a learning barrier or a steep learning curve for senior Saudi professionals struggling to remain current regarding relevant issues and to implement green design strategies. This struggle could be repeated in future generations if students are not introduced to this information until after they have graduated and are practicing. In addition, instilling the meaning, value, and tools of green architecture in future architects as students might expedite the implementation of green building practices in Saudi Arabia.
5. Buildings have a major impact on resource consumption and play a significant role in environmental degradation. Therefore, it is of great importance that future Saudi practitioners understand and appreciate the many issues surrounding green building as well as larger-scale holistic sustainability, and how the field affects all scales.
6. In the long term, the study will help reduce negative environmental impacts associated with buildings; increase the awareness and perception of the importance of green architectural design among the public, architects, designers, and decision makers; enhance the role of architecture in society as a proponent of resource conservation; and reduce the energy consumption associated with buildings in Saudi Arabia.

8.2.2 Opportunities for Theoretical Shifts from the Study

The outcomes of this research have the potential to contribute to four theoretical domains within the field of architecture. The influence of the research on these domains is discussed below.

- **Normative Design**

Architecture today should give buildings and places individuality, particularly with regard to the character of the space. However, in Saudi Arabia, many recently designed buildings are striking in their exterior appearance, finishing, and construction, but at the expense of local values, national heritage, and cultural norms and customs.

Currently, buildings in Saudi Arabia are totally dependent on the use of mechanical systems for comfort control rather than being environmentally responsive. For example, designing a building as a "bunker" can lead to technical, aesthetical, and social failures. By reducing contact with the outside, and ignoring the natural light and view, occupants can lose a sense of comfort, health, and well-being. According to Christian Norberg-Schulz, this loss "cuts us away from a natural, elemental feeling of belonging to a place. We just close ourselves within walls, put on a machine, and have the right temperature" (1979b). Therefore, the proposed educational framework has the potential to be a catalyst for change in the current normative architecture design in Saudi Arabia.

- **Socially Responsive Architecture**

The proposed educational framework merged qualitative and quantitative knowledge with the Saudi Arabian context. The qualitative aspects of this research considered socio-cultural and religious principles. In particular, the results of Chapter two and Chapter six (Section 6.1.1.1) demonstrated that socio-cultural and religious norms provide principles that influence architectural design in Saudi Arabian society. These aspects have a particular influence on the design of private property, specifically, the separation of male and female domains based on the legal status of women that is quite different from the West.

Through this study, qualitative requirements of Saudi society (including culture, privacy and religion) are also merged with green architecture knowledge such as daylighting and ventilation. These more quantitative aspects are covered by the proposed framework primarily through performance indicators like energy modeling, daylighting analysis, life cycle cost analysis, embodied energy, etc. Indirectly, the proposed framework also responds to concerns for limited resources like oil. Currently, resource conservation typically is not a concern for architectural design in Saudi Arabia. This is due to several factors such as the availability and low cost of oil, governmental subsidies for oil production and electricity generation, and absence of similar subsidies for renewable energy programs. However, more recently, this situation has been changing and the government has started to reduce energy subsidies (Aldosary 2016). This has in turn contributed to a rising awareness of environmental concerns.

The outcome of this study will help professionals to establish new dialogues between designers and users, perhaps challenging the concept of privacy, and establishing more appropriate design solutions that meet local requirements in Saudi society. As a result of this study, architects and decision-makers will be able to implement ways of designing that apply green and sustainable architecture issues in new ways. This study will increase the potential for architecture to redefine the social response of architecture and be a catalyst for change in Saudi Arabia.

- **Eco-Architecture**

The goal of this research is to promote concepts like eco-architecture in Saudi Arabia. Currently, eco-architecture as demonstrated by Ken Yeang (2009) or Peter Buchanan are currently not common in Saudi Arabia. Based on Ken Yeang's book, and Buchanan's *Ten Shades of Green*, the proposed framework suggests redefining eco-architecture in the context of Saudi Arabia.

Architecture can indirectly influence change by promoting heightened awareness of resource consumption, by means of buildings that demonstrate a response to environmental factors. People have to be aware of the importance of long-term reductions in energy use and buildings designed to be environmentally responsive. They should also increase their awareness not just of space but also of their lifestyles—how they connect and how they act. This may provide an even greater contribution to society. When awareness of the environment is created in a person, the person brings this understanding back into their community. Therefore, the community should have a role and responsibility to educate, encourage collaborative thinking, and change in dealing with the natural environment.

Because it influences the way buildings are designed in Saudi Arabia, the framework suggested in this research can have an influence on the pre-knowledge stage. This can be through graduating architects and designers that they can design and create buildings that demonstrate a response to environmental factors (post-architecture), can teach children in schools and the public at large indirectly about the importance of resource conservation. For example, green buildings that respond to the sun or wind—like photovoltaic systems and wind turbines—can be implemented in schools in locations where they are easily visible to the students. This link between architecture and socio-cultural domains that can influence the young generation. This also has the potential to transform into a knowledge loop that accelerates the increasing environmental awareness (Figure 8-1).

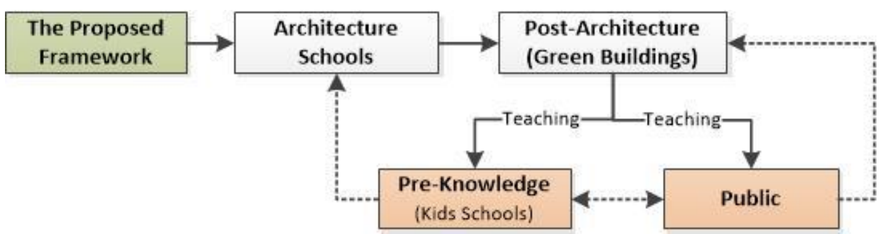


Figure 8-1 A knowledge loop and environmental awareness

Moreover, to elevate public awareness, in Saudi Arabia, some recently constructed buildings are more than just beautifully designed—they can be good for the environment as well and demonstrate green design principles while becoming iconic, from both the exterior and interior. For example, in Riyadh, buildings like King Fahad National Library and the Olaya Metro Station were designed to demonstrate green design principles both inside and out. These two buildings are located on the most important road in Riyadh (i.e. King Fahad Road); therefore, these buildings can serve as precedents to the Saudi public and teach people about green architecture principles.

Based on the above mentioned factors, the proposed architectural educational framework can be a catalyst for change in at least two ways, direct impacts and indirect impacts. With direct impacts, future architects can reduce resource consumption and their environmental impact by designing buildings for low energy use, water conservation, and fewer or reduced materials. Indirect impacts can be achieved by promoting heightened awareness among schools children and the public for resource consumption by the building demonstrating a response to environment factors.

- **Phenomenology**

Modern architecture can be strongly related to the notion of a universal past. Related to this, Frampton (1985) proposed the position of "critical regionalism" where he states that architecture "should not be sentimentally identified with the vernacular. Critical regionalism is a recuperative, self-conscious, critical endeavor, and nothing can be further from the vernacular in the initial sense of the term" (Frampton 1987), p. 378). In his proposal, Frampton recalls Paul Ricoeur's questions "how to become modern and to return to sources; how to revive an old, dormant civilization and take part in universal civilization" (Ricoeur 1965), pp. 276-277). According to Frampton's proposal, critical regionalism should embrace modern architecture, and the past should inform future moves for its universal progressive qualities, while at the same time principles and values should be rooted in the local context of the building included topography, climate, and light. In addition, he emphasizes tectonic form rather than on scenography and the sense of touch rather than visual sense. In Saudi Arabia, for critical regionalism to be implemented will require knowing how a region is to be (re)defined under the circumstance of whole cultural abandonment and therefore its shifting boundaries.

As mentioned before, the development of oil resources in the late 1940s and mid-1970s caused rapid economic growth in Saudi Arabia, which then witnessed an accelerated transformation of the physical environment and building development. The transformation was accelerated by the migration of people to urban centers, which also transformed architectural styles. Buildings started to change from old-style (vernacular architecture) to imported "modern" architecture to meet the increasing demand for various types of buildings—including housing, commercial, and industrial buildings (Abu-Ghazzeh 1997). For example, the new-style of house (villa) was imported originally in the 1930s by foreign labors and professionals brought into Saudi Arabia, and was developed in the 1950s when the Aramco[25] Home Ownership Program forced people to submit a design for their houses in order to qualify for a loan (Lebkicher, Rentz, and Steineke 1960). Because of the shortage of architects in Saudi Arabia at that time, people relied upon Aramco architects and engineers to design their new houses. This new villa style, constructed out of blocks and reinforced concrete was widespread across the country. This led to the homogenization in building design, form, materials, and construction in all regions of Saudi Arabian. For example, the single-family houses located in Riyadh, Jeddah, Dammam, Makkah, and other cities are all the same in every aspect. The few differences in villa style came from being filtered at the personal and cultural levels, as people made changes in their houses to meet their religious and social values.

It is the premise of this research that building design in Saudi Arabia should not look the same from region to region; they should be different and need to respond to their own identity and local context. This means that buildings in each region in Saudi Arabia should express a local identity. However, new technological developments and foreign concepts may still be applicable and add value. Although these new technologies may change one's lifestyle, new meanings may emerge. Personal values and past experiences may influence one's evaluation of these new innovations and allow them to choose those that provide a sense of continuity (al-Naim 2008).

In applying this concept of the critical regionalism in Saudi Arabia, this research proposed how to design green and modern buildings that return to a local identity, revive traditional architecture, and have a strong connection to the local context. Buildings in Saudi Arabia need to use green strategies in tandem with traditional and vernacular. This is opposed to Western styles that are not particularly responsive to the local climatic conditions or socio-cultural and religious issues of Saudi Arabia. However, this does not mean that Saudi Arabia cannot benefit from the procedural knowledge of Western architecture as well as green design strategies, and new green technologies.

This research suggested the benefits of vernacular architectural elements that have not been in use in Saudi Arabia for several decades—such as the Mashrabiya and the courtyard. These two elements can be redeveloped and incorporated into the design of

[25] Aramco is officially the Saudi Arabian Oil Company.

Saudi homes as energy reduction strategies and for privacy. In addition, the Mashrabiya and courtyard can serve to create a sense of space. For example, the geometry of the Mashrabiya (fundamentally grounded in Islamic culture) can work as a sunscreen element and as a boundary between the inside and the outside, while at the same time connecting residents to the external environment.

The outcome of this study supports the phenomenological concept of modernization that creates a balance between old and new, and between qualitative and quantitative knowledge. The proposed framework has the potential to extend the boundaries of how one experiences architecture in Saudi Arabia in the future.

8.3 Barriers, Constraints, and Solutions in Integrating Green Knowledge in Architectural Education

Interviews were conducted with professors from the three selected case study architectural programs: University of Oregon, Arizona State University, and University of Southern California. At the beginning of each interview, the participants were asked: "What are the biggest barriers that you have experienced in integrating green knowledge in architectural education?" Participants perceived a number of barriers regarding the integration of green and sustainability themes within architectural education. Some of them believed that the faculties themselves are holding back the implementation of green and sustainable themes in architectural design studios. Some participants were reluctant to place blame on the established culture of education, while others were not hesitant to rebuke the educational status quo of the studio and curriculum structure in regards to class time and required equipment. The following barriers were taken from Western experts and professors. Therefore, research solutions and reflections about implementing green and sustainable themes into architectural educational system are very important when considering teaching classes in schools of architecture in Saudi Arabia:

Participant-A noted that his/her school is "a different place, in that most courses are where people come and study sustainability cases developed in [his/her] books, but getting people to use them in class was a problem." To overcome this problem, he/she naturally started to make connections between design and human investment to promote the sustainable and green issues in classrooms.

In Saudi Arabia, this issue can be addressed through the warm-up period of the studio that was explained in Section 7.2.2.1 (i.e. Foundational Knowledge Stage). The instructor should prepare multiple visits to known green projects or buildings and let the student see and touch real aspects of green architecture. In addition, the studio instructors should guide the students to further master the criteria and strategies related to green building. Moreover, professionals and guests with expertise in ecological architecture should be invited to the studio to give seminars and presentations about recently constructed buildings. All of this will help students to engage green and sustainable issues.

Participant-B noted that to cover all sustainable and green architectural issues, there is a problem with timing. As he/she said, “There is not enough time in the day; in the week; in the term to do all of those things.”

Therefore, the complete green knowledge base that is shown in this research (see Table 6.3) cannot be taught in one or two design studios; rather it should be distributed across the program. For example, the narrative part of this research presented one important topic (i.e. “Low Energy and High Performance,” Topic-3) of the six topics of the final Framework (see Table 6.3). It was proposed to be presented as a scenario of how green topics can be implemented into the architectural design studio in a hypothetical school of architecture in Saudi Arabia. Therefore, the other five topics should be taught in other studios using a similar approach. Multiple design studios can overcome the barrier of the time in a day, week, and semester and allow a school program to cover all of green knowledge within the proposed framework.

Participant-B also noted another problem of accessing required tools and equipment that could be used to test and simulate a design project. He/she mentioned that there is a library at his/her university of low cost tools and equipment that students can use to help them validate and simulate their design. He/she said, “We’ve been unable to do that at the [school] through private funding and through grant funding, but to purchase enough equipment; there is a library of tools and equipment that students can use to help validate their design.” However, students should also be aware of other ways to simulate their design—included clay models, energy, and daylighting simulations, and other ways that may very helpful during practice.

In Saudi Arabian schools, it is recommended that the school programs provide all required tools and equipment that can be used to test and simulate design projects and be available to the students in the school's labs or library. Therefore, for the proposed framework to work properly, all required equipment, analytical tools and empirical case study application as mentioned in the proposed framework (Table 6-3) should be available for student use in the school's labs. In addition, software programs such as climate analysis software, energy, lighting, wind and acoustic simulations software should be installed on the school's computer labs.

Participant-C said that the biggest barrier in design are bad habits, or as he/she said, "We have habits and students got used to a sort of habit of looking at the window and thinking it's just a façade, but they're not looking at the window and thinking [about] daylight." In addition, he/she added, that the "students only look at certain aspects and look at one aesthetic and this neglects all of other aspects." He/she saw that the biggest barrier for him/her "is to break these habits, and breaking these habits are not only for the students but also for the instructors…that are trained in a certain way." Therefore, Saudi Arabian instructors need to teach students about positive habits of thinking such as considering the influence of design decisions on energy, daylighting, building performance, not only on aesthetics and beauty of buildings. As he/she said, "Instructors cannot push students only to aesthetics and beauty of buildings, because part of it is also to see good performance in a building that also has aesthetics and beauty." Therefore, the role of the instructor is to provide the students with green knowledge such as comfort and energy efficiency in design that must be achieved through making a balance between aesthetic issues and environmental solutions.

Two participants reported environmental issues as significant factors in implementing green knowledge. **Participant-D** saw that the biggest barrier is the design studio faculty of whom many do not appreciate or "do not believe in environmental control issues" and their importance to the design, and "they do not want to talk about it with students." However, "the biggest problem is if they do not know it." While **Participant-E** said, "The biggest barriers are not very much imposed by the school. The biggest barrier in my opinion is society." In general, he/she believed that students and people do not have the appreciation they should have or the understanding of where the energy comes from and how they use it in buildings. He/she added, "The barriers at the school are not as great as the barriers from the students themselves." Therefore, students need to focus on green issues in order to appreciate the need to conserve energy.

To address this issue, society can look to architecture in order to increase their awareness of resource waste and the need for conservation. Buildings can express the client's and architect's attitude toward resource conservation. Some recently constructed buildings demonstrate green design principles and became iconic, from both the exterior and interior. For example, Ken Yeang's building can be seen as an approach to heighten awareness and teach people about resource consumption. His buildings speak to us about resource conservation. For example, the Solaris building in Singapore is considered one of Yeang's greenest buildings.

In Saudi Arabia, some buildings are more than just beautifully designed—they can be good for the environment as well. In Riyadh, buildings like King Fahad National Library and the Olaya Metro Station were designed to demonstrate green design principles on both the exterior and interior. These two buildings are located on the most important road in Riyadh (i.e. King Fahad Road), therefore, these buildings can serve as precedents to the Saudi public and teach people about green architecture principles.

The education of the architect should support this view too—that well-designed buildings can be energy efficient. Therefore, instructors and school administrators should cooperate to make environmentally responsive design criteria as a priority in the architectural school programs to build architects' skills in this area from the beginning of their studies (EDUCATE 2012a). In addition, instructors should seek to promote environmentally responsive design criteria through direct experiential learning, using appropriate methodologies, tools, and techniques (see Section 8.4).

8.4 Recommendations and Lessons Learned

The final knowledge framework (see Table 6-3) suggests that issues and knowledge associated with environmental design that aims to achieve and support comfort, well-being, delight, and energy efficiency in buildings are complex and multifaceted. This study suggested recommendations and lessons learned that were drawn from the research outcomes and from the narrative. Overall, the implementation of recommendations will vary for each program, depending on the faculty, university setting, initiatives, and student body. However, overcoming the above-mentioned barriers (see Section 8-3) and the incorporation and integration of green and sustainability themes in architectural education should be discussed at two levels: individual methods used in courses and the philosophical approach of the program. Therefore, the following principles provide the most promising opportunity for the integration of green and sustainability themes within architectural education and need to be taken into account in Saudi Arabia:

1. At the individual faculty level, the following recommendations should be considered:

- Educators should seek to promote environmentally responsive design criteria through using direct experiential learning, appropriate methodologies, tools, and techniques.
- Educators must continually evolve the knowledge base of green architectural design through exemplar research and architectural practice.
- Instructors should use the eight instructional principles (see Section 7.1.5, Chapter-7) that were derived from constructivism to help students understand and control complexity.
- Classes should be taught based on problem-solving skills to improve "the ability of the student to synthesize social, environmental, technical and aesthetic considerations into a cohesive and unified architecture entity and [include] an understanding of process and product" (NAAB 1995).
- Instructors should use authentic and large projects (where applicable) in the design studio.
- Instructors must integrate green and sustainability themes into studio courses.
- Educators should design the learning environment to reflect the complexity of the environment in which, at the end of learning, students should be able to function.
- In the design studio, educators need to emphasize process and decision making in partnership with the end product.
- Instructors should encourage students to examine and experience existing buildings.
- Professionals and expert guests in ecological architecture should be invited to the studio to give seminars and presentations about past buildings that are known or considered as green buildings.

2. At the program level, or in a cohort of faculty, the following recommendations should be considered:

- Environmentally responsive design criteria must be seen as a priority in architectural school programs to build architects from the beginning of their studies (EDUCATE 2012a).

- The new green architecture knowledge framework needs to excite and inspire students rigorously, and creatively address contemporary design challenges.
- The new green architecture knowledge framework must encourage critical awareness, responsibility and reflection on the numerous interdependencies within the design process.
- The framework should integrate green and sustainability themes as a standard into studio courses.
- The framework must address green and sustainability issues early in the students' educational journey.
- The university should provide the program with the required tools and equipment that can be used to test and simulate a project.
- Faculty need to establish partnerships with other disciplines and open courses to other students within these other disciplines.
- The university should establish an interdisciplinary sustainability certificate.
- The program should create a task force to focus on engaging other disciplines on campus and beyond.
- As an accreditation board is not yet used in Saudi Arabian architectural schools, it is recommended that Saudi Arabia architectural schools take advantage of the expertise of Western countries around the world and establishing their own accreditation board.
- The above-recommended accreditation board should fully integrate environmentally responsive design criteria into the process of accreditation by requiring that students of the program possess skills and knowledge defined by a set of performance criteria modified to incorporate green and sustainable issues.

As previously mentioned (see Section 7.2.1, Chapter-7), for green architecture design education to be successfully integrated in Saudi Arabia, it must satisfy both qualitative (i.e. cultural) and quantitative (i.e. performance indicators) conditions within the Kingdom. Once these quantitative and qualitative domains have been integrated with green knowledge, the common area between these aspects must inform the design studio (see Figure 8-1).

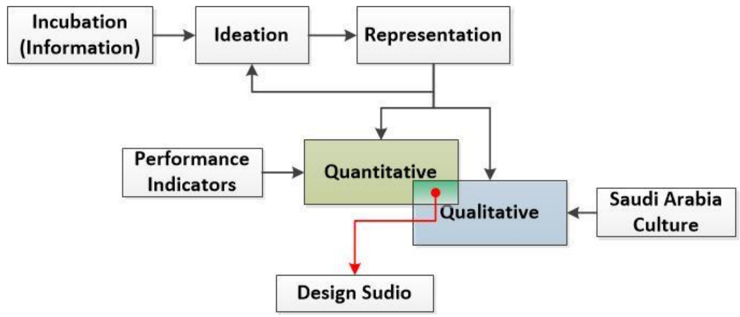


Figure 8-2 The design processes in architecture education

The interaction between the quantitative and qualitative dimensions should support good design particularly as it relates to low energy consumption and high quality of life (i.e. a good place), which is the main goal of the proposed framework. In building design, merging and integrating quantitative and qualitative dimensions can challenge the norms of the society, religion, culture, and how people interact with a building. For example, to meet the requirements associated with religion and culture in Saudi Arabia, buildings such as schools, banks, and hospitals were designed based on gender-specific floor plans. Gender separation then led architects to create many buildings and spaces that consume excess energy for air-conditioning and lighting. However, this study has demonstrated that architecture can create a balance between people's needs, such as comfort, health, religious and cultural requirements, and requirements for energy savings.

Architecture has the power to inspire us, to make us feel good, and more importantly, well-designed buildings can reflect positively on our social values. This study posed a framework for architectural education in Saudi Arabia. More importantly, it demonstrated how architecture can start to become a catalyst for change and how the educational system can support these changes. The final educational framework explained how to facilitate dialogues between society, religion, culture, and the educational system in Saudi Arabia. In addition, it showed how these dialogues could encourage students to think of new ways of design that can unite green design elements and Islamic culture. Applying the proposed framework in architectural schools in Saudi Arabia must meet the requirements of Saudi society while remaining faithful to green architecture principles.

8.5 Implications for Future Studies

Architectural education is becoming increasingly reflexive, looking at internal processes, structures, influences, and cultural constructs. Therefore, future efforts should take the constantly changing context of professionals and the profession itself into consideration, including green and sustainability themes, systems thinking, and the design process. Doing so will provide a sound foundation for the future of architectural education. Therefore, researchers in Saudi Arabia who are interested in the integration of sustainability and green building themes into their curricula should continue to unravel the complex context of architectural education. To this end, here are some suggested areas for further research in Saudi Arabia:

- The other topics (Topics 1, 2, 4, 5, and 6) of the new framework of this study could be applied to existing design studios in Saudi Arabia. Through the use of a similar approach or scenario presented in the narrative study (see Chapter-7), one can investigate, explore, and assess the growth of student engagement in that studio, and how green themes from that topic can be covered by architectural education.
- Understanding the role of the design studio as the main core of design education, discover how other courses can interact with this core, and address barriers that affect implementing green and sustainable themes in the design studio.
- Consider the development of teaching methods and student assessment, including what currently exists, what is being developed, and potential goals for the future.
- Explore potential boundaries for developing a program and faculty identity within the context of architectural education in Saudi Arabia.
- Explore community engagement in architectural education in Saudi Arabia, and how students can be engaged in public processes through real world projects.

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10. Appendix A: Interviews (Western Model)

10.1 The AS-IS Knowledge Framework Interview Questions

Group 1: Introductory questions

To establish a background about the respondent, the role he/she played in implementing green knowledge in education systems.

- Describe your ROLE(s) for integrating green knowledge into architectural curricula?
- What are the biggest barriers that you have experienced in integrating green knowledge in architectural education?
- In your program, what green knowledge domains are added to the curriculum?
- What do you think about the conversations surrounding green knowledge within architectural education? What topics and definitions come up frequently in these conversations?

Group 2: AS-IS Knowledge framework validation questions

The contents of the presented framework are structured in an "ontology" consisting of six topics headings, and categories and clusters as demonstrated in Table-1.

Starting from the knowledge priorities, I classified green architecture knowledge in six heading topics including environmental dimension, climate and comfort, low energy and high performance, quality of life, impacts and resources, and architecture and urban development. Each topic has its categories and clusters that reflect its green criteria (Table-1).

- What do you think about the classification of the six topics of the green knowledge framework?

Should I add other topics?	
Should I remove a specific topic?	
Do you have any comments and suggestions on topics?	

Table-1 the Hierarchy of the Green Architecture Knowledge Framework

Green Architecture Knowledge		AS-IS Knowledge: Categories	Clusters
Topic 1	Environment	The Environmental Challenge	○ Climate Change / Global Warming ○ Environmental Pollution ○ Environmental Policies
Topic 2	Climate, Comfort	Climate	○ Climate and Weather
		Comfort	○ Thermal Comfort, and Standards ○ Visual Comfort, and Standards ○ Indoor Air Quality (Fresh Air and Absence of Toxic Materials) ○ Building Typology ○ Outdoor Spaces and Off-Gassing
		Acoustics	○ Acoustics in Design ○ Materials in Acoustics ○ The Reverberation Process
		Building, and Place, and Space	○ Physically Democratize the Workplace (e.g. Ventilation, and Lighting control) ○ Give Buildings and Place Individuality, with Regard to Space and Character ○ Place Image and Emotions in Design ○ Create a Space that has a Sense of Strangeness and Familiarity ○ Create a Sense of Security, and Isolation ○ Produce a Sense of Loneliness and Silence in the Space
Topic 3	Low Energy / High Performance	Heating and Cooling	○ Thermal Environment ○ Psychometric ○ Thermal Behavior of Building ○ Building Envelope Performance ○ Dynamic Response of Buildings ○ Moisture Control ○ Passive Design Principles ○ Passive Design Systems ○ Active Design Systems
		Ventilation	○ Natural Ventilation ○ Mechanical Ventilation
		Lighting	○ Physics of Light ○ Natural Lighting ○ Artificial Lighting
Topic 4	Quality of Life	Urban Quality	○ Eco-Master Planning ○ Environment, Society and Economy ○ Laws, Regulations, Ethics
Topic 5	Impacts and Resources	Ecological Footprint	○ Environmental Impacts
		Resources and Waste Management	○ Reuse old Building Materials and Components ○ Water Management (e.g. Recycle, Reduce, Rainwater Harvesting) ○ Waste Management (e.g. Recycle, Reduce…) ○ Durability, and Adaptability Materials
		Replenishable Sources	○ Renewable Energy Sources (e.g. Sun, Wind, Waves Energy, and Gravity and Geo-Thermal Power…) ○ Replenished Materials (e.g. Wood, or Clay (for Brick) and Sand (for Glass)
		Embodied Energy	○ Embodied Energy and Life-Time Energy Use ○ Material with Lowest Embodied Energy (Wood, then Brick) ○ Materials with Most Embodied Energy (Aluminum)
Topic 6	Architecture and Urban Development	Buildings and Cities	○ Use of Energy ○ Building Must be Close to Public Transport ○ Rethinking in Cities and other Forms of Human Settlement ○ Rehabilitating Existing Built Environments and Cities
		Embedded in Place	○ Drawing on Local Wisdom ○ Updating Vernacular Architecture

Topics 1: Environment

		Categories	Clusters
Topic 1	Environ ment	The Environmental Challenge	o Climate Change / Global Warming o Environmental Pollution o Environmental Policies

- What do you think about the classification of this topic?

Should I add a new category?	
Should I add/remove any cluster?	

Topics 2: Climate and Comfort

		Categories	Clusters
Topic 2	Climate, Comfort	Climate	o Climate and Weather
		Comfort	o Thermal Comfort, and Standards o Visual Comfort, and Standards o Indoor Air Quality (Fresh Air and Absence of Toxic Materials) o Building Typology o Outdoor Spaces and Off-Gassing
		Acoustics	o Acoustics in Design o Materials in Acoustics o The Reverberation Process
		Building, and Place, and Space	o Physically Democratize the Workplace (e.g. Ventilation, and Lighting control) o Give Buildings and Place Individuality, with Regard to Space and Character o Place Image and Emotions in Design o Create a Space that has a Sense of Strangeness and Familiarity o Create a Sense of Security, and Isolation o Produce a Sense of Loneliness and Silence in the Space

- What do you think about the classification of this topic?

Should I add/remove any category?	
Should I add/remove any cluster?	

Topics 3: Low energy and High performance

		Categories	Clusters	
Topic 3	Low Energy / High Performance	Heating and Cooling	○ Thermal Environment ○ Psychometric ○ Thermal Behavior of Building ○ Building Envelope Performance ○ Dynamic Response of Buildings	○ Moisture Control ○ Passive Design Principles ○ Passive Design Systems ○ Active Design Systems
		Ventilation	○ Natural Ventilation ○ Mechanical Ventilation	
		Lighting	○ Physics of Light ○ Natural Lighting ○ Artificial Lighting	

- What do you think about the classification of this topic?

Should I add/remove any category?	
Should I add/remove any cluster?	

Topics 4: Quality of Life

		Categories	Clusters
Topic 4	Quality of Life	Urban Quality	○ Eco-Master Planning ○ Environment, Society and Economy ○ Laws, Regulations, Ethics

- What do you think about the classification of this topic?

Should I add a new category?	
Should I add/remove any cluster?	

Topics 5: Impacts and Resources

Topic		Categories	Clusters
Topic 5	Impacts and Resources	Ecological Footprint	○ Environmental Impacts
		Resources and Waste Management	○ Reuse old Building Materials and Components ○ Water Management (e.g. Recycle, Reduce, Rainwater Harvesting) ○ Waste Management (e.g. Recycle, Reduce…) ○ Durability, and Adaptability Materials
		Replenishable Sources	○ Renewable Energy Sources (e.g. Sun, Wind, Waves Energy, and Gravity and Geo-Thermal Power…) ○ Replenished Materials (e.g. Wood, or Clay (for Brick) and Sand (for Glass)
		Embodied Energy	○ Embodied Energy and Life-Time Energy Use ○ Material with Lowest Embodied Energy (Wood, then Brick) ○ Materials with Most Embodied Energy (Aluminum)

- What do you think about the classification of this topic?

Should I add/remove any category?	
Should I add/remove any cluster?	

Topics 6: Architecture and Urban Development

Topic		Categories	Clusters
Topic 6	Architecture and Urban Development	Buildings and Cities	○ Use of Energy ○ Building Must be Close to Public Transport ○ Rethinking in Cities and other Forms of Human Settlement ○ Rehabilitating Existing Built Environments and Cities
		Embedded in Place	○ Drawing on Local Wisdom ○ Updating Vernacular Architecture

- What do you think about the classification of this topic?

Should I add/remove any category?	
Should I add/remove any cluster?	

- What green issues do you feel are well incorporated in the…

Foundational Knowledge Stage?	Intermediate Knowledge Stage?	Advance Knowledge Stage?	Future Knowledge Stage?

- How all of the six topics poll together in the final year or in the final thesis?

Group 3: Conclusion

- Would you like to add any additional information, comments, or clarification on any of the previous questions?
- Is there anything else you would like to talk about that we have not covered?
- Are you willing to see the product of this research, and comments on it?

10.2 Invitation Letters for Participation

Dear XXX,

My name is Mohammed Aloshan, and I am a Ph.D. student in Architecture Design and Research at Virginia Tech. My research focus is on the development of a new knowledge-based educational framework for green building design in Saudi Arabia. This study seeks to reveal how knowledge related to green building can be structured and strategically implemented into architectural design education in Saudi Arabia. This is a grounded theory study involving in-depth interviews with a specific number of faculty from purposefully selected Universities to better understand their views and experiences involving environmental responsive design within architectural education.

The University of Oregon's architecture program was selected as a case study of this research. The University of Oregon is number one in the nation in 2013 for sustainable design practices and principles, and you have been chosen because of your reputation and your experiences in implementing green knowledge in architectural education. Also, my committee indicates you as an expert in this area. Your participation in this research will assist in achieving and improving the validity and accuracy of the study's assessment of current Western knowledge, specifically in green architecture design education. The duration of the interview approximately about 45-60 minutes.

Please let me know if you have any questions. I appreciate your time and look forward to hearing from you at your earliest convenience.

Regards,

11. Appendix B: Interviews (Saudi Arabia Model)

11.1 TO-BE Knowledge Framework Interviews Questions

The contents of the presented framework structured in an ontology consisted of four Topics, Categories and Clusters as demonstrated in **Error! Reference source not found.**. he four topics included historical, environmental, economic, and socio-cultural category. Each topic has its categories and clusters that reflecting its local context (**Error! Reference ource not found.**).

- What do you think about the classification of the four aspects of the Saudi Arabia context?
    - Should I add a new topic?
    - Should I remove a specific topic?
    - Do you have any comments and suggestions?

Topic 1: Historical Aspect

- What do you think about the classification of the historical aspect?
    - Should I add a new category?
    - Should I add/remove any criteria?
    - Do you have any comments and suggestions on this category and its criteria?

Topics 2: Economic Aspect

- What do you think about the classification of the economic aspect?
    - Should I add/ remove any category?
    - Should I add/remove any criteria?
    - Do you have any comments and suggestions on this category and its criteria?

Topics 3: Socio-Cultural Aspect

- What do you think about the classification of the Socio-Cultural aspect?
    - Should I add/ remove any category?
    - Should I add/remove any criteria?

- Do you have any comments and suggestions on this category and its criteria?

Topics 4: Environmental Aspect

- What do you think about the classification of the Environmental Aspect?
  - Should I add/ remove any category?
  - Should I add/remove any criteria?
  - Do you have any comments and suggestions on this category and its criteria?

Conclusion

- Would you like to add any additional information, comments, or clarification on any of the previous questions?
- Is there anything else you would like to talk about that we have not covered?