EVALUATION ON THE LEVEL OF AWARENESS ON CIRCULAR ECONOMY STRATEGIES AMONG BUILT ENVIRONMENT STUDENTS IN THE UNIVERSITY OF BENIN.

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A DISSERTATION SUBMITTED TO THE DEPARTMENT OF ARCHITECTURE, FACULTY OF ENVIRONMENTAL SCIENCE, IN PARTIAL SATISFACTION OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF BACHELOR OF SCIENCE (B.SC) IN ARCHITECTURE

PROJECT SUPERVISOR

ARC. FELIX OMOBUDE

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CERTIFICATION

This is to certify that this dissertation titled EVALUATION ON THE LEVEL OF AWARENESS ON CIRCULAR ECONOMY STRATEGIES AMONG BUILT ENVIRONMENT STUDENTS IN THE UNIVERSITY OF BENIN, was carried out by MOMOH EHI GLORIA, with Matriculation Number ENV2103353, in the Department of Architecture, Faculty of Environmental Science, University of Benin, Edo State, Nigeria.

This work has been read, assessed, and approved as partially meeting the requirement for the award of the degree of Bachelor in Science (B.Sc) in Architecture.

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Head of Department

DEDICATION

This project is dedicated to the Almighty God, the author and finisher of our faith who has been with me since the beginning of my life on earth. Also, I dedicate this project with great love and affection to my parents, Teachers, friends, and loved ones.

ACKNOWLEDGMENT

I would like to express my deepest gratitude to God Almighty who has done wonders for me thus far, I would also like to thank my parents and my siblings for their love and support. I am also grateful to my colleagues who were always willing to share their knowledge and expertise.

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ABSTRACT

The circular economy has come forth as a dire approach for addressing challenges in the environment that is associated with the consumption of resources and generation of waste especially in the built environment. Given the importance of professionals of the built environment in achieving sustainability, it can be deemed as important to check and assess the level of awareness of circular economy strategies amongst students in the tertiary stage. This study evaluated the level of awareness of circular economy strategies amongst built environment students in the University of Benin, Nigeria.

A descriptive survey research design was used for this study. The collation and collection of data was done using structured questionnaires which were then distributed to students from these built environment disciplines; Architecture, Quantity Surveying, Estate Management, Geoinformatics, and Structural Engineering. The obtained data were analysed using descriptive tools such as percentages and the results were then presented in tables and charts.

Findings from the study showed that while a reasonable number of students possess a basic knowledge of circular economy concepts, their awareness was very limited to regular sustainability practices like reduce, reuse and recycle. There was little to no knowledge on circular economy strategies and other advanced circular economy concepts particularly those related to DfD and material passport. The study also identified variations in awareness by department with design based disciplines having more sustainability knowledge than non design based disciplines.

The study concludes that circular economy strategies are not adequately taught or present in the current curriculum of built environment students in the University of Benin. It therefore recommends the integration of circular economy in relevant courses and an increase in practical application of these strategies as these measure will help equip the students with the skills and knowledge to promote sustainable practices in the built environment through circular economy strategie

CHAPTER ONE
INTRODUCTION

1.1 BACKGROUND OF STUDY

The built environment, its design, the construction and management of all spatial domains, all of which are man-made, are shaped by many unique disciplines: the Architect, the Builder, the Engineer, the Regional planner, and others. It involves the human-made surroundings catered mainly for human activity and ranges in scale from simple things like a shed or hut to skyscrapers, small villages to entire cities. Man naturally co-exists with the natural environment and uses it to create its own, solely for its wellbeing.

This built environment acts as a heavy influence in the way people are raised i.e., the social aspect of living and development, and also in the economy (what people would call money circulation), meaning its significance is quite hefty in the development of the human race. But this wonderful "creation of man" has a downside: it is one of the largest consumers of natural resources and a major contributor to the generation of waste and the greenhouse theatricals. More than any other globally, the sector in charge of the built industry, the construction industry, is responsible for nearly 40 percent of all energy related carbon emissions and takes the most in the world's raw material share between it and all other sectors. People want more shelter, more infrastructure, more urban development, and the people on the other side of the coin, making it available for the general public, would inherently want more raw materials to fulfill or maybe keep up with the demand, and the consequences? Pressure on natural systems and major environmental challenges.

In response to these challenges, a concept evolved. The concept of circular economy (CE). This concept has gained popularity since its inception in the year 1999 as a sustainable alternative to the already existing way of living, which some would call the traditional linear economy model of "take, make, throw away (dispose)." This circular economy promotes the continuous use of available resources through strategies such as reduce, reuse, recycle, repair, refurbishment, remanufacturing, and designing for longevity. For this concept to be effective upon implementation, the professionals involved in the construction sector need to be taught and possess a strong understanding of sustainability and the circular economy. The students of the built environment, the next generation of architects, builders, estate managers, surveyors, and planners, are key to making sure this concept comes to fruition.

Despite the birth of this sustainability model, the circular economy, there is evidence that curricula in many higher institutions across the nation in the disciplines of the built environment do not cover principles and applications. In Nigeria, sustainability has been increasingly discussed in academic settings, but it seems like little is known about the actual knowledge of CE strategies anywhere. The University of Benin, for instance, presents an important case for evaluating this knowledge.

1.2 PROBLEM STATEMENT

The need for creative solutions that reduce waste, prolong product lifecycles, and encourage resource efficiency has increased due to the global trend towards sustainability. With its emphasis on reuse, recycling, regeneration, and responsible consumption, principles that are becoming more and more important in the built environment sector, one of the biggest producers of waste and consumers of raw materials worldwide, the circular economy (CE) has emerged as a crucial framework for accomplishing these goals (Geissdoerfer et al., 2017; Pomponi & Moncaster, 2017).

Despite its importance, circular economy strategies are still not widely used in building, architecture, urban planning, and related fields. This is particularly true in developing nations, where adoption of sustainability is frequently restricted by inadequate educational exposure, low awareness, and weak policy frameworks (Adenle et al., 2022; Oke et al., 2023). The next generation of professionals, architects, builders, planners, quantity surveyors, and engineers, who will be in charge of creating and executing sustainable systems are represented by built environment students. As such, their awareness of and comprehension of CE strategies is essential for propelling future sustainability transitions (Andrews et al., 2021; Nobre & Tavares, 2021).

Recent research indicates that university students' awareness of circular-economy (CE) ideas varies significantly between subjects and nations, despite the fact that patterns often indicate gaps between conceptual knowledge and practical involvement. While 85.5% of students showed high knowledge of CE principles, only 55.5% indicated positive attitudes and 68.2% revealed CE-aligned actions, according to Dewi, Lestari, and Hidayat (2022). This suggests that awareness does not always convert into practical readiness. According to a study conducted in five European universities, 36% of students had a "clear" comprehension and 37% had a "very clear" understanding following their exposure to CE-focused modules (Andrews et al., 2021). Additionally, 37.5% of participants in a large-scale CE literacy survey largely linked CE to the "4Rs," indicating basic awareness but little deeper systemic comprehension (Nobre & Tavares, 2021).

Comparable studies with professionals in the built environment and design reveal similar patterns: According to Lofthouse and Prendeville (2018), 63% of practitioners had used CE in their work, indicating a changing industry landscape and the necessity for students entering the area to be CE-proficient. Despite growing policy attention to waste minimisation and resource efficiency, construction and planning students frequently receive limited CE education due to weak curricular integration, as regional studies in Ghana and Nigeria further highlight disparities in CE exposure (Oke et al., 2023; AlJaber, 2024).

Despite growing literature on CE awareness in higher education, there is a notable absence of empirical evidence about the level of awareness on CE strategies among built-environment students at the University of Benin. Existing studies tend to be national or regionally focused, compare broad student populations, or examine practitioners. They therefore do not capture local curriculum content, institutional teaching practices, or socio-cultural factors that shape awareness at UNIBEN. As a result, it is unclear whether built-environment students at the University of Benin possess only superficial familiarity with CE (e.g., knowing the "4Rs") or have deeper level understanding.

Therefore, this study aims to close this gap in knowledge by analysing the level of awareness of circular economy strategies among University of Benin built-environment students, evaluating differences in knowledge among the various built-environment departments, and identifying instructional and institutional strategies that can improve the integration of circular-economy principles into built-environment education. By doing this, the project hopes to produce data that will guide the creation of curricula, improve training focused on sustainability, and better equip upcoming professionals for the shift to circular practices in the built environment.

1.3 AIM OF THE STUDY

The aim of this study is to evaluate the level of awareness of circular economy strategies amongst the built environment students in the University of Benin.

1.4 OBJECTIVES OF THE STUDY

The main objective of this study is to evaluate the levels of awareness on circular economy strategies among built environment students in the University of Benin. **The specific objectives of this study are:**

1. To compare the level of awareness of Circular economy strategies between different departments within the built environment students in University of Benin.
2. To examine how well built-environment students understand the applications of circular economy strategies in University of Benin.
3. To evaluate the extent to which CE concepts are integrated into the built-environment curriculum in the University of Benin
4. To recommend strategies for improving circular economy education in the University of Benin.

1.5 RESEARCH QUESTIONS

1. How does the level of awareness of circular-economy strategies differ across the various departments within the built-environment disciplines in the University of Benin?

2. To what extent do built-environment students in the University of Benin understand the applications of circular-economy strategies?

3. To what extent are circular-economy concepts integrated into the built-environment curriculum in the University of Benin?

4. What strategies can be adopted to improve circular-economy education among built-environment students in the University of Benin?

1.6 SIGNIFICANCE OF THE STUDY

This study is significant as it seeks to reveal the level of CE strategies that are known and inculcated into built environment students of different departments in the University of Benin. This study will offer valuable insights that can inform university policies, enhance students' theoretical and practical knowledge in their respective fields. This study will also benefit students by highlighting areas where their knowledge can be strengthened through specific learning that targets their shortcomings. Additionally, the results of this study will serve as a valuable resource for educators and counsellors, guiding them in the design of programmes and workshops that will help with the learning of CE strategies.

1.7 SCOPE OF THE STUDY

This study focuses on the undergraduate students in the built environment-related departments in the University of Benin, which include Architecture, Quantity surveying, Estate Management, Geoinformatics, Structural Engineering, and Civil Engineering.

1.8 LIMITATIONS OF THE STUDY

This study will be limited to self-reported data collected through questionnaires that may be influenced by the honesty and accuracy of the respondents. Academic calendar schedules may also limit the sample size of data collected. The study is also limited to only the University of Benin.

1.9 DELIMITATIONS OF THE STUDY

This study is delimited just to built environment students within the University of Benin, covering most of the departments in the Faculty of Environmental Sciences and Engineering.

1.10 DEFINITION OF TERMS

The definitions below are adapted from the Oxford English Dictionary.

- Built environment- The human made surroundings in which people live and work, including buildings, infrastructure, and other physical developments.
- Circular economy- An economic system aimed at eliminating waste and continual use of resources through reuse, repair, refurbishment, and recycling.
- Linear economy- An economic system based on the extraction of resources, production and consumption of goods, and the disposal of waste after use.
- Circular economy strategies- methods or approaches adopted to support a circular economy, particularly those that reduce waste and extend the life of materials and products.
- R-models- A set of strategies used within the circular economy framework.
- Closed loop system- a system which outputs, especially waste materials, are reused as inputs, minimising loss of resources.
- Design for disassembly- A design approach in which products or buildings are created so that they can be easily taken apart at the end of their use.
- Material efficiency- The effective use of materials to achieve maximum productivity while minimising waste.

1.11 LIST OF FIGURES

CHAPTER TWO

LITERATURE REVIEW

2.1 DEFINITIONS OF CIRCULAR ECONOMY

One of the most persistent issues in CE literature is the lack of a universally agreed definition. Ekins et al. (2019) explicitly state that "there is no single agreed definition of the circular economy" (p. 10). Definitions vary depending on whether the emphasis is environmental conservation, economic growth, or social well-being. At the micro level, CE may be defined in terms of product design and business models, while at the macro level it may encompass entire national or regional strategies.

Korhonen et al. (2018) go further, describing CE as "a vague and contested concept" (p. 39). They argue that its popularity derives from its ability to unify diverse approaches under a single label, but that this same vagueness constitutes a weakness, as it hinders scientific precision and practical application. The danger, according to Korhonen et al., is that CE becomes a rhetorical device, adopted enthusiastically but inconsistently understood or measured. The definitional ambiguity has direct implications for education. When CE is introduced to students, the absence of a clear framework risks reducing it to simplistic notions, such as recycling. This narrows students' understanding and prevents them from engaging with higher-order strategies such as design for disassembly, remanufacturing, or systemic resource planning.

The term circular economy (CE) can be defined as a system of the economy that protects how valuable products are, the materials and resources that make these products, keeping them for as long as possible while minimizing waste generated, and the regeneration of ecosystems. According to Geisendorf and Pietrulla (2017), the circular economy is an umbrella concept characterized by closed-loop material cycles, reuse, and systemic efficiency. The Ellen MacArthur Foundation (2013) also describes the circular economy as a system of the industry that restores and regenerates by how it is designed and is built upon the principles of eliminating waste, keeping materials in circulation, and bringing back natural systems.

2.1.1 Linear Economy versus Circular Economy

In order to understand CE, it helps to compare it with the "**linear economy**", which has been prevalent in industrial production since the times of the Industrial Revolution. The conventional linear economy follows a "take–make–dispose" concept, where the raw materials are extracted and then metamorphosed into products, consumed, and then thrown away as waste. This paradigm has aided in economic growth and development at large, but has also contributed significantly to degrading the environment, including rapidly diminishing the available resources, polluting the environment, and increasing greenhouse gas emissions.

The circular economy challenges the linear economy by promoting restorative processes. Rather than products leaving the system as waste, they are recovered back into use. In practice, this would entail designing products to last longer, to be repaired and reused, while making sure discarded products are recycled into new ones or used as inputs in other applications. According to Geisendorf and Pietrulla (2017), the circular economy represents a set of strategies and a shift in paradigm that repurposes the connection between producing, consuming, and the environment.

2.1.2 Historical Development of the Circular Economy

The roots of the concept of circular economy can be linked back to several ideas of the 20th century. Kenneth Boulding (1966) wrote in his essay on The Economics of the Coming Spaceship Earth, that the Earth should be seen as a "closed world" (self-contained system) with limited resources that would need economic concepts that would be cyclical rather than linear extraction. Frosch and Gallopoulos (1989) brought about the concept of industrial ecosystems, which pushed that man-made industrial systems should mimic the ecosystems of nature by having resources exchange and reducing waste. In the 1990s, the "cradle-to-cradle" thought, which was developed by Braungart and McDonough, went even further to create products with their entire lifespan in mind, and making sure materials could be reused or biodegraded at the end of life. Around the same time, Japan also brought about their policies on recycling and resource circulation, while China formalized CE through its Circular Economy Promotion Law in 2009.

The term "circular economy" gained a lot of attention in the 2010s, mostly through the work of the Ellen MacArthur Foundation, which made the concept of CE popular globally and developed structures such as the ReSOLVE model (Regenerate, Share, Optimize, Loop, Virtualize, Exchange). The European Union also played a vital role with its Circular Economy Action Plan of 2015, which was later updated in 2020, setting targets for recycling, waste reduction, and the design of sustainable products. Thus, the development of CE chronologically portrays a subtle but gradual transition from abstract thoughts and philosophies to practical policy and business structures. As Geisendorf and Pietrulla (2017) observed, the circular economy has evolved into a concept that is widely recognizable with different interpretations but a similar focus on the efficiency of resources and system regeneration.

2.2 The R-Models of the Circular Economy

One of the most widely used approaches in the circular economy is the adoption of "R-strategies" or "R-models." These models categorize the strategies for extending product lifecycles, reducing the amount of resources we extract, and also reducing waste. While earlier R models focused on the "3Rs" of Reduce, Reuse, and Recycle, the modern frameworks have expanded this to up to 9Rs or even more, depending on the scope of the CE concept. The R-models are often classified in a hierarchy, with preventive measures such as refusing and reducing ranked above recycling and recovery, which some would call end-of-line measures (Geisendorf & Pietrulla, 2017).

- **Refuse (R0)**

Refuse is the r-model that is seen as the most absolute strategy, as it involves avoiding unnecessary consumption altogether. In the environment, this could mean asking questions as to whether new buildings are needed, or whether reusing structures that already exist could meet the demand instead. For example, instead of constructing new office spaces, organizations might adopt arrangements that are flexible enough to accommodate the working needs of their employees, thereby reducing the need for space. Refusal helps challenge the culture of overconsumption and the following mini-trends, and requires persuasive shifts in consumer behavior and business models.

- **Reduce (R1)**

Reduce is the R-model that aims to minimize the amount of resources and energy used in production and consumption. In construction, this could involve designing buildings that use fewer materials while making sure the building is structurally stable, or adopting construction techniques that reduce waste during the construction process. Reducing can also be applied at the stages of operation by improving how energy is used up, thereby lowering overall use of resources. Witjes et al. (2017) emphasize that the R-model reduce, aligns strongly with the inclusion of sustainable methods in the corporate world because they lead to both environmental and cost savings.

- **Reuse (R2)**

Reusing is another R-model that stretches a product's lifespan i.e., how long we use products by using them again for the same purpose. Reuse might include the gathering of already used construction materials, such as bricks, steel, or timber, to be used again in new projects. Furniture and fixtures can also be reused within or across buildings. This R-model or strategy can be deemed as important in third-world countries like Nigeria, where the costs of acquiring materials are high and informal markets, which would be called black markets in Nigeria, already sell used goods.

- **Repair (R3)**

The R-model of repair involves the transformation and fixing of products that are broken or damaged. The R-model of repair includes changing spoiled and defective parts of building components, such as roofs, windows, rather than replacing them prematurely. Repair cultures are often more visible in regions where new products are expensive or less accessible. However, modern consumer culture and rapid technological change sometimes discourage repair by making it cheaper or easier to replace items, a challenge that CE seeks to address.

- **Refurbish (R4)**

Changing products that are mostly spoiled, back to their former state, and even upgrading them is the r-model of refurbish. In the world of construction, refurbishment may include redesigning and rebuilding the interior of the building, changing from manual to modern technology, etc. Refurbishment elongates and enhances the capacity and durability of a building, thereby minimizing the need to build newer structures and abandoning older ones.

- **Remanufacture (R5)**

Remanufacturing refers to reconstructing products back to how they were when they were first made using reused and new products. In construction, remanufacturing might involve the use of reclaimed structural steel that is reprocessed and certified for reuse in new projects. Remanufacturing ensures quality standards comparable to new products while drastically reducing the need for virgin resources. It is commonly applied in industrial machinery, automotive components, and increasingly in modular construction.

- **Repurpose (R6)**

Repurposing involves using products or materials for applications other than their original intended use. In architecture, this can imply the reuse of shipping containers as a new form of housing or converting old dilapidated warehouses into residential or commercial buildings. Repurposing shows the creativity and innovation of man, and the ability to use materials to create structures that remain productive and functional beyond their original lifecycle.

- **Recycle (R7)**

Recycling is one of the most familiar circular strategies, which involves the process of changing waste materials into new products. While this model is practiced globally, recycling is often seen as less preferable in the R-hierarchy because it typically involves downcycling, in which the materials lose quality and value after they are processed. For example, concrete rubble can be crushed and used as aggregate in road construction, but the value of the material has now been lowered compared to its original use. Geisendorf and Pietrulla (2017) stress that recycling should not be the primary focus of CE but rather an option to fall back on when other higher-order strategies, such as reuse, repair, and remanufacturing, are not feasible.

- **Recover (R8)**

Recovery is the final strategy in the hierarchy, involving the extraction of energy or raw materials from waste that cannot otherwise be reused or recycled. This includes waste-to-energy processes such as incineration with energy recovery, or biogas production from organic waste. While recovery ensures that some value is extracted from waste, it does not prevent resource depletion and may still generate emissions, making it the least desirable option within the circular framework.

2.2.1 Hierarchical Nature of R-Models

The R-models are not only a set of strategies but also a framework of how the circular economy is prioritized. Preventive strategies, such as refusing and reducing, are considered more sustainable because they avoid resource use altogether, while strategies that restore, like recycling and recovery, are not seen as efficient because they occur after waste has already been generated. The R-hierarchy emphasizes that focus should be shifted to mainly design and consumption processes rather than relying on end-of-life solutions.

2.2.2 Application of the R-Models in the Built Environment

In the built environment, there are many opportunities where the R-models are used in day-to-day construction:

- **Refuse**: Totally rejecting the idea of building new structures and questioning why the urban space would need to be expanded or rebuilt.
- **Reduce**: Using already-made materials to reduce the waste generated.
- **Reuse**: Collecting or gathering of materials like bricks, timber, and steel from demolition sites.
- **Repair**: Maintaining housing stock to extend lifespans.
- **Refurbish**: Upgrading schools, offices, or housing for optimum efficiency of energy.
- **Remanufacture**: Processing reclaimed steel or timber for new construction.
- **Repurpose**: Turning abandoned factories into new forms of housing.
- **Recycle**: Processing waste from demolishing buildings into secondary aggregates.
- **Recover**: Using construction wood waste for bioenergy.

2.2.3 Critiques of the R-Models

While the R-models provide a clear framework, scholars note a lot of limitations. Firstly, the boundaries between strategies are not always clear, as refurbishing may be mixed up with repair or remanufacturing. Secondly, the hierarchy assumes that higher-order strategies are always preferable; however, in practice, how feasible it is depends on where and how it is used. For example, in Nigeria, repair and reuse may be more realistic than large-scale recycling due to the lack of infrastructure. Geisendorf and Pietrulla (2017) also highlight that focusing narrowly on Rs poses a problem for business models and consumption patterns. Nevertheless, the R-models remain a valuable and practical tool for translating CE principles into strategies that can be acted upon. For education, they serve as a way to introduce students to CE thinking and encourage and encourage the students to critically evaluate the flow of resources in the built environment.

2.2.4 Academic Positioning of the Circular Economy

Geisendorf and Pietrulla (2017) argue that CE differs in the way it is interpreted depending on academic disciplines, with economists, engineers, and environmental scientists emphasizing different aspects. They classify CE in two key ways:

- **Focus**: Narrow efficiency-focused approaches (e.g., waste minimization, resource loops) versus broader systemic approaches (e.g., redefining production and consumption patterns).
- **Scope**: Micro-level (products, firms), meso-level (eco-industrial parks, cities), and macro-level (national and global economies).

This type highlights how flexible CE is, but also highlights the concept's ambiguity. For example, at the micro level, CE may refer to a company adopting recycling or eco-design strategies. At the meso level, it may describe mutual exchange between industries, where clusters of firms exchange resources. At the macro level, it can mean a nation redesigning its economy around closed-loop systems.

Scholars such as Witjes, Vermeulen, and Cramer (2017) caution that while CE provides practical strategies for closing loops i.e., a circular closed system, it should not, however, be removed from the sustainability agenda. They emphasize that CE needs to be included in our day-to-day structures, such as organizations, cultures, to achieve meaningful outcomes.

2.2.5 Regularization and Policy Positioning

Globally, CE has been regularized in different ways. In the European Union, CE is structured as both an environmental and economic strategy, meaning it is seen as a way to curb environmental losses and also boost economic competitiveness. In China, CE has been adopted as a means of addressing pollution and the lack of resources, but also as a way to drive the modern industry. In contrast, in many developing economies, including Nigeria, CE has not yet been regularized in policy, though waste management and recycling initiatives are in line with CE principles. This disparity shows how CE is positioned differently across contexts. In some regions, CE is an innovation strategy; in others, it is a waste management tool. For higher education and research, this diversity presents both opportunities and challenges, as students must learn to navigate competing interpretations of CE.

2.2.6 Critiques of Academic Positioning

Despite its popularity, CE has faced criticism for the vagueness of the concept. Geisendorf and Pietrulla (2017) argue that having multiple ways to define it could result in diluting CE into a catch-all term without any clear boundaries. Kirchherr et al. (2017), in a major review, found over 100 definitions of CE, highlighting how different they were in emphasizing environmental, economic, or social categories. Some scholars also criticize CE for being overly focused on technological solutions such as recycling, not including the cultural and behavioral patterns that help come about the changes that are needed.

Another criticism is that CE is often framed as apolitical i.e, it overlooks the issues of power, justice, and inequality. For example, recycling industries in developing countries usually rely on informal labor under unsafe conditions, thus raising questions about how socially sustainable CE practices are. From this perspective, academic positioning of CE must go beyond technical strategies to include governance, ethics, and equity.

2.3 CIRCULAR ECONOMY STRATEGIES

2.3.1 Design for Disassembly (DfD)

Design for Disassembly can be seen as one of the main ideas behind the creation of what one would call the "built-scape" that is revolutionized to be made sustainable because it makes architects and designers to sit and make reason on all the possible instances and happenings of a building long before it is even built. The goal is quite simple: let us create buildings that can be easily taken apart, repaired and worked on to be reused instead of broken down and thrown away. This idea always pops up in sustainable design literature because the construction industry produces a large amount of waste in which its entirety comes from demolished buildings with no hope for their reuse.

2.3.1.1 Concept

Design for Disassembly encourages architects and designers to desist from viewing and treating buildings like permanent objects and start seeing in terms of temporarity. Jonathan Chapman explained this mindset when he noted that sustainable design often requires "treating products as evolving systems rather than fixed end points" (Chapman, 2005). In building terms, the "product" is the building itself so when it is being thought of as a system that will change, upgrade and remove, we will automatically start seeing the light which leads us to make choices that make disassembly easier.

The United States Environmental Protection Agency highly encourages this method. They describe DfD as the process of "selecting materials and assembly methods that allow components to be separated without losing their value" (EPA, 2016). Preserving value can be seen as the spine of Design for Disassembly.

2.3.1.2 Why It Matters in the Built Environment

Buildings devour materials, energy, money and then give up waste at every stage of their lifecycle. At the very, demolition turns them into piles of rubble that could therefore usually end up in wastelands. The concept of DfD contests this way of construction. According to Kibert, who one could say is a leading sustainable construction scholar, the construction industry needs to "shift from waste-heavy linear processes to regenerative practices" (Kibert, 2016). DfD is one of the ways in practicality that this momentum would come about.

Making the knowledge of DfD available to students in the built environment disciplines, it would be more likely that they designed structures that hinders the production of excess waste. Reduce encourages reuse and follows the ways of the circular economy. This awareness hence becomes very viable, especially in places where construction waste is handled poorly.

2.3.1.3 Principles of Design for Disassembly

a. Use of Mechanical Fasteners Instead of Adhesives

Most of the entirety of buildings are not reusable but they can be. One of the easiest ways would be avoiding the usage of strong adhesives that make parts and components very hard to separate like glues and welding. Brands like the Building Materials Reuse Association usually make emphasis on using mechanical connections because they allow components to be easily removed with no damage.

An idea paraphrased from Guy and Shell (2007) notes that buildings created and thoughtfully designed for it to be disassembled "depend on reversible joints so that materials retain integrity during removal." This means screws, bolts, clips and brackets are much more sustainable than glues.

b. Standardized and Modular Components

Components that are made in modules can be handled in different ways such that it gives the opportunity for it to be rearranged, replaced or removed in a way that would not affect the rest of the structure. This also helps with upgrades in the future. William McDonough and Michael

Braungart, forerunners of circular design focused thinking, explained that creating designs in modules tend to increase "the potential for endless cycles of use" (paraphrased from *Cradle to Cradle*, 2002).

c. Layering and Access

In DfD, one could compare the design of buildings to onions i.e. it involves different layers that are quite accessible without disturbing other parts. For example, electrical systems, plumbing and finishes should be accessible in a way that when repairs or upgrades are made, they don't require breaking walls or floors.

Stewart Brand, in *How Buildings Learn* (1994), argued that buildings perform better when their layers "age and adapt independently." This idea highly correlates to designing for disassembly.

d. Material Identification and Documentation

If in the future, builders cannot identify materials, it would be hard for them to reuse said materials. DfD emphasizes on creating something like a materials passport which is clear labeling and documentation of every choice of material used. Some DfD books even read that "a building without documentation is a building headed for demolition."

2.3.1.4 Environmental and Economic Benefits

The environmental benefit here would be the reduction of waste. The Construction Leadership Council (2018) reported that buildings created and designed with the ways of DfD "can reduce demolition waste by up to 70 percent" when properly executed. This way materials can continue their circulation in the economy rather than being discarded.

In the economy, DfD can taper down the cost of construction in the long term. Materials that can be taken out without being destroyed can be sold off or used again. According to a European Commission sustainability report (2019), reusable building components have "a residual value that lowers lifecycle costs."

2.3.1.5 Relevance to Students in the Nigerian Built Environment Context

In Nigeria, the waste gotten from construction continues to grow in a very exponential way. A large sum of buildings are demolished without formal practices relating to deconstruction. In a situation where the students at the University of Benin understand DfD deeply, they most certainly would be able to contribute to changing this pattern.

Local scholars such as Akadiri (2012) have highlighted that sustainability in construction in developing countries depends on “early awareness of environmental design strategies among young professionals.” This directly supports the importance of this thesis topic.

2.3.2 Expanded Design for Adaptability

Design for adaptability is coming up as one of the main concepts that shapes construction into something sustainable because it enables changing buildings without being destroyed. Instead of restricting the use of a structure into one fixed use, adaptability comes into play by making sure architects and designers leave open the options for future changes. Gorgolewski (2017) explained that buildings that are considered adaptable “remain valuable for longer periods because they support several generations of use.” Hence this moves the conversation from achieving needs that are short termed to long term performance in construction. In simple terms, one could say it is like designing a building that is an all-rounder, it can grow, shrink, switch functions or rearrange itself into something new without wasting materials.

2.3.2.1 Why Adaptability Matters in Modern Construction

Cities in modern times grow quite rapidly and the needs of the people/users change quickly, so buildings that are unable to adapt end up abandoned or are in constant renovation. The Ellen MacArthur Foundation (2016) highlighted that most buildings struggle to stay useful due to the fact that these buildings were designed without a thought for change. This leads to unnecessary construction waste, additional costs, and lengthy periods of disruption in the construction process. By planning for adaptability at the beginning, architects/designers alleviate these problems and aid the development of cities for the better.

2.3.2.2 Understanding Functional Change Over Time

Something important in the concept of adaptability is fully accepting that a building's purpose might change in ways that one cannot fully predict. A space built as a library might in the future turn into a digital learning hub. Durmisevic (2018) explained that designing in flexibility "gives buildings a higher chance of survival when external conditions shift." This means the chances of a building becoming obsolete or being demolished is less likely.

2.3.2.3 Structural Flexibility

Structural flexibility can be described as designing the building's main framework so that it would be able to support different layouts. Architects/Designers hence use wider spans that do not need a lot of interior columns, which makes the spaces easier to organize and redesign. They also plan that structural grids end up matching different room sizes, making it easier to separate or combine rooms later. Gorgolewski (2017) pointed out that simple and well spaced structural systems allow new interior arrangements without expensive changes in the structural system thus reducing the environmental and financial cost of upgrades in the nearest future

2.3.2.4 Spatial Flexibility

Spatial flexibility narrows its focus on the internal environment. Open plans make it easy to replace and redesign existing layouts in the future. Movable partitions allow for the expansion of rooms and also its reduction whenever it is needed. Spaces for circulation are kept very simple and direct so they do not obstruct how the building would later be used. The Ellen MacArthur Foundation (2016) described flexible interiors as "spaces that can shift functions without heavy modifications." This would therefore be beneficial to schools, offices, clinics and community buildings which regularly see the use of new spaces as the user needs change.

2.3.2.5 Adaptable Service Systems

Building services such as electrical wiring, plumbing, and ventilation need to be made accessible for upgrades if one thinks of creating an adaptable structure. In adaptable buildings, these systems are placed in spaces or routes that can easily be accessed by their respective technicians like raised floors, suspended ceilings, or service walls. Durmisevic (2018) explained that when service systems are open and reachable, "maintenance becomes more efficient, and components can be replaced without damaging structure." This then saves a lot of resources over the lifecycle of the said adaptable building. Scenarios where whole walls need to be broken just to replace a small pipe could be generally avoided.

2.3.2.6 Material Choices That Support Adaptability

There are some materials that can handle changes better than others in repetition. Lightweight partitions, modular flooring, adjustable ceilings, and removable wall panels allow architects and designers to create brand new interiors easier. Gorgolewski (2017) said in his publishing that materials with reversible fixings support more transitions in a smoother fashion because they can be removed and reinstalled without damage. The use of these types of materials hence reduces the amount of waste that is usually created when buildings are renovated.

2.3.2.7 Economic Advantages of Adaptability

Buildings that are built with adaptability in mind tend to reduce long term costs because they do not require major reconstruction when building needs change. The Ellen MacArthur Foundation (2016) explained that extending the life of buildings through adaptability “reduces the economic burden of demolition and new construction.” Instead of outright spending when it comes to the tearing down of structures, owners can simply elevate what they already have. This also helps businesses keep their momentum during renovations so that they do not lose money since adaptable buildings support shorter downtime.

2.3.2.8 Environmental Impact and Resource Conservation

Buildings in which one can switch up its interiors, exteriors or the building's components are easily changed instead of being demolished to help reduce pollution from construction waste. Fewer raw materials need to be produced, which lowers environmental damage derived from the mining process and manufacturing. Durmisevic (2018) noted that adaptable design contributes to circular construction because it keeps buildings in use longer promoting a merry-go-round of materials thus reduces the pressure on landfills and protects the nature's ecosystems from unnecessary extraction of new materials.

2.3.2.9 Challenges to Implementing Adaptability

Even though adaptability is useful, there are quite some challenges involved. Some of these clients do not want to spend extra money on flexibility during the initial construction stage. Durmisevic (2018) explained that people often struggle to plan needs in the future because of the unpredictability. There is also a lack of training, since many builders focus on what they already know, which are the traditional construction methods. However, these challenges can be overcome through better education on these matters and more awareness of the long term benefits of the idea called adaptability.

2.3.3 Design for Recycling

Design for recycling narrows its focus on making sure that materials in construction can be recovered, processed, and used again after a building reaches the end of its lifecycle. In most cases, materials used end up becoming waste but by designing to recycle these materials are then kept in circulation by planning for their future recovery. The Ellen MacArthur Foundation (2016) highlighted that recycling supports a circular construction system by bringing back materials for them to be used again thus reducing the pressure on the extraction of raw resources and keeps to minimum the environmental impact of the activities in construction.

2.3.3.1 Core Principles

The main principle when it comes to design for recycling is selection materials that can be recycled without losing its quality. Metals such as steel and aluminium are quite good examples due to the fact that they can be repeatedly recycled. Architects/Designers also deviate from unnecessary mixing of materials. Gorgolewski (2017) noted that recycling becomes more effective when the selected materials are used in a way that is kept simple and in recognisable forms. This aids in the identification of the materials by future workers and separation of components during demolition.

2.3.3.2 Avoiding Difficult Material Combinations

Some methods involved in the creation of construction materials make recycling difficult by bringing together and bonding materials in ways that cannot be undone. Strong adhesives, embedded fixtures, and mixes of composites often reduce the success of recycling. Durmisevic (2018) said that connections that enable reverse and simple material pairings improve recyclability and reduce waste obtained from demolition. Architects/Designers can choose fasteners that work mechanically or separable layers rather than permanent bonding to make recycling easier.

2.3.3.3 Recycling Processes and Technologies

The ability to recycle efficiently depends on the technologies that are available for processing. For example, concrete can be crushed down into aggregate for new construction, while materials that have metals in them or metals themselves can be melted and reshaped. Glass can be processed again and plastics can be shredded and remoulded. Architects/Designers who are able understand these processes can make informed decisions about materials and assemblies.

2.3.3.4 Environmental and Economic Benefits

Recycling reduces waste that ends up in landfills and lowers the environmental burden of extracting new materials. It also uses less energy than manufacturing from raw resources which one could say reduces carbon footprint. The Ellen MacArthur Foundation (2016) highlighted that material recovery helps stabilise the usage and circulation of resources and really lowers the dependence on primary production.

2.3.3.5 Application in Nigeria

In Nigeria, construction waste has no definite arrangement, it is often mixed and dumped without sorting, hence limits the ability for it to be recycled. The Design for recycling concept can improve this by encouraging clearer organisation of materials right from the onset i.e. the planning stage. Markets, schools, and residential projects could gain from recyclable materials that are simple to recover. Using steel frames, removable façade panels, and separable interior finishes will bring about a more circular building culture.

2.3.3.6 Challenges and Limitations

Recycling facilities are low in number in many areas, and there is low awareness of material recovery systems. Durmisevic (2018) observed that limited infrastructure gravely affects the success of recycling as a whole. Lack of technical training for separating and processing materials during demolition is also a major challenge. Despite these issues, the concept of design for recycling remains monumental to sustainable construction efforts.

2.3.4 Adoption of Off-Site Construction Techniques

Off-site construction techniques involve the production of major building components in a controlled factory environment before bringing them to the site for assembly. This approach is becoming important in discussions concerning the circular economy because it supports cleaner production, reduces waste and makes the building process easier to manage by saving time on site.

2.3.4.1 Concept

The main idea behind off-site construction is to pivot a majority of the work away from the unpredictable circumstances that could happen on site which allows factories to use precise measurements, and advanced cutting systems. Errors that normally cause waste during on-site work are now reduced because materials are already shaped and fitted under more precise conditions. By working in controlled spaces, builders can track the use of materials better referencing material passports as we mentioned earlier. Off-cuts that would normally be disposed of can be collected and returned into the production cycle.

2.3.4.2 Material Efficiency and Waste Reduction

Components like wall panels, floor finishes and roof members are designed with exact dimensions which makes it easier to calculate how much material is needed and prevents unnecessary cutting. According to the Ellen MacArthur Foundation (2019), the circular economy brings about designing out waste from the beginning, and off-site production helps to meet this goal. Scraps made out of timber and steel can be separated immediately instead of being mixed with dirt and debris like on regular construction sites. Stahel (2016) highlights that a good waste prevention system makes it possible for materials to be reused, and working off-site aids by reducing the mixing of materials.

2.3 4.3 Faster Assembly and Reduced Site Disturbance

Off-site construction brings about sustainability by limiting the work done on the construction site. The site becomes a place mainly for assembly rather than full blown construction activities thus reducing the noise, dust and disturbance accumulated to neighboring communities. It also reduces the time spent on site which means less energy and less labour is used by machines and temporary facilities. The Ellen MacArthur Foundation (2019) says that efficiency is a key part of keeping materials in circulation and reducing the impact on the environment during the construction process, which is why faster assembly aligns with the goals of the circular economy.

Weathering and moving activities on the site tends to increase the risks of material damage. Rain, wind and poor handling normally cause a lot of construction waste, but factory-made components usually arrive protected. Stahel (2016) highlights that careful handling and storage of materials help extend their lifecycle, and off-site construction provides these necessary protection.

2.3.4.4 Support for Future Disassembly and Reuse

Assembly with bolts, connectors and simple fitting systems being used instead of permanent methods is what makes off-site construction using prefabricated components simple and interesting. This in turn supports circular thinking because it makes buildings more adaptable. Geissdoerfer et al. (2017) highlighted that adaptability and reuse are important strategies for slowing resource loops. Off-site construction aids with this because prefabricated components can be successfully taken apart again with minimal damage becoming useful in future renovations or upgrades. Instead of breaking down entire sections of a building, individual modules can be replaced or repaired thus reducing demolition waste and allowing materials to stay in use for a longer period of time.

2.3.5 Reverse Logistics

Reverse logistics refers to the organisation of the movement of materials, components and products from the point of use back to manufacturers, recyclers or other centres of recovery. It acts as an important strategy in the circular economy because it helps keep materials in continuous use. The core idea of logistics is moving things forward from factory to customer. Reverse logistics is quite the opposite as it involves moving things backward, from the customer back to the company. The main aim of this is to get value back from the returned products or dispose of them properly.

Reverse logistics processes:

- **Returns Management:** this involves the handling of items that customers send back because they are damaged, wrong size, or unwanted.
- **Remanufacturing/Refurbishment:** this involves the fixing of used products to make them "brand new" for resale. This in turn saves a lot of material and money.
- **Recycling:** this involves the breaking down of products into raw materials (plastic, metal) to be used again in new manufacturing.
- **End-of-Life Disposal:** this involves safely getting rid of products that cannot be recovered, following all precedent environmental rules.

RL is different from something called "green logistics," which is more generally about making the whole supply chain more eco-friendly, that is, using less fuel in trucks. RL is specifically about the flow of physical goods going backward as it is in its name “reverse” logistics.

2.3.5.1 Why Reverse Logistics Matters: Drivers and Benefits

There are many factors that encourage companies to pay attention to RL. Listed below are the main drivers:

- **Money (Economic Benefits):** Reusing materials and products saves money on buying new raw materials. Selling refurbished items creates new revenue streams. This is a big motivation.
- **Rules and Laws (Legislative Pressures):** Governments are making stricter laws about waste and product responsibility. Companies must take back electronics or batteries; it is the law.
- **Customer and Society Demands (CSR):** People care more about the environment now. They like companies that are sustainable and have easy return policies. Good RL improves a company's image and customer loyalty.

When RL is done well, it gives companies an advantage over competitors. It is not just a cost center; it can be a profit center.

2.3.5.2 Common Problems (Barriers) in Managing Reverse Logistics

While the benefits are clear, the management in RL is quite difficult. Supply chains are primarily designed for forward movement; the reverse journey makes it more complex and messy.

- **Uncertainty:** Companies have no idea *when* items will return, *how many* items will return, or *what condition* they will return in thus making planning very difficult.
- **Information Systems:** Many businesses use software that has been designed only for shipping *out*. They then lack the right systems to configure the tracking of items coming *back in*, making inventory control a major issue.
- **Complexity:** Complications of networks are unavoidable. Returned items might need centers for sorting, facilities for repair, or recycling plants. This is a very different network from standard warehouses and distribution centers.

2.3.5.3 Benefits of Reverse Logistics for the Built Environment

The concept of reverse logistics encourages a more sustainable construction sector in several ways by reducing waste, lowering material costs, and decreasing the impact on the environment by limiting the demand for new raw materials. It also promotes cleaner work environments because there's a reduction in the waste of materials on site. Geissdoerfer et al. (2017) state that circular strategies improve the economic and environmental outcomes when systems in the construction industry support the return and reuse of materials. Reverse logistics does all these by organising the path materials follow after use.

2.4 RELATIONSHIP BETWEEN R-MODELS AND CIRCULAR ECONOMY STRATEGIES

The literature on the circular economy presents two related but distinct concepts: the R-models and circular economy strategies. Although they are sometimes used interchangeably, it is important to differentiate them in order to provide more clarity on the concept.

- **The R-Models: Principles of Circularity**

The R-models refer to a hierarchy/ order of actions designed to keep resources in circulation and minimize waste. Initially focused on the “3Rs” of Reduce, Reuse, and Recycle, the model has expanded to include up to nine Rs, such as Refuse, Repair, Refurbish, Remanufacture, Repurpose, and Recover (Geisendorf & Pietrulla, 2017). Each R represents a principle that can be applied at different stages of a product or material's lifecycle. For example, Refuse encourages avoiding any form of unnecessary consumption, while Repair ensures that existing products remain functional for as long as they can. The R-models therefore represent the philosophies around CE, highlighting the kinds of actions that align with this circular model.

- **Circular Economy Strategies: Pathways for Implementation**

Circular economy strategies are the practical approaches through which R-models are realized in real life. The strategies include eco-design, design for disassembly, product-service systems, industrial symbiosis, circular procurement, and extended producer responsibility (Ellen MacArthur Foundation, 2013; Witjes, Vermeulen, & Cramer, 2017). These strategies provide the structure for including circular principles into production, consumption, and governance. For example, "design for disassembly" is a strategy that directly applies the principles of reuse, refurbish, and remanufacture by ensuring that building components can be dismantled and recovered at the end of their lifecycle.

2.4.1 R-Models as the "What" and CE Strategies as the "How"

A useful way to differentiate the two is to view the R-models as the "what" and CE strategies as the "how." The R-models define the types of circular actions that should be prioritized, whereas CE strategies describe the practical measures on how to achieve them. For example:

- ***The R-model Reuse*** identifies with keeping products in circulation. A corresponding CE strategy is the creation of material exchange platforms where construction materials that are reclaimed end up being sold.
- ***The R-model Refurbish*** emphasizes restoring damaged or broken products back to usable condition. A CE strategy that applies this principle is the redesigning of existing buildings to improve energy performance rather than demolishing and rebuilding.
- ***The R-model Recycle*** sets the principle of reprocessing waste materials into new inputs. CE strategies operationalize this through advanced recycling technologies and closed-loop supply chains.

2.5 **CIRCULAR MATERIALS IN THE CIRCULAR ECONOMY**

The concept of circular materials lies at the core of the circular economy, as materials determine the flows, lifecycles, and environmental impacts of production and consumption systems. Circular materials are defined as those that can be safely and continuously cycled within biological or technical systems without losing value (Braungart & McDonough, 2002). They are designed to re-enter either the natural environment as nutrients or the industrial system as inputs for new production processes. In this way, circular materials operationalize the principle of "closing the loop," ensuring that economic activities remain regenerative rather than extractive.

2.5.1 Biological and Technical Cycles

According to the Ellen MacArthur Foundation (2013), circular materials can be categorized into two broad cycles:

- **Biological Materials:** These are materials that can safely return to the biosphere and decompose without causing harm, ideally restoring ecosystems. Examples include timber, natural fibers such as hemp or cotton, and biodegradable composites. In the built environment, circular biological materials are increasingly being applied in the form of bamboo, timber-based engineered products, and bioplastics.
- **Technical Materials:** These are materials that cannot safely return to nature but can circulate within industrial systems without losing quality. Examples include metals such as steel and aluminum, which can be remelted indefinitely, and high-performance plastics that can be chemically recycled. In construction, technical circular materials include recycled steel, modular concrete systems, and durable glass that can be reprocessed into new products.

2.5.2 Design for Circular Materials

The adoption of circular materials requires a fundamental rethinking of design. Products and buildings must be designed for disassembly, enabling materials to be separated and recovered at the end of their life cycles. Geisendorf and Pietrulla (2017) emphasize that design decisions determine up to 80 percent of a product's environmental impact, meaning that embedding circular material strategies at the design stage is essential. In the construction sector, circular material design can involve modular components that are easily dismantled, standardized connections for reuse, and labeling systems that track the origins and properties of materials (sometimes referred to as “material passports”). Such approaches ensure that materials retain value and avoid downcycling.

2.5.3 Circular Materials in the Built Environment

Circular materials are especially important because the built environment uses more raw materials than any other industry. Linear material flows, the extraction, use, and disposal of resources as waste, are a major component of traditional building. This is challenged by circular materials, which allow for large-scale reuse, recycling, and repurposing. Examples consist of:

- Recycled aggregates from demolition and construction trash that are used to make fresh concrete or build roads.
- Cross-laminated wood (CLT), a low-carbon and renewable substitute for concrete and steel.
- Reclaimed steel is one of the most environmentally friendly building materials accessible since it can be remelted without losing strength.
- Renewable and biodegradable bio-based insulation materials, like cork, hempcrete, and sheep's wool.
- Alternatives to cement, such as fly ash and slag, which lessen carbon emissions and dependency on virgin cement.

2.5.4 Circular materials in Nigeria

Although there are still few circular material practices in Nigeria, material recovery is becoming more popular informally. Scrap metal markets are ubiquitous, where steel and aluminum are gathered and resold for remanufacturing. Timber repurposing is very frequent, particularly in informal house building. However, there aren't many systematic frameworks for incorporating circular materials into regular construction, which emphasizes how crucial it is for aspiring built environment experts to be aware of the issue.

2.5.5 Challenges in Adopting Circular Materials

The broad use of circular materials is hampered by a number of issues, despite their potential. Among these are:

- **Technological barriers**: Advanced recycling processes are not always available, and not all materials can be recycled without losing quality.

- **Economic barriers**: In situations where resource extraction is subsidized or waste management systems are inadequate, virgin materials are frequently less expensive than recycled alternatives.
- **Regulatory obstacles**: Many nations, including Nigeria, have building laws and standards that do not allow for recycled or repurposed materials.
- **Cultural barriers**: Because second-hand or recycled materials are perceived as being of poorer quality or prestige, there is frequently opposition to using them.

2.5.6 Circular Materials and the R-Models

The CE R-models and circular materials are very similar. For instance:

- Materials that are robust and modular allow for reuse and repair.
- Materials that can last several life cycles are necessary for refurbishment and remanufacturing.
- Materials that can be broken down and reprocessed without suffering a major loss of quality are the foundation of recycling and recovery.

This connection demonstrates how important material selection is to implementing higher-order circular techniques. Many of the R-strategies remain restricted or unfeasible in the absence of circular materials.

2.6 OBJECTIVES AND RELEVANCE FOR CIRCULAR ECONOMY

The circular economy's goals go beyond reducing waste, they also include a comprehensive reorganization of systems of production and consumption to bring economic activity into line with sustainable development ideals. The CE is important because it provides practical methods for operationalizing sustainability by tying social well-being, economic resilience, and environmental preservation together.

2.6.1 Circular Economy and the Triple Bottom Line

Elkington (1997) developed the triple bottom line concept, which emphasizes the necessity of balancing social, environmental, and economic goals in development. All three dimensions are directly impacted by the circular economy:

- **Economic Goals**: By encouraging resource efficiency and lowering reliance on virgin materials, CE lowers costs. Reuse, repair, and remanufacturing-based business models have the potential to create new jobs and revenue streams. By 2030, CE could release trillions of dollars in global economic value, according to a 2016 World Economic Forum assessment.

- **Environmental Goals:** By minimizing waste, cutting carbon emissions, and closing material loops, CE eases the strain on natural ecosystems. CE tackles important environmental issues including biodiversity loss and climate change by rebuilding natural systems and designing out waste.
- **Social Objectives:** CE opens up additional job opportunities, especially in the recycling, repair, and renovation sectors. By lowering pollution, maintaining cleaner urban settings, and encouraging inclusive innovation, it can also enhance human well-being. However, given that many recycling sectors in underdeveloped nations depend on informal labour under insecure conditions, Witjes et al. (2017) warn that delivering social benefits necessitates the intentional inclusion of fairness and justice within CE frameworks.

2.6.2 CE and the Sustainable Development Goals (SDGs)

Since its adoption in 2015, the CE has been more closely associated with the Sustainable Development Goals of the United Nations. CE initiatives directly assist a number of objectives:

- **SDG 12** (Responsible Consumption and Production): By placing a strong emphasis on resource management, waste reduction, and material efficiency, CE exemplifies the goals of sustainable consumption and production.
- **SDG 13** (Climate Action): CE helps mitigate climate change by reducing greenhouse gas emissions through increased energy efficiency and less resource extraction.
- **SDG 11** (Sustainable Cities and Communities): By facilitating resource-efficient infrastructure and structures, CE strategies in the built environment support sustainable urban development.
- **SDG 9** (Industry, Innovation, and Infrastructure): Through innovative business models and product-service systems, CE promotes industrial innovation
- **SDG 8** (Decent Work and Economic Growth): CE creates jobs in the recycling, remanufacturing, and repair industries.

2.7 NIGERIA AND THE CIRCULAR ECONOMY

The circular economy is still a relatively new concept in Nigeria. Poor waste management, excessive raw material consumption, and high urban pollution are only a few of the nation's numerous environmental issues. Nigeria is a crucial location for researching and implementing circular economy concepts because of these issues. Although there are sustainability policies in place, they are frequently not strictly enforced. Markets and unorganized laborers are the main sources of recycling, particularly for scrap metal, plastics, and electronic trash. This demonstrates that people are already engaging in some unstructured circular economy activities. For instance, a lot of Nigerians fix or repurpose things like apparel, electronics, and auto parts. Large-scale mechanisms that promote the circular economy, including formal recycling sectors or governmental initiatives, are still scarce, though. Nigerian universities discuss sustainability in their curricula, but the circular economy is not yet a primary area of study. This results in a knowledge and awareness gap. In order for architectural, engineering, and planning students to use CE practices after graduation, they must learn about them.

2.7.1 Benin City and the University of Benin

Locally, Benin City is a developing metropolis that has problems with resource usage and trash. The city's housing and construction industries are growing, consuming a lot of resources. Instead of being recycled or reused, waste from these operations is frequently disposed of in landfills or open places. Teaching aspiring professionals how to design and construct using the principles of the circular economy is crucial because of this. One of the main institutions for teaching students about the built environment is the University of Benin. Building technology, urban planning, and architecture are among the topics that students study. These courses equip students to oversee construction projects and design buildings. However, the program does not yet completely incorporate circular economy concepts like lifecycle thinking, material reuse, and design for disassembly. Recycling may be well-known to many students, but they might not be familiar with more general CE concepts like material passports or product-service systems.

Examining University of Benin students' understanding of CE will reveal their level of knowledge and areas for improvement. With this knowledge, education may be enhanced and students can be better equipped to make career decisions that promote sustainability.

2.8 EDUCATION AND AWARENESS OF CIRCULAR ECONOMY PRINCIPLES

2.8.1 The Role of Education in Advancing Circular Economy Principles

One of the best methods to teach people about and encourage them to practice sustainability is through education. According to the United Nations Educational, Scientific, and Cultural Organization (UNESCO), education for sustainable development equips students with the values, attitudes, abilities, and information necessary to build a more sustainable society. This includes the ideas of the circular economy, which demonstrate how to use resources more efficiently, cut waste, and encourage innovation.

Universities all throughout the world are essential in teaching students to handle sustainability-related issues. They offer a setting for education, research, and creativity. Higher education can assist future professionals who will steer communities and industry towards sustainability, claim Witjes, Vermeulen, and Cramer (2017). This is crucial for students studying the built environment since their work will influence the design of infrastructure, cities, and buildings. These kids may make decisions that conserve resources and reduce waste if they comprehend the circular economy.

2.8.2 Awareness Levels and Student Perceptions of CE

CE "has entered the policy and business mainstream but remains unevenly integrated into education systems," according to Ekins et al. (2019) (p. 25). Because of this disparity, students have varying levels of awareness; some are exposed to CE through sustainability courses, while others only learn about it indirectly. Since "students and practitioners may equate it with recycling, ignoring higher-value strategies," Korhonen et al. (2018) contend that the concept's ambiguity exacerbates this issue (p. 42). This little awareness is especially troublesome in the field of built environment education. Although they are not exposed to techniques like disassembly or remanufacturing design, students frequently comprehend recycling. This disparity illustrates the difficulties in integrating the circular economy into educational programs. Ekins et al. (2019) claim that the integration of CE concepts into higher education has lagged behind in that adopting it in policy and industry creates a disconnect between field practice and academic training.

Although some studies from South Africa and Kenya indicate that sustainability is receiving attention, the circular economy is still a relatively new concept. In Nigeria, the majority of research focuses on waste reduction or environmental management, with very little attention paid to students' awareness of the circular economy. Students at the University of Benin might be accustomed to recycling and reusing materials in their daily lives, but they might not be aware of more complex CE ideas like industrial symbiosis, material passports, or design for disassembly. This makes it crucial to assess students' knowledge and perspectives on circular economy tactics.

2.9 THEORETICAL FRAMEWORK

The key concepts that direct a study are explained by a theoretical framework. It demonstrates which models or ideas the researcher applies in order to address the study issues. This paper examines the level of knowledge regarding circular economy techniques among University of Benin built environment students. The framework integrates concepts from learning theories and circular economy theory because the subject relates to both sustainability and education. Background information on resource management that aims to decrease waste and enhance sustainability is provided by the circular economy. Theories of education describe how consciousness is developed and how pupils learn. By combining these concepts, the framework demonstrates how students may comprehend and apply the concepts of the circular economy.

2.9.1 Circular Economy Conceptual Foundations

The central idea of this study is the circular economy. According to Geisendorf and Pietrulla (2017), it is a broad concept that encompasses a variety of methods for optimizing resource utilization. It is described as an industrial system that regenerates and restored by the Ellen MacArthur Foundation (2013). Three key concepts are listed by the foundation. The first is getting rid of pollution and waste. The second is extending the useful life of materials and products. The third is promoting the regeneration of natural systems.

The classic linear economy is not the same as the circular economy. Taking materials, turning them into products, using them, and eventually discarding them is the main goal of the linear economy. This harms the environment and wastes resources. Instead, the circular economy establishes cycles in which goods can be recycled, remade, mended, or reused. This approach lowers pollution, conserves resources, and opens up new commercial prospects.

According to this study, the circular economy serves as both an environmental remedy and a model for student learning. The acts that promote circularity are explained by the R-models, which include Refuse, Reduce, Reuse, Repair, Refurbish, Remanufacture, Repurpose, Recycle, and Recover. Strategies for the circular economy that demonstrate how these acts might be implemented in practice include eco-design, design for disassembly, product-service systems, and industrial symbiosis. They serve as the primary basis for this awareness research.

2.9.2 Learning-Based Integration of CE (LEAPFROCS Framework)

Witjes, Vermeulen, and Cramer (2017) created the LEAPFROCS framework to describe how organizations might include sustainability. The acronym represents learning-based methods for evaluating corporate sustainability. Development and Introspection for Organizational Transformation Plans. According to the paradigm, integrating sustainability into an organization requires learning and reflection. The framework emphasizes the importance of feedback, communication, culture, and leadership. Leaders need to be in favour of sustainability. The culture of the organization must encourage change. Communication must be clear, and feedback must be used to create improvements. Implementing sustainability is made simpler by these points.

Universities are also organizations, hence the LEAPFROCS framework is helpful for this study. The environment is provided by the university, and the learners are the students. The institution must incorporate CE into the curriculum and learning environment if it wants students to understand about the circular economy. University leadership, faculty instructional strategies, and student reflection all contribute to raising awareness. Thus, this paradigm aids in explaining how education may increase students' understanding of CE.

2.9.3 Education for Sustainable Development (ESD) and Competency Theory

An additional crucial theory for this research is Education for Sustainable Development (ESD). ESD is the process of equipping students with the knowledge, beliefs, and attitudes necessary to make sustainable decisions, according to UNESCO (2017). The premise is that education should prepare students to behave appropriately in society, not only to acquire knowledge.

Key competencies that are essential for sustainability are listed by ESD. Competence in systems thinking is the first. This entails having the ability to recognize the connections among many aspects of the economy, society, and environment. The second is anticipatory competence, or the capacity to plan forward and anticipate long-term effects. Normative competence, or knowing the values and concepts that drive sustainability, is the third. The fourth is strategic competency, which refers to the capacity to plan and execute sustainable initiatives. The final one is interpersonal competency, which is about cooperating and working with people.

Applied to a circular economy, these competences are particularly valuable. Pupils who are proficient in systems thinking can comprehend the environmental impact of building materials. Those who possess anticipatory competence are able to envision the consequences of unrestrained use of resources. Students who possess normative competence are better able to comprehend the significance of the circular economy for sustainability and equity. Their ability to think strategically enables them to plan initiatives that incorporate CE concepts. They can collaborate with other students, educators, and professionals to implement the circular economy in the real world thanks to their interpersonal competency.

ESD assists students studying the built environment by demonstrating the knowledge and skills they must acquire in order to apply CE in their profession. ESD is therefore a crucial component of the theoretical framework.

2.9.4 Awareness and Knowledge Gap

For this investigation, awareness and knowledge gaps are also crucial. Students' level of awareness refers to their knowledge of circular economy tactics. Why certain groups know more than others is explained by the knowledge gap theory. According to the hypothesis, knowledge gaps are caused by variations in exposure, education, and information availability. This hypothesis is highly applicable in the Nigerian environment. Because they observe recycling and reuse in their communities, some students may be familiar with these concepts, but they may not be familiar with more complicated CE concepts like material passports or industrial symbiosis. This occurs as a result of the lack of CE in the majority of academic curricula and the paucity of public discourse on the subject. Assessing pupils' awareness of the built environment aids in identifying knowledge gaps. It also demonstrates what the institution may do to enhance CE instruction and learning.

2.10 EMPIRICAL REVIEW

The empirical review examines research on awareness, education, and the circular economy. The understanding of CE in various regions of the world is demonstrated by this research. They also demonstrate the extent of research conducted in Nigeria and Africa. This research can determine the gaps it seeks to fill by examining these studies.

2.10.1 Global Empirical Studies on CE Awareness

Global understanding of the circular economy has been the subject of numerous studies. Kirchherr, Reike, and Hekkert (2017) examined 114 definitions of CE and discovered that recycling is still the primary meaning for many people. Their research revealed that although CE is a broad term, it is frequently interpreted narrowly. Universities and businesses in Europe have started incorporating CE into their curricula and operations. For instance, research conducted in the Netherlands indicates that design studios and sustainability courses are used to promote CE to engineering and architecture students. These studies also show, nevertheless, that pupils struggle to relate theory to practice. This demonstrates that profound comprehension is not always a prerequisite for awareness.

Since CE is a component of national policy, awareness levels are greater in China. CE is now a widely used term in industry and education thanks to the Circular Economy Promotion Law. Students are more familiar with CE principles, particularly in engineering and environmental sciences, according to studies from Chinese universities. This demonstrates how policy assistance can affect awareness and education. According to surveys, knowledge of CE is rising in emerging nations outside of Africa, like Brazil and India, although it is still low when compared to China and Europe. The majority of professionals and students in these nations are aware of waste management and recycling, but they are less familiar with more sophisticated CE tactics like material passports or product-service systems.

2.10.2 Empirical Studies in Africa

Research on CE is currently scarce in Africa. Research from South Africa indicates that people are becoming more conscious of sustainability, particularly in higher education. Green design, renewable energy, and waste reduction are subjects covered in the curricula of some colleges. CE as a whole, however, is still not taught very often.

According to waste management research conducted in Kenya, pupils understand the value of recycling and reusing, but few are familiar with broader CE concepts. Instead of implementing systemic CE techniques, the majority of attention is still on finding solutions to waste issues. Few studies on CE awareness and education have been published in other African nations. Africa is therefore a crucial region for new research, particularly given the continent's severe resource shortages and rapid urbanization.

2.10.3 Empirical Studies in Nigeria

The majority of studies on waste management and sustainability in Nigeria has concentrated on community and industry activities rather than education. For instance, research has looked at how unofficial rubbish pickers in places like Lagos recycle metals and plastics. Despite not being referred to as CE, these findings demonstrate that Nigerians already engage in some kind of circularity. While studies on Nigerian higher education frequently touch on environmental consciousness, they hardly ever specifically address the circular economy. According to some research, university students are aware of recycling, planting trees, and conserving energy, but they are unfamiliar with more sophisticated CE techniques like industrial symbiosis and design for disassembly.

There is a knowledge gap as a result of these investigations. Because their future profession will require a lot of resources, students studying the built environment, who will go on to become architects, engineers, and planners, are particularly crucial. However, little research has been done on their awareness of CE concepts.

2.10.4 Gaps Identified in the Literature

From the review of studies, several gaps can be identified. Africa has seen relatively little research, with the majority of global studies concentrating on China and Europe. Studies on waste management and fundamental sustainability techniques are the only ones conducted in Africa. Few emphasize CE as a comprehensive framework. While there are studies on sustainability in Nigeria, there are hardly any on students' awareness of CE. The University of Benin's built environment students' awareness of CE techniques has not been the subject of any particular study. These inadequacies highlight the significance of this study. By assessing a group of students who will influence Nigeria's future built environment's awareness of CE strategies, it advances knowledge.

CHAPTER THREE

METHODOLOGY

3.1 PREAMBLE

This chapter will describe the techniques used to collect study-related data. It will go over the research design, study area, study population, sample size, sampling approaches, data collection tools, and data collection and analysis procedures.

3.2 RESEARCH DESIGN

Descriptive research designs will be used in this investigation. The purpose of the descriptive design is that it allows for the systematic assessment of the current level of awareness and understanding of circular-economy strategies among built-environment students in the University of Benin**.** The design enables the researcher to observe, describe, and quantify characteristics such as knowledge, perceptions, and exposure to CE concepts without manipulating any variables, allowing comparisons across departments and identification of gaps in knowledge and curriculum integration. Using this design, provides a clear framework for collecting standardized data through questionnaires and provides empirical evidence to inform improvements in CE education.

3.3 AREA OF STUDY

This research was conducted in the University of Benin, Edo State. It focused on the built environment departments, involving the departments of Architecture, Quantity Survey, Geo-informatics, Estate Management, and Structural Engineering.

3.4 POPULATION OF THE STUDY

For the purpose of this research, the target population includes built environment students across various departments such as Architecture which has 279 Students, Quantity Survey has 176 students, Geo-informatics has 102 students, Estate students, Estate Management has 153 students, and Structural Engineering has 389 students. The total population of the study is 1099 which consists of all the undergraduate students across all levels in these departments

3.5 SAMPLE SIZE

In this study, the sample size consists of 100 respondents selected from different segments of the population. This size is adequate for capturing perspectives across all built environment students while remaining manageable for analysis within the project scope.

3.6 SAMPLING TECHNIQUE

For this study, stratified random sampling technique was employed. Stratified random sampling was used to ensure adequate representation of all departments. The total population of built environment students is 1099. The population was first divided into five departments (strata). Then, using the proportional allocation method, the sample size for each department was calculated based on its share of the total population. The distribution thereby resulted in selecting Architecture with 26 respondents, Quantity Survey 16 with respondents, Geo-informatics with 9, Estate Management with 14 respondents and Structural Engineering with 35 respondents. The formula used was:

Population of the Department ÷ Total Population × Total Sample Size

After proportional allocation, within each department, students were randomly selected to receive the questionnaire.

3.7 INSTRUMENT FOR DATA COLLECTION

Our instrument for data collection will consist of a structured questionnaire, which will be administered to 100 respondents who are built environment students across all the various departments. The questionnaire will be divided into two sections: Section A and Section B.

Section A: this section collects personal data from the respondents, including information such as gender, age, department, level and other relevant demographic factors.

Section B: This section will contain a list of items or statements formulated with respect to the four research objectives and corresponding research questions related to the evaluation of the level of awareness of circular economy strategies among built environment students in University of Benin.

All items in section B were presented in close ended, multiple choice or likert scale format to generate quantifiable data.

3.8 METHOD OF DATA COLLECTION

This study will adopt primary and Secondary methods of data collection, which the primary method include structured questionnaires. A one-time survey method will be utilized, involving a face-to-face administration of the structured questionnaires to various respondents. While the secondary data collection will be Textbooks, Journals, Monographs, Newspapers, Magazines, etc.

3.9 METHOD OF DATA ANALYSIS

Data collected from this study will be analyzed using descriptive statistical methods (a simple percentage and frequency distribution table). These methods were used to summarise respondents' awareness, exposure and perceptions of circular economy strategies across departments.

3.10 ETHICS IN RESEARCH

The following ethical considerations were observed in this study; confidentiality, justice, non-maleficence, beneficiate and cultural sensitivity.

CHAPTER FOUR

DATA PRESENTATION, ANALYSIS AND DISCUSSION OF FINDINGS

This chapter reviews the results and analysis of the quantitative data, the compilation of the questionnaire conducted among various built environment departments in the University of Benin including architecture, Quantity surveying, Estate Management, Geo-informatics, and Structural Engineering, the results and the analysis of the quantitative findings of the study.

SECTION A: SOCIO-DEMOGRAPHIC CHARACTERISTICS OF THE RESPONDENTS.

TABLE 1.1 AGE OF THE RESPONDENTS

AGE	RESPONSES	PERCENTAGE
16 – 20	23	22.7
21 – 25	73	72.7
26 Above	4	4.6
TOTAL	**100**	**100**

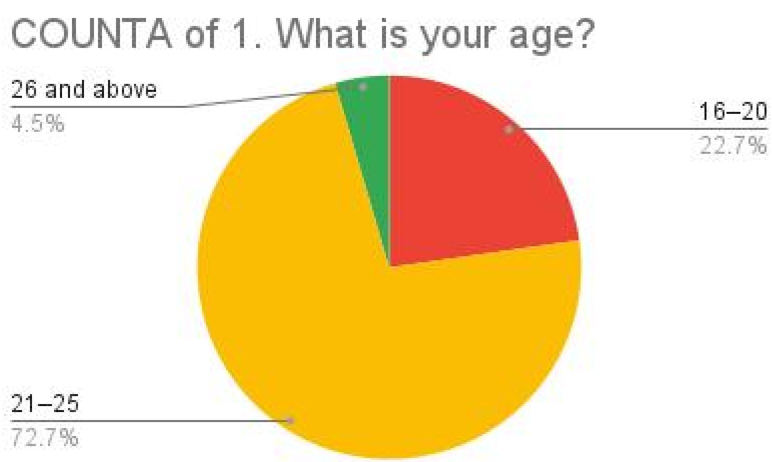

Figure 1: A pie chart showing the percentages of the ages of the respondents

SOURCE: FIELD SURVEY 2025

From the table the results show that the age of the respondents. The results reveal that the respondents between the ages *16 – 20* are accounted as *22.7%*, the respondents between the ages

21 – 25 are accounted as *72.7%*, and the respondents between age *26 and above* are accounted as *4.5%*. This shows that the respondents between ages 21-25 counts as the majority of the population.

TABLE 1.2 GENDER OF RESPONDENTS

GENDER	**PERCENTAGE**
Male	71.1
Female	28.9
TOTAL	**100**

SOURCE: FIELD SURVEY 2025

From the table 1.2 above, the results show the gender of the respondents. The results show that *71.1.%* of the respondents are *male*, and *28.9%* of the respondents are *female*. This shows that the majority of the respondents are male.

TABLE 1.3 DEPARTMENT OF RESPONDENTS

DEPARTMENT	**RESPONSES**	**PERCENTAGE**
Architecture	26	26
Quantity Surveying	16	16
Estate Management	14	14
Geo-informatics	9	9
Structural Engineering	35	35
TOTAL	**100**	**100**

SOURCE: FIELD STUDY 2025

From the table 1.3 above, the results show the departments of the respondents. The results show that *26%* of the respondents study *Architecture*, *16%* of the respondents study *Quantity Surveying*, *14%* of the respondents study *Estate Management*, and *9%* of the respondents study Geo-informatics and *35%* of the respondents study *Structural Engineering*.

TABLE 1.4 ACADEMIC LEVEL OF THE RESPONDENTS

LEVEL	**PERCENTAGE**
100	0

200	0
300	16.7
400	47.6
500	35.7
TOTAL	**100**

SOURCE: FIELD STUDY 2025

From the table 1.4 above, the results show that *0%* of the respondents are *100 level*, *0%* of the respondents are *200 level*, *16.7%* of the respondents are *300 level*, *47.5%* of the respondents are *400 level*, and *35.7%* of the respondents are *500 level*. This shows that the majority of the respondents are from 400 level.

SECTION B: RESEARCH QUESTIONS

OBJECTIVE 1: THE LEVEL OF AWARENESS OF CE STRATEGIES BETWEEN DIFFERENT DEPARTMENTS WITHIN THE BUILT ENVIRONMENT STUDENTS IN THE UNIVERSITY OF BENIN

TABLE 1.1 HOW FAMILIAR ARE YOU WITH THE TERM CIRCULAR ECONOMY

OPTIONS	PERCENTAGE
Very familiar	11.1
Somewhat familiar	48.9
heard of it but not sure	15.6
Not familiar at all	24.4
TOTAL	**100**

SOURCE: FIELD SURVEY 2025

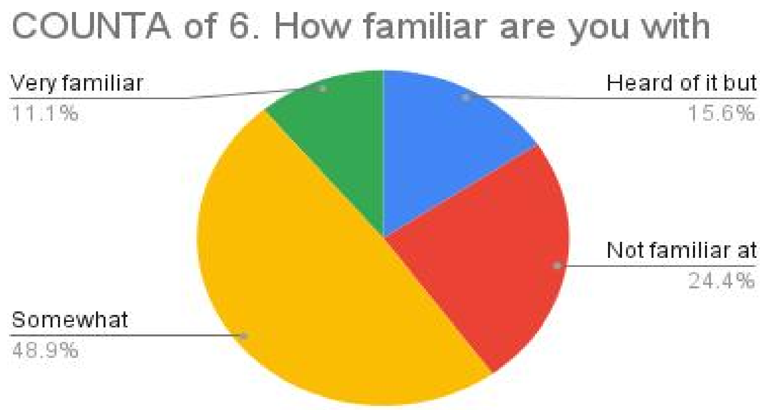

Figure 2: A pie chart showing the level of awareness of respondents on circular economy.

From the table 1.1 above, data shows that *11.1%* of the respondents are *very familiar* with the concept of CE, *48.9%* of the respondents are *somewhat familiar*, *15.6%* of the respondents have *heard of it but are not sure*, and 24.4% of the respondents are *not familiar* with the concept at all.

TABLE 1.2 HOW WELL DO YOU UNDERSTAND THE MAIN PRINCIPLES OF CIRCULAR ECONOMY (E.G. REUSE, REDUCE, RECYCLE, ETC.)

OPTIONS	**PERCENTAGE**
Very well	17.8
Moderately well	51.1
Slightly	17.8
Not at all	13.3
TOTAL	**100**

SOURCE: FIELD SURVEY 2025

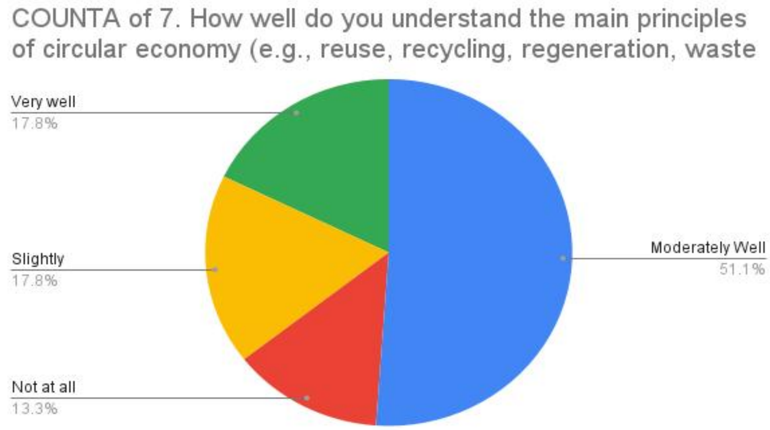

Figure 3: A pie chart showing the level of understanding of the main principles of circular economy among respondents.

From the table 2.2 above, data shows that *17.8%* of the respondents *understand* the main principles of CE, *51.1%* of the respondents understand *moderately well*, *17.8.%* of the respondents understand it *slightly*, and *13.3%* of the respondents *do not understand* the principles at all.

TABLE 1.3 HOW WELL DO YOU UNDERSTAND THE STRATEGIES OF CIRCULAR ECONOMY (E.G. DESIGN FOR DISASSEMBLY, MATERIAL PASSPORT, ETC)

OPTIONS	PERCENTAGE
Very well	13.3
Moderately well	35.6
Slightly	24.4
Not at all	26.7

SOURCE: FIELD SURVEY 2025

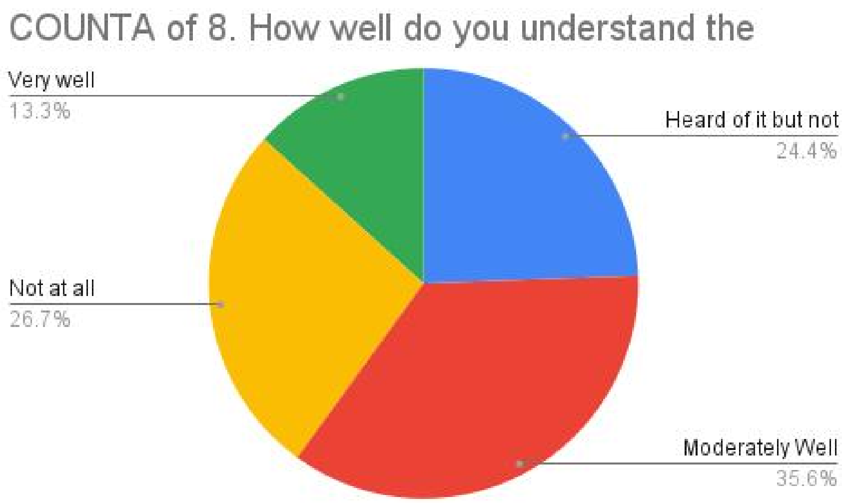

Figure 4: A pie chart showing the level of understanding of the strategies of circular economy among respondents.

Since the question allowed respondents to select multiple options, the percentages represent the proportion of respondents who selected each item. Thus percentages do not total 100 percent.

From the 1.3 above, data shows that *13.3%* of the respondents *understand* the strategies of CE, *35.6%* of the respondents understand *moderately well*, *24.4%* of the respondents understand it *slightly*, and *26.7%* of the respondents *do not understand* the strategies at all.

TABLE 1.4 HAVE YOU BEEN TAUGHT OR EXPOSED TO CIRCULAR ECONOMY CONCEPTS IN YOUR COURSES OR DEPARTMENT

OPTIONS	**PERCENTAGE**
Yes, extensively	4.4
Yes, but briefly	57.8
Not sure	17.8
No exposure	20
TOTAL	**100**

SOURCE: FIELD SURVEY 2025

From the table 1.4 above, data shows that *4.4%* of the respondents have been taught the concepts of CE *extensively*, *57.8%* of the respondents have been *briefly taught*, *17.8%* of the respondents are *not sure*, and *20%* of the respondents have *no exposure* to the concept at all.

TABLE 1.5 HOW WELL WOULD YOU RATE THE AWARENESS OF CE STRATEGIES AMONGST STUDENTS IN YOUR DEPARTMENT

OPTIONS	PERCENTAGE
High	2.2
Moderately	42.2
Low	40
Very low	15.6
TOTAL	**100**

SOURCE: FIELD SURVEY 2025

From the table 1.5 above, data shows that *2.2%* of the respondents rate their awareness with the concept of CE *very high*, *42.2%* of the respondents rate the awareness *moderately*, *40%* of the respondents rate it *low*, and *15.6%* of the respondents rate the awareness amongst them as *very low.*

OBJECTIVE 2: BUILT ENVIRONMENT STUDENTS UNDERSTANDING ON THE APPLICATIONS OF CIRCULAR ECONOMY STRATEGIES IN THE UNIVERSITY OF BENIN

TABLE 2.1 HOW FAMILIAR ARE YOU WITH THE PRACTICAL APPLICATIONS OR CIRCULAR ECONOMY STRATEGIES IN THE BUILT ENVIRONMENT (E.G. SUSTAINABLE BUILDING MATERIALS, DESIGN FOR DISASSEMBLY, ETC)

OPTIONS	PERCENTAGE
Very familiar	22.2
Somewhat familiar	46.7
heard of it but not sure	28.9
Not familiar at all	6.7

SOURCE: FIELD SURVEY 2025

Since the question allowed respondents to select multiple options, the percentages represent the proportion of respondents who selected each item. Thus percentages do not total 100 percent.

From the table 2.1 above, data shows that *22.2%* of the respondents are *very familiar* with the concept of CE, *46.7%* of the respondents are *somewhat familiar*, *28.9%* of the respondents have *heard of it but are not sure*, and *6.7%* of the respondents are *not familiar* with the concept at all.

TABLE 2.2 HAVE YOU APPLIED OR OBSERVED CIRCULAR ECONOMY PRINCIPLES IN ANY OF YOUR COURSE PROJECTS, WORKSHOP OR FIELDWORKS

OPTIONS	PERCENTAGE
Yes	35.6
Rarely	46.7
Never	17.8
TOTAL	**100**

SOURCE: FIELD SURVEY 2025

From the table 2.2 above, data shows that *35.6%* of the respondents *applied or observed CE principles in their course projects*, *46.7%* of the respondents *rarely applied* or observed it in their course projects, *17.8%* of the respondents have *never* done it at all.

TABLE 2.3 HOW CONFIDENT ARE YOU IN IDENTIFYING WAYS TO IMPLEMENT CE STRATEGIES IN CONSTRUCTION AND DESIGN PROJECTS?

OPTIONS	PERCENTAGE
Very confident	4.4
Confident	35.6
Slightly Confident	53.3
Not Confident	**11.1**

SOURCE: FIELD SURVEY 2025

Since the question allowed respondents to select multiple options, the percentages represent the proportion of respondents who selected each item. Thus percentages do not total 100 percent.

From the table 2.3 above, data shows that *4.4%* of the respondents are *very confident* identifying ways to implement CE strategies in construction and design projects, *35.6%* of the respondents are *confident*, *53.3%* of the respondents are *slightly confident*, and *11.1%* of the respondents are *not confident* with identifying ways to implement CE strategies at all.

TABLE 2.4 WHICH OF THE FOLLOWING CIRCULAR ECONOMY PRACTICES HAVE YOU ENGAGED WITH OR LEARNED TO APPLY DURING YOUR STUDIES

OPTIONS	PERCENTAGE
Use of recycled or sustainable building materials	59.1
Waste reduction in project design	38.6
Designing deconstruction or reuse	25
Energy and resource efficiency measures	45.5
None of the above	11.4

SOURCE: FIELD SURVEY 2025

Since the question allowed respondents to select multiple options, the percentages represent the proportion of respondents who selected each item. The percentages do not total 100 percent.

From the table 2.4 above, data shows that *59.1%* of the respondents engaged with the use of recycled or sustainable building materials, *38.6%* of the respondents engaged with waste reduction in project design, *25%* of the respondents engaged with designing with deconstuction or reuse, and *45.5%* of the respondents engaged in energy and resource efficiency measures while *11.4%* engaged with none of the above.

OBJECTIVE 3: THE EXTENT TO WHICH CE CONCEPTS ARE INTEGRATED INTO THE BUILT ENVIRONMENT CURRICULUM IN THE UNIVERSITY OF BENIN

TABLE 3.1 HAVE ANY OF YOUR COURSES INCLUDED TOPICS ON CIRCULAR ECONOMY STRATEGIES (E.G. REVERSE LOGISTICS, RECYCLING, MATERIAL PASSPORT)

OPTIONS	PERCENTAGE
Yes	22.7
Rarely	52.3
Not at all	25
TOTAL	**100**

SOURCE: FIELD SURVEY 2025

From the table 3.1 above, data shows that *22.7%* of the respondents *have* their courses include topics on circular economy strategies, *52.3%* of the respondents *rarely have* and *25%* of the respondents *do not have* at all.

TABLE 3.2 HOW OFTEN ARE CIRCULAR ECONOMY PRINCIPLES DISCUSSED IN YOUR LECTURES, TUTORIALS, OR PRACTICAL SESSIONS

OPTIONS	PERCENTAGE
Very often	13.6
Sometimes	31.8
Rarely	47.7
Never	6.8
TOTAL	**100**

SOURCE: FIELD SURVEY 2025

From the table 3.2 above, data shows that *13.6%* of the respondents *very often* have CE principles discussed in their lectures, *31.8%* of the respondents *sometimes* do have CE principles discussed, *47.7%* of the respondents *rarely* do and *6.8%* of the respondents *do not have* these discussions at all.

TABLE 3.3 DOES YOUR DEPARTMENT PROVIDE WORKSHOPS, SEMINARS OR FIELD VISITS

OPTIONS	PERCENTAGE
Yes	6.8
Rarely	52.3
Never	40.9
TOTAL	**100**

SOURCE: FIELD SURVEY 2025

From the table 3.3 above, data shows that *6.8%* of the respondents are provided workshops/seminars/field visits on CE, *52.3%* of the respondents are rarely provided, and *40.9%* of the respondents are not provided with any of these at all.

TABLE 3.4 HOW ADEQUATELY DO YOU THINK THE CURRENT CURRICULUM EQUIPS STUDENTS TO IMPLEMENT CIRCULAR ECONOMY STRATEGIES IN REAL WORLD PROJECTS.

OPTIONS	PERCENTAGE
Very adequately	4.5
Moderately	29.5
Slightly	45.5
Not at all	20.5
TOTAL	**100**

SOURCE: FIELD SURVEY 2025

From the table 3.4 above, data shows that *4.5%* of the respondents very adequately think that the current curriculum equips students to implement CE strategies in real world projects, 29.5% of the respondents think they are moderately equipped, 45.5% of the respondents think slightly and *20.5%* of the respondents do not think the curriculum equips students at all.

OBJECTIVE 4: RECOMMENDATION OF STRATEGIES FOR IMPROVING CIRCULAR ECONOMY EDUCATION IN THE UNIVERSITY OF BENIN

TABLE 4.1 WHICH OF THE FOLLOWING STRATEGIES WOULD MOST IMPROVE YOUR UNDERSTANDING OF CIRCULAR ECONOMY STRATEGIES

OPTIONS	PERCENTAGE
More courses focused on CE principles	39.5
Inclusion of CE topics in existing courses	65.1
Workshops, seminars or short courses on CE	55.8
Industrial attachments or field visits focused on CE	55.8
Online resources or E-learning module	32.6

SOURCE: FIELD SURVEY 2025

Since the question allowed respondents to select multiple options, the percentages represent the proportion of respondents who selected each item. The percentages do not total 100 percent.

From the table 4.1 above, data shows that *39.5%* of the respondents think more courses focused on CE would improve their understanding of the strategies, *65.1%* of the respondents think that inclusion of CE topics will aid their understanding, *55.8%* of the respondents think workshops and seminars, *55.8%* of the respondents think industrial attachments and field visits and *32.6%* of the respondents think online resources or E-learning modules would improve their understanding.

TABLE 4.2 HOW IMPORTANT IS IT FOR THE DEPARTMENT TO PROVIDE TRAINING ON CE TOOLS, METHODS, AND CASE STUDIES

OPTIONS	PERCENTAGE
Very important	50
Important	40.9
Slightly important	6.8
Not important	2.3

SOURCE: FIELD SURVEY 2025

Since the question allowed respondents to select multiple options, the percentages represent the proportion of respondents who selected each item. The percentages do not total 100 percent.

From the table 4.2 above, data shows that *50%* of the respondents think it is *very important* for the department to provide training on CE tools and methods, *40.9%* of the respondents think it is *important*, *6.8%* of the respondents think it is *slightly important*, and *2.3%* of the respondents think it is *not important* at all.

TABLE 4.3 WOULD COLLABORATION WITH INDUSTRY PROFESSIONALS OR CE PRACTITIONERS HELP IMPROVE YOUR UNDERSTANDING AND APPLICATION OF CIRCULAR ECONOMY STRATEGIES

OPTIONS	PERCENTAGE
Significantly	63.6

Slightly	0
Moderately	34.1
Not at all	2.3
TOTAL	**100**

SOURCE: FIELD SURVEY 2025

From the table 4.3 above, data shows that *63.6%* of the respondents think collaboration with industry professionals would *significantly* improve their understanding and application of CE strategies, *0%* of the respondents think it would *slightly* improve, *34.1%* of the respondents think it would *moderately* improve, and *2.3%* of the respondents do not think it would improve their understanding and application of CE strategies

TABLE 4.4 WHICH OF THE FOLLOWING WOULD MOST MOTIVATE YOU TO ENGAGE WITH CE LEARNING OPPORTUNITIES

OPTIONS	PERCENTAGE
Integration of CE into grading/assessment	50
Recognition or certificates for CE projects	54.5
Access to practical case studies and real world examples	70.5
Support from lecturers and mentors	25

SOURCE: FIELD SURVEY 2025

Since the question allowed respondents to select multiple options, the percentages represent the proportion of respondents who selected each item. The percentages do not total 100 percent.

From the table 4.4 above, data shows that *50%* of the respondents would be most motivated with the integration of CE into grading and assessment, *54.5%* of the respondents would be most motivated with recognition of certificates for CE projects, *70.5%* of the respondents would be most motivated with access to practical case studies and real world examples, and *25%* of the respondents would be most motivated with support from lecturers and mentors.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

5.1 SUMMARY OF FINDINGS

This study evaluated the level of awareness of circular economy (CE) strategies amongst built environment students in the University of Benin. The research focused on students from the departments of Architecture, Quantity Surveying, Estate Management. Geoinformatics and structural Engineering, using a descriptive survey design and structured questionnaires to collate data. The findings were drawn from quantitative data gathered through the questionnaires and distributed to 100 respondents across various departments.

Findings from the study show that there is general awareness of circular economy concepts amongst the students, with the findings pointing to the awareness of basic ideas such as Re-use, Reduce and Recycle. However, this awareness is only surface level and concentrated on these three and nothing more showing that there is limited understanding of higher and more complicated strategies of circular economy such as design for disassembly, reverse logistics and so on.

The results further show that the awareness levels of these strategies differs across the departments. Students in architecture and Quantity Surveying show that they have a higher level of familiarity with the Circular economy concepts and strategies compared to other students in engineering-based departments. This difference shows that students in more design oriented disciplines are taught more sustainability and environmental based topics more frequently than their engineering counterparts.

In terms of application, the study demonstrated that most of these students have difficulties with applying circular economy principles to real world field work within the built environment. As the study had shown, the students recognised the importance of sustainability in the built environment, very few of them could clearly state where and how CE strategies are to be integrated in real world building construction processes

The study also brings to light how little circular economy concepts and strategies are integrated into the framework of the curriculum of the students in the built environment disciplines. The exposure to CE the students do have is usually indirect, little or somewhat found in the talks of sustainability but never as a topic on its own.

5.2 CONCLUSIONS

Based on the findings of this study, it is concluded that the built environment students at the University of Benin possess a moderate but largely basic awareness of circular economy strategies. Most students demonstrated familiarities with general sustainability concepts, particularly the traditional 3Rs which are Reuse, Reduce and Recycle. This shows that the students have been exposed to sustainability related courses during the course of their study. However, this awareness does not reach the point of thorough understanding of circular economy or its strategies. The findings suggest that the students' awareness is quite limited in scope, with little to no understanding of the circular economy strategies and its benefits across the entire lifecycle of building and infrastructure thus rendering their limited awareness insufficient for effective use in professional practice.

The findings confirm arguments in existing literature that the circular economy is yet to be fully included into the curricula of higher education, particularly in developing countries like Nigeria. Any exposure to concepts is often indirect or fragmented and only included under the umbrella of sustainability or environmental courses rather than presented as structured content solely to it. In consequence, the students are unable to develop an understanding of CE strategies throughout their academic studies. Without any deliberate effort to inculcate this into the curriculum, students will be most unlikely to acquire the depth of knowledge needed to be able to implement these strategies in their fieldwork of respective disciplines despite the significant benefit that the strategies offer in the built environment.

The study concludes that there are noticeable differences in the level of awareness of circular economy strategies across the built environment departments. Students in a more design oriented department such as Architecture and Quantity Surveying showcased a higher awareness compared to the engineering based counterparts. This difference shows how inconsistent the structure of the curriculum is, the course emphasis and the nature of teaching across departments.

With the significant role the built environments presents in the depletion of natural resources and the generation of waste, the limitations in the awareness that has been observed amongst the students dampens the growth of sustainable building in Nigeria and the world at large and makes it an opportunity missed for an advancement in the grounds of sustainability. The study therefore emphasizes the need for the restructuring of the educational sector that would prioritise the inculcation of circular economy and its strategies as a core component of environmental sciences in the Nigeria.

5.3 RECOMMENDATIONS

Based on the findings in this study, the following recommendations are proposed:

- **Integration into the study curriculum**

Circular economy strategies should be solely integrated into the curriculum of built environment students in the University of Benin. The university should undertake a comprehensive review of the curricula to evaluate where and how to incorporate CE into the curricula. To improve students' overall awareness of circular economy strategies, foundational courses across all built environment departments should make sure circular economy concepts are incorporated. The nature of teaching should shift from the traditional 3Rs to the present frameworks for CE to aid addressing the problem of resource inefficiency, generation of waste and increment of sustainable development in the built environment.

- **Practical application**

Circular economy strategies should be integrated into design studio works, workshops and project based learning. The students should be required to apply the strategies such as DfD , reverse logistics, adaptability, e.t.c. in their academic projects. Awareness campaigns, seminars, and sustainability focused events should be organised regularly to reinforce classroom and studio learning and also promote a wider engagement with CE concepts amongst students.

- **Capacity building for lecturers**

Academic staff should be trained and equipped with up-to-date knowledge on circular economy and its applications. This will further improve the quality of teaching and ensure the consistency of delivery in circular economy concepts. With equitable knowledge, lecturers will be able to utilise case studies, real life examples and contemporary research to demonstrate how these concepts are applied in practice.

- **Collaborations in industry**

There should be partnerships established between the university and construction industry stakeholders to expose students to real life circular economy practices through site visits, internships and guest lecturers.

- **Policy and institutional support**

The university administration should support sustainability driven initiatives by encouraging research, seminars and student led sustainability programs focused on circular economy principles. Other stakeholders and bodies in the construction industry should also organise awareness of sustainability and CE concepts in schools of tertiary learning thus promoting the awareness levels.

- **Promote interdisciplinary learning across built environment departments**

To address the difference in awareness across departments, there should be shared modules or courses on sustainability and CE strategies in all departments. Joint courses, collaborative projects, e.t.c. should be encouraged across Architecture and related departments which will in turn promote the consistency in knowledge and promote collaborative nature of professional practice with the construction industry.

5.4 CONTRIBUTION TO KNOWLEDGE

This study contributes to existing literature by providing empirical evidence on the level of awareness of circular economy strategies among built environment students in a Nigerian university context. It highlights departmental differences in awareness levels and identifies gaps in curriculum integration, thereby offering a foundation for future educational and policy interventions.

5.5 SUGGESTIONS FOR FURTHER STUDIES

Future research could expand this study by:

1. Conducting comparative studies across multiple Nigerian universities.
2. Assessing lecturers' awareness and teaching capacity regarding circular economy concepts.
3. Investigating the effectiveness of curriculum reforms aimed at improving circular economy education.

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APPENDIX

QUESTIONNAIRE

Dear Respondent,

My name is **MOMOH EHI GLORIA**, a final-year student in the Department of Architecture, Faculty of Environmental Sciences, and University of Benin. I am conducting a research study as part of the requirements for the award of a bachelor's degree. This questionnaire is designed to gather information for my final year project titled **"EVALUATION OF THE LEVEL OF AWARENESS OF CIRCULAR ECONOMY STRATEGIES AMONG BUILT-ENVIRONMENT STUDENTS IN THE UNIVERSITY OF BENIN."**

Your responses will be treated with utmost confidentiality and will be used solely for academic purposes. Kindly answer the questions honestly and to the best of your knowledge.

SECTION A: DEMOGRAPHIC INFORMATION

1. What is your age?
2. What is your gender?
3. What is your department?
4. What is your level?
5. Relationship status

SECTION B: RESEARCH QUESTION

OBJECTIVE 1: THE LEVEL OF AWARENESS OF CE STRATEGIES BETWEEN DIFFERENT DEPARTMENTS WITHIN THE BUILT ENVIRONMENT STUDENTS IN UNIVERSITY OF BENIN.

6. How familiar are you with the term Circular Economy (CE)*?*
7. How well do you understand the main principles of circular economy (e.g., reuse, recycling, regeneration, waste minimisation)?
8. How well do you understand the strategies of circular economy (e.g. design for disassembly, material passport, etc

9. Have you been taught or exposed to circular-economy concepts in any course or departmental activity?

10. How would you rate the overall level of awareness of CE strategies among students in your department?

OBJECTIVE 2: BUILT ENVIRONMENTS STUDENTS UNDERSTANDING ON THE APPLICATIONS OF CIRCULAR ECONOMY STRATEGIES IN UNIVERSITY OF BENIN.

11. How familiar are you with the practical applications of circular-economy strategies in the built environment (e.g., sustainable building materials, waste reduction, recycling, and design for disassembly)?

12. Have you applied or observed circular-economy principles in any of your course projects, workshops, or fieldwork?

13. How confident are you in identifying ways to implement CE strategies in construction and design projects?

14. Which of the following circular-economy practices have you engaged with or learned to apply during your studies? (Check all that apply)

OBJECTIVE 3: THE EXTENT TO WHICH CE CONCEPTS ARE INTEGRATED INTO THE BUILT-ENVIRONMENT CURRICULUM IN THE UNIVERSITY OF BENIN

15. Have any of your courses included topics on circular-economy strategies (e.g., sustainable materials, waste management, recycling, energy efficiency)?

16. How often are circular-economy principles discussed or applied in your lectures, tutorials, or practical sessions?

17. Does your department provide workshops, seminars, or field visits focused on circular-economy applications?

18. How adequately do you think the current curriculum equips students to implement circular-economy strategies in real-world projects?

OBJECTIVE 4: RECOMMENDATION OF STRATEGIES FOR IMPROVING CIRCULAR ECONOMY EDUCATION IN THE UNIVERSITY OF BENIN

19. Which of the following strategies would most improve your understanding of circular-economy concepts? (Select all that apply)

20. How important is it for the department to provide training on CE tools, methods, and case studies?

21. Would collaboration with industry professionals or CE practitioners help improve your understanding and application of circular-economy strategies?

22. Which of the following would most motivate you to engage with CE learning opportunities? (Select all that apply)