Journal of Responsible Production and Consumption

Design professionals' awareness and engagement in design for adaptability (DfA) practices

Jenefailus Nikoi Kotei-Martin and Kofi Agyekum
Department of Construction Technology and Management, Building Science, Engineering and Materials Research Team, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana

Hayford Pittri
Institute of Sustainable Built Environment, School of Energy, Geoscience, Infrastructure and Society, Heriot-Watt University, Edinburgh, UK

Alex Opoku
Department of Architectural Engineering, College of Engineering, University of Sharjah, Sharjah, United Arab Emirates

Bernard Tuffour Atuahene
School of Architecture, Built Environment and Creative Industries, University of Bradford, Bradford, UK, and

Rhoda Gasue
Department of Construction Technology and Management, Building Science, Engineering and Materials Research Team, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana

Abstract

Purpose – Design issues are one of the factors contributing to waste production in the Ghanaian construction industry (GCI). Design for adaptability (DfA) is a construction approach that provides buildings with adaptive capabilities during the design phase. It facilitates easy modification, with no or limited demolition, waste reduction, sustainable construction and circularity. However, as to whether design professionals operating in the GCI are aware of this concept and its benefits and whether they consider some of its practices in the designs they produce are something that is yet to be ascertained. Therefore, this study aims to investigate the awareness and engagement of DfA practices among design professionals in the GCI.

Design/methodology/approach – The study adopted a quantitative research approach to retrieve responses from 236 design professionals (i.e. architects and civil/structural engineers) via survey questionnaires. The data retrieved from the respondents were analyzed using both descriptive and inferential statistical tests.

Journal of Responsible Production and Consumption
Vol. 2 No. 1, 2025
pp. 85-111
Emerald Publishing Limited
2977-0114
DOI 10.1108/JRPC-12-2024-0072

Findings – The findings revealed that the design professionals were moderately aware of the concept of DfA. Notwithstanding this moderate level of awareness, the design professionals' frequency of engagement in DfA practices was high, and factors such as profession, experience and type of firms they worked in, among others, did not influence their level of engagement in DfA practices.

Originality/value – This study pioneers research on DfA implementation in the GCI. It highlights design professionals' awareness and engagement in adaptability practices, thereby revealing gaps in knowledge, encouraging sustainable design and promoting resilience in architecture, which could ultimately contribute to a future-proofing built environment in Ghana.

Keywords Design for adaptability, Adaptable buildings, Sustainable construction, Design professionals, Construction industry, Ghana

Paper type Research paper

1. Introduction

In recent years, awareness of the environmental impact of construction activities has increased globally. One of the key environmental issues widely discussed among studies in the construction industry is wastage of all types (Frempong-Jnr *et al.*, 2023; Agyekum *et al.*, 2024). According to Agyekum *et al.* (2022), the building industry uses 40% of materials and 32% of energy consumption and generates approximately 35% of global waste products. The continued construction, endless demolition and frequent disposal of building projects are the fundamental sources of waste (Celadyn, 2019), which also contributes approximately 11% to global carbon emissions (Zhao *et al.*, 2023). Construction and demolition waste is influenced by the growing need for housing and municipal expansion (Negash *et al.*, 2021). An increase in housing and municipal expansion means increased wastage. Various researchers have called for the need to control these wastages. The adaptive reuse of buildings in line with the ideas of circular economy principles has been accepted as a sustainable practice capable of dealing with this menace (Foster, 2020; Hamida *et al.*, 2023; Watt *et al.*, 2023).

Ross *et al.* (2016) defined adaptability as a mechanism through which the physical components of a building can be deconstructed, refurbished, reconfigured, repurposed or expanded effortlessly. Therefore, in providing a building with these adaptive capabilities, it is expedient that considerations for the adaptive reuse of the building be integrated with the building design at the design stage (Akinade *et al.*, 2020; Askar *et al.*, 2021). The concept of designing buildings for adaptability highlights the end-of-life (EoL) phase of buildings such that their components can be reused (Askar *et al.*, 2022). Rockow *et al.* (2021) defined design for adaptability (DfA) as the process of designing buildings that can be easily modified throughout the building's lifecycle to meet the changing needs of society. Approximately 33% of construction waste is estimated to be circumvented by design (Munaro and Tavares, 2023); thus, DfA can reduce material usage, greenhouse gas emissions and energy consumption through its intrinsic adaptive capabilities (Baker *et al.*, 2017; Askar *et al.*, 2022). DfA also provides the best design method to enhance the preservation of building materials and extend the service life of buildings (Celadyn, 2019).

Agyekum *et al.* (2024) indicated that design, procurement, material storage and operating issues are the primary factors behind the waste of building materials in the Ghanaian construction industry (GCI), which ultimately leads to carbon emissions. Presently, there are several barriers between design practices and the future in which buildings are designed for a closed-loop circular economy (Watt *et al.*, 2023). Nonetheless, a few studies in Ghana have addressed circular design principles, such as design for deconstruction (DfD), design for disassembly (DfDass) and design for maintainability (DfM) (Pittri *et al.*, 2023; Agyekum *et al.*, 2023) which are closely related to DfA. Design for deconstruction focuses on salvaging the components of a building at its EoL phase for reuse (Pittri *et al.*, 2023), limiting this design principle to solely the EoL phase. DfM emphasizes the integration of maintenance principles at the design stage to ensure effective and efficient building maintenance (Agyekum *et al.*, 2023). However, this principle is also limited to the operational phase of buildings. Although DfA has been accepted as a key proactive approach to sustainable construction (Askar *et al.*, 2022), which focuses on both the operational and EoL phases of a building, there have been no studies in Ghana on this all-important sustainability concept. This assertion was reiterated by Agyefi-Mensah (2013), who opined that the level to which designs in the GCI fulfil the criteria of functionality and adaptability remains uncertain. Thus, design professionals must anticipate and embrace future uncertainties by using adaptable design principles, while also taking prudent risks (Watt *et al.*, 2023). Notwithstanding this recommendation by Agyefi-Mensah (2013), which also echoes the growing need for adaptable designs in response to environmental and societal changes, most design professionals lack awareness and engagement in these practices. Although serious, this is not surprising because no professional may want to engage in practices they have no or limited knowledge of. Therefore, as part of the growing concern of design professionals to engage in circular practices, this study poses the main research question, "what is the level of awareness and engagement of design professionals in design for adaptability practices in the Ghanaian construction industry?" From this question, the aim of the study was coined, i.e. to investigate the awareness and engagement of DfA practices among design professionals in the GCI. To achieve this aim, two specific objectives were set as follows: (1) to determine the level of awareness of design professionals of the concept of DfA; and (2) to determine the frequency of engagement of design professionals in the practice of DfA.

2. Literature review

This section reviews the literature pertinent to the theme under investigation. It is divided into three subsections. The first subsection introduces readers to the concept of DfA. The second and third subsections review literature on the two specific objectives, i.e. design professionals' awareness and engagement of DfA practices and the current state of DfA implementation in the GCI.

2.1 The concept of design for adaptability: definition and practices

The adaptability concept is not novel since its origin can be traced to a study on "supports as an alternative to mass housing" (Habraken, 1961). Currently, adaptability has been adopted by various disciplines such as ecology, architecture, business, engineering, education, planning and management (Pinder and Saker, 2013; Heidrich *et al.*, 2017). In these disciplines, the definition of adaptability is predicated on the ability of a system to modify changing environments to meet a particular purpose. From a building construction perspective, Geraedts (2016) averred that a building's adaptive capability encompasses all the features that allow it to maintain its usefulness by shifting needs and conditions over its entire technological history in an environmentally responsible and financially rewarding manner. The design phase plays a critical role in determining how buildings should be adapted, reused or demolished (Foster, 2020). According to McFarland *et al.* (2021a), DfA is the deliberate design of buildings to facilitate future modifications. Askar *et al.* (2022) also mentioned that DfA is a preconfigured design paradigm embedded in the design stage of buildings in response to emerging user needs and future demands. This suggests that materials, components, techniques, management decisions and information channels required to facilitate the adaptability of buildings must be developed during the design phase.

Gosling *et al.* (2013) proposed two alternative approaches to increase the adaptive capability of buildings: process-based and design-based enablers. While process-based enablers focus on management decisions, design-based decisions emphasize the design requirements for enhancing building adaptability. Gosling *et al.* (2013) further proposed four design-based enablers: layering of building elements, indeterminacy, interchangeable components and deconstruction design. Other studies have also identified 11 design-based enablers to enhance design decisions related to DfA (Ross *et al.*, 2016; Watt *et al.*, 2023). The DfA principles includes accurate information, reserve capacity, layering of building components and systems, open-plan layouts, simplicity, access for assessment, commonality, appropriate materials, mechanical connections, modularity and design for deconstruction. These principles have briefly been expounded below.

Accurate information focuses on providing records of the materials, components, systems, future modifications and adaptability plans for the building throughout its life cycle (Anastasiades *et al.*, 2020). With this information, designers can make well-informed decisions during the planning stages for potential changes to the building, as well as safeguard DfA strategies previously envisaged. The *reserve capacity* of a building considers its capability to handle a potential increase in future loads, which may be due to alterations in the load path, installation of additional mechanical equipment, changes in the building functionality or modifications for code compliance (Ross *et al.*, 2016). The *layering of building components and systems* emphasizes the design of buildings with distinct and easily accessible layers that can be modified independently without jeopardizing the integrity of others (Hamida *et al.*, 2023). *Open plan layouts* underscore design for flexibility within the interior space of the building by increasing the level of openness free of structural or mechanical obstructions to allow for easy reconfiguration (McFarland *et al.*, 2021b). *Simplicity* involves designing buildings such that their structural systems and load-transfer mechanisms are easily understood to reduce the uncertainty that future designers might encounter during the adaptation process (BRE Global, 2017). *Access for assessment* ensures that, while designing, access points are sufficiently available to inspect, upgrade, replace or maintain elements and components within the building to sustain their longevity (McFarland *et al.*, 2021a). *Commonality* involves designing buildings with consistent and repetitive component details throughout the building to enhance easy replacement (Ross *et al.*, 2016). Using *appropriate materials* focuses on the use of durable and nontoxic materials within buildings to secure their reuse capability in other building projects (Rockow *et al.*, 2021). *Mechanical connections* consider the design of buildings with elements that can be either assembled or disassembled with ease at any point during the lifecycle of the building, such as steel and precast concrete (Dams *et al.*, 2021). *Modularity* emphasizes the use of standard components or connection details between components in building projects (Hamida *et al.*, 2023). *Design for deconstruction* focuses on designing in a way that preserves the functional value of elements and components so that they can be salvaged for adaptive reuse at the end of the building life cycle (Pittri *et al.*, 2023).

Designing for adaptability addresses several environmental, social and economic challenges by providing sustainable and long-term design solutions to these effects. Through DfA, the reuse of materials reduces the need for new resources and the embodied energy associated with creating new construction components, as well as eliminating waste (Hamida *et al.*, 2023). By optimizing the building aspect ratio to maximize the dispersion of internal heat and minimize heat absorption from solar radiation, DfA provides buildings with climate-proofing capabilities to withstand continuous changes in climatic conditions (Huang *et al.*, 2016; Pranskūnienė and Zabulionienė, 2023) emphasized that designing to reuse existing buildings (i.e. heritage buildings) maximizes the society’s appreciation for a building’s cultural worth, while also reviving its historical relevance. DfA is also a viable approach to obtain economic sustainability, especially when compared to constructing new buildings; adaptive reuse of existing buildings allows for speedy configuration and repurposing, saving time and resources (Hamida *et al.*, 2023). The DfA practices identified in the reviewed literature are summarized in Table 1.

Table 1. Summary of DfA practices

S/N	DfA practices	Literature source (s)
DP 1	Designing to ensure the functional resilience of buildings	BRE Global, 2017; McFarland *et al.*, 2021b; Rockow *et al.*, 2021; Hamida *et al.*, 2023; Watt *et al.*, 2023
DP 2	Creating designs having in mind the structural durability of the building	BRE Global, 2017; McFarland *et al.*, 2021a; Rockow *et al.*, 2021; Hamida *et al.*, 2023; Watt *et al.*, 2023
DP 3	Outlaying the structure to have space-plan flexibility	McFarland *et al.*, 2021a; Rockow *et al.*, 2021; Watt *et al.*, 2023
DP 4	Keeping a balance of structural durability and space-plan flexibility in designs	McFarland *et al.*, 2021a; Rockow *et al.*, 2021; Watt *et al.*, 2023
DP 5	Endorsing the use of durable elements in design specification	Kelly *et al.*, 2011; Melton, 2020; Rockow *et al.*, 2021; Watt *et al.*, 2023
DP 6	Recommending the use of flexible connection methods within the building	McFarland *et al.*, 2021a; Rockow *et al.*, 2021; Watt *et al.*, 2023
DP 7	Designing with materials that can be easily dismantled	Ross *et al.*, 2016; BRE Global, 2017; Anastasiades *et al.*, 2020; Watt *et al.*, 2023
DP 8	Creating a structural grid that allows for a modular building skin	Ross *et al.*, 2016; Melton, 2020; Hamida *et al.*, 2023; Watt *et al.*, 2023
DP 9	Designing space plans based on standard material dimensions	Ross *et al.*, 2016; BRE Global, 2017; Melton, 2020; Anastasiades *et al.*, 2020; Hamida *et al.*, 2023; Watt *et al.*, 2023
DP 10	Incorporating design measures that maintain comfortability and a healthy indoor environment	McFarland *et al.*, 2021a; Rockow *et al.*, 2021; Watt *et al.*, 2023
DP 11	Creating designs using bioclimatic and biophilic principles	Ross *et al.*, 2016; Hart *et al.*, 2019; Melton, 2020; Kanters, 2020; Anastasiades *et al.*, 2020; Watt *et al.*, 2023
DP 12	Organizing building layers (i.e. the site, structure, skin, services, space plan, etc.) according to their end-of-life span in designs	Ross *et al.*, 2016; Rockow *et al.*, 2021; Hamida *et al.*, 2023; Watt *et al.*, 2023
DP 13	Designing to ensure that building service systems are separated	Ross *et al.*, 2016; Rockow *et al.*, 2021; Hamida *et al.*, 2023; Watt *et al.*, 2023
DP 14	Recommending the use of recyclable materials in design specifications	Ross *et al.*, 2016; Hart *et al.*, 2019; Melton, 2020; Kanters, 2020; Anastasiades *et al.*, 2020; Watt *et al.*, 2023
DP 15	Endorsing the reuse of materials in designs	Ross *et al.*, 2016; Hart *et al.*, 2019; Melton, 2020; Kanters, 2020; Anastasiades *et al.*, 2020; Watt *et al.*, 2023
DP 16	Creating designs to ensure the possibility of vertical expansions	Ross *et al.*, 2016; Melton, 2020; Kamara *et al.*, 2020; Rockow *et al.*, 2021; Hamida *et al.*, 2023; Watt *et al.*, 2023

(*continued*)

Table 1. Continued

S/N	DfA practices	Literature source (s)
DP 17	Using building elements that can be reassembled in design	Melton, 2020; Dams *et al.*, 2021; Hamida *et al.*, 2023; Watt *et al.*, 2023
DP 18	Designing with a deconstruction plan in mind	Ross *et al.*, 2016; Askar *et al.*, 2022; Pittri *et al.*, 2023; Watt *et al.*, 2023
DP 19	Ensuring that components can be selectively disassembled	BRE Global, 2017; McFarland *et al.*, 2021a; Rockow *et al.*, 2021; Hamida *et al.*, 2023; Watt *et al.*, 2023
DP 20	Creating designs that preserve the heritage of buildings	Ross *et al.*, 2016; Hart *et al.*, 2019; Melton, 2020; Kanters, 2020; Anastasiades *et al.*, 2020; Watt *et al.*, 2023

Source(s): Table created by authors

2.2 The awareness and engagement of design for adaptability practices

The adaptability of buildings has become a topic of increasing interest in architecture, engineering and construction literature (Heidrich *et al.*, 2017). Some studies have discussed its capability to preserve heritage buildings (Mehr and Wilkinson, 2021; Arfa *et al.*, 2022), developed tools to assess the adaptive potential of buildings (Conejos *et al.*, 2014; Herthogs *et al.*, 2019) and identified design principles to guide its actualization (Watt *et al.*, 2023). As user needs and demands change and environmental circumstances fluctuate as a result of variables such as climate change, the ability of buildings to adapt and respond to these changes becomes critical (Kamara *et al.*, 2020).

To promote the implementation of adaptability in the building industry, global reports on finding solutions to current environmental challenges have advocated an adaptive approach. Regarding climate change-related issues, the Intergovernmental Panel on Climate Change (IPCC, 2014) proposed that one sustainable approach to dealing with climate change is to increase the adaptive capacity of communities, infrastructure and buildings. According to the European Commission (2020), design for durability, adaptability and waste reduction are methodologies that have the potential to decrease waste production, optimize material utilization and reduce the environmental footprint of projects.

The extant literature reveals a nuanced but evolving discourse on DfA within the construction industry, highlighting both conceptual foundations and critical implementation challenges. Heidrich *et al.* (2017) provided a seminal exploration of building adaptability, delineating its conceptual boundaries by systematically analyzing its ontological meaning, multidimensional characteristics and fundamental architectural implications. Mlote *et al.* (2024) advanced the discourse by demonstrating the complex interplay of demographical, technological and economic drivers that underpin adaptability's functional, environmental and socioeconomic benefits. The study critically reveals the multifaceted nature of adaptive design beyond mere architectural transformation. Kamara *et al.* (2020) importantly problematized the narrow technological perspective, arguing that construction practitioners must critically engage with exogenous factors such as statutory legislative changes and shifts in building ownership that precipitate architectural adaptations. This perspective challenges traditional static design paradigms. Hamida *et al.* (2023) innovatively bridged conceptual domains by integrating circularity and adaptability, establishing sophisticated design and operational determinants that provide practitioners with a robust framework for adaptive responsiveness in architectural environments. Vafaie *et al.* (2023) made significant methodological contributions by systematically identifying ten strategic categories of success factors for adaptive reuse strategies, particularly in heritage building regeneration. The study offers a structured approach to navigating the complex architectural and historical preservation landscape. Melton (2020) critically examined architects' pivotal role in the DfA framework, recommending strategic client engagement strategies that emphasize the environmental and economic drawbacks of conventional demolition and reconstruction practices. This approach represents a paradigmatic shift toward more sustainable architectural practices. Askar *et al.* (2022) further advanced the field by advocating for comprehensive assessment criteria to evaluate adaptive capabilities across diverse building typologies, thereby providing practitioners with a rigorous methodological toolkit for adaptive design evaluation. Collectively, these scholarly contributions underscore the emerging complexity of DfA, revealing it as a dynamic, interdisciplinary domain that transcends traditional architectural conceptualizations.

In Europe, Asia, North America and Australia, the awareness of designing and constructing adaptable buildings continues to increase, with the retrofitting and repurposing of existing buildings for residential and commercial purposes (Pinder and Saker, 2013; Aigwi *et al.*, 2022; Tleuken *et al.*, 2022). Nonetheless, within Africa, countries continue to struggle to deliver resilient (adaptable) infrastructure (e.g. buildings) within urban and rural communities

(Chirisa *et al.*, 2016). Although DfA practices and principles have been initiated, challenges remain regarding their engagement levels. Askar *et al.* (2022) averred that the limited availability of practical guidelines and design support tools that enable performance assessment and simulation of the added value of DfA practices throughout the lifecycle of a building presents a challenge to its practicality. The study also mentioned a lack of supportive legislation to address its adoption. Despite the importance of designing for adaptability in buildings, it has yet to become a staple priority for clients and construction professionals (e.g. architects and engineers) (Melton, 2020).

2.3 The current state of design for adaptability implementation in the Ghanaian construction industry

DfA is regarded as one of the sustainable design practices in literature due to its potential to conserve resources through its adaptive reuse capabilities (Rockow *et al.*, 2021; Askar *et al.*, 2022; Watt *et al.*, 2023). Within the Ghanaian construction context, numerous studies have advocated the adoption of sustainable design practices in the construction industry to address its environmental impact (Atombo *et al.*, 2015; Pittri *et al.*, 2024) Asman *et al.* (2019) examined the critical components that influence sustainable design practices in Ghana and stated that waste reduction, reuse and recyclability principles are among the major factors that ensure environmental preservation. Asare *et al.* (2020) also explored the application of building information modeling-lifecycle assessment (BIM-LCA) integration to provide sustainable design solutions based on simulations that considered the carbon effects of the design solution. Concerning concepts of adaptable buildings in Ghana, Oppong and Masahudu (2014) investigated the challenges of managing the adaptation and retrofit of existing buildings in Ghana to facilitate effective project management solutions in the future. Koranteng *et al.* (2019) evaluated the functional efficiency of the spatial configuration of apartment buildings in Ghana. However, few studies have discussed the implementation of DfA practices in the GCI. Agyefi-Mensah (2013) explored the functionality and adaptability of design solutions for public apartments in Ghana. The study held that design professionals need to focus on the future use of buildings, not just on the current activity of users. Kotei-Martin *et al.* (2025) also examined the challenges to the implementation of DfA practices among design professionals in Ghana. Some of the challenges included the lack of collaboration between design professionals and other construction stakeholders on realizing adaptable buildings and the lack of education and training on DfA practices, among others.

2.4 The identified gap

From the review of the related literature, it is evident that there exists a gap in the literature when it comes to DfA. This gap lies in the limited understanding of how design professionals perceive and implement adaptability practices. There is also very limited information on professionals' awareness of DfA and DfA knowledge transfer, among others. As a starter, this study focuses on investigating design professionals' awareness and frequency of engagement in DfA practices. This is because understanding the level of awareness of design professionals of DfA can highlight opportunities to enhance sustainable practices. Ascertaining their level of engagement in DfA practices provides an avenue to identify gaps in knowledge and skills among the professionals that can inform the development of targeted educational programs to promote the adoption of DfA strategies in the construction industry.

3. Research methodology

3.1 Research approach and strategy

This study sought to investigate the awareness and engagement of DfA practices among design professionals in the GCI. To achieve this aim, two specific objectives were set as follows: (1) to determine the level of awareness of design professionals of the concept of DfA; and (2) to determine the frequency of engagement of design professionals in the practice of DfA. While any study could adopt any methodological approach, each method is suited to specific types of research questions and their stated objectives (Newhart and Patten, 2023). A quantitative research approach was deemed suitable for this study because of the two research questions that guided the study, i.e. (1) What is the level of awareness of design professionals of the concept of DfA? and (2) What is the frequency of engagement of design professionals in the practice of DfA? According to Creswell (2009), quantitative research normally asks the questions "what," "how many" and "how much." From the research questions that guided this study, it was obvious that the quantitative research approach was suitable. This approach allows the collection of quantifiable measures of variables and inferences to be drawn from the population (Queirós *et al.*, 2017). According to Bryman (2016), if a study seeks to determine the differences between various variables using numerical data and statistical means of analysis, the quantitative research method is the most appropriate. Since the awareness and frequency of engagement of DfA principles were to be assessed among a large population (i.e. design professionals), it was expedient to adopt the quantitative approach to retrieve numerical data to be able to generalize findings using statistical techniques from a sample to the larger population (Kotei-Martin *et al.*, 2025). The strategy that works best with the quantitative research approach adopted for this study is the survey strategy (Newhart and Patten, 2023). The survey strategy was suitable because it allowed the gathering of quantitative data from a broad range of design professionals, thereby facilitating the identification of trends and patterns in the level of awareness and frequency of engagement.

3.2 Survey design and administration

3.2.1 Questionnaire design and validation. This study used questionnaires to gather numerical data to obtain generalized findings about the awareness and frequency of engaging in DfA practices among design professionals in Ghana. Roopa and Rani (2012) indicated that questionnaires are the most effective when it comes to the structured collection of quantitative data, guaranteeing that the acquired results are internally consistent and coherent. The questionnaire for this study was developed by adapting the variables identified from related literature reviewed on the topic (*see* Table 1). The content of questionnaires can be either open- or closed-ended. Closed-ended questions were used in this study. This was premised on Sreejesh *et al.* (2014), who opined that closed-ended questions allow the researcher to seek the opinions of respondents based on a predefined set of variables. The questionnaire was divided into three parts. The first part contained questions that sought the demographic background of the respondents, including their occupation, the type of firm they work in, years of experience and their professional background in the GCI. The second part of the questionnaire required respondents to indicate their level of awareness of the concept of DfA based on their familiarity with the DfA concept, whether they had any formal education or professional training in DfA, and their willingness to participate in a DfA training program. The questions in the second part required a "yes" or "no" response. In the third part, respondents were asked to rate their frequency of engagement in 20 DfA practices on a five-point Likert scale (1 = never, 2 = rarely, 3 = sometimes, 4 = often and 5 = always). The five-point Likert scale is well adopted in studies focused on various concepts in the construction industry (Manu *et al.*, 2021; Pittri *et al.*, 2023). A sample of the questionnaire is shown in Appendix 2.

Before the questionnaire was administered, its validity had to be determined through piloting. Tsang *et al.* (2017) indicated that the assessment of a questionnaire's validity involves examining whether it accurately measures the desired constructs. A two-step pilot process was conducted before data collection to ensure the validity of the questionnaire used in this study. In the first step, a draft questionnaire was piloted among four academic professors; two had an architectural background and the other two were experts in the structural system of buildings. This group was asked to determine whether: the questions were easy to interpret and understand, the questions did not omit other important DfA practices and strategies for implementation and the questions could be adapted for future studies/references. Upon their approval, the second piloting stage was conducted among six design professionals in the GCI with experience in designing adaptable buildings. During the piloting process, the respondents were asked to determine: whether there was clarity in the instructions of the questionnaire, whether the average time involved in answering the questionnaire was okay and the suitability of the overall flow of questions. As there are no absolute rules to guide the determination of a sample size for validating a questionnaire (Tsang *et al.*, 2017), this study selected 10 respondents for the process. It is, therefore, expedient to note that after a few clarifications on the content of the questionnaire during the piloting stage, it was approved for further administration.

3.2.2 Survey administration. The study population consisted of design professionals (Architects and Civil/Structural Engineers) who were either self-employed or working with consultancy, construction or engineering firms in the GCI. These professionals were deemed fit for this study because they are responsible for providing optimum design solutions as part of the traditional procurement process for construction projects in Ghana. However, determining the population of design professionals (i.e. Architects and Civil/Structural Engineers) is challenging despite the existence of recognized professional bodies in Ghana (Botchway *et al.*, 2023; Amudjie *et al.*, 2023). Therefore, two nonprobability sampling techniques were used in this study (i.e. purposive and snowball sampling). Chronologically, this study purposively identified the potential respondents from the professional bodies they belong to (i.e. Ghana Institute of Architects [GIA], Ghana Institution of Engineers [GhIE] and Institution of Engineering and Technology Ghana [IET]). Snowball sampling was then used to recruit additional participants for this study through referrals from design professionals who shared similar attributes with the target population. These sampling techniques enabled the researchers to retrieve 236 valid responses. This sample size was deemed appropriate since researchers reached saturation with the 236th respondent. Moreover, this approach has been used by Kotei-Martin *et al.* (2025) and is considered viable and reliable in achieving the aim of their study.

3.3 Analyses of data

The data collected for this study were fed into Microsoft Excel for preliminary inspection to ensure the completeness of all responses. After confirming the completeness of the retrieved data, the data were transferred into the Statistical Package for Social Science software version 26 for analysis and results. Descriptive analysis (i.e. frequencies, mean score ranking and standard deviations) coupled with inferential analysis (i.e. one-sample *t-test*, independent sample *t-test* and one-way analysis of variance [ANOVA]) were used to analyze the data. Before *t*-tests are used, normality tests are conducted since they fall under parametric tests (Gerald, 2018). However, the normality tests are overlooked for robust analyses such as the ANOVA and *t*-tests since they assume that the samples drawn from the population were normally distributed (Kwak and Park, 2019; Agyekum and Amudjie, 2024). Moreover, data related to the demographic background of the respondents were analyzed using frequencies. To determine the engagement levels of respondents regarding the 20 DfA practices, the one-sample *t-test*, independent sample *t-test* and one-way ANOVA were used. The reasons for using these parametric tests are provided in Section 4.

4. Results and discussion

4.1 Demographic background of respondents

The demographic information of the design professionals targeted for this study revealed that out of the 236 responses retrieved, 105 (44.5%) respondents were architects and 131 (55.5%) were Civil/Structural Engineers. Of the respondents, 126 (53.4%) worked in consultancy firms, 52 (22.0%) in construction firms, 31 (13.1%) in engineering firms and 27 (11.4%) in freelancing firms. Considering the working experience of respondents, 55 (23.3%) had between 1 and 5 years of experience, 76 (32.2%) had 6–10 years of experience, 21 (8.9%) had between 11 and 15 years of experience, 41 (17.4%) had between 16 and 20 years of experience and 43 (18.2%) had over 20 years of experience. In addition, 88 (37.3%) respondents were members of the GIA, 139 (58.9%) were members of the GhIE and 9 (3.8%) were members of the IET Ghana (Ghana) (see Appendix 1 for a tabular presentation).

4.2 Objective 1: Awareness level of design professionals of design for adaptability

The first objective sought to determine the design professionals' level of awareness of the concept of DfA. The results of this objective are shown in Table 2. Of the 236 respondents, 140 (59.3%) were aware of the DfA concept prior to the survey and 96 (40.7%) were not aware of the DfA concept. This shows that a moderate number of design professionals in the GCI are aware of the DfA concept. However, regarding whether they had any formal education on the DfA concept, only 73 (30.9%) respondents had received formal education on DfA or related lessons. Concerning professional training on DfA, 180 (76.3%) respondents had no professional training on DfA. Nonetheless, the majority of respondents (231, 97.9%) were willing to participate in professional development training on the concept

Table 2. Summary of awareness level of design professionals of DfA

Demographic	Frequency	%
Awareness of DfA concept		
Yes	140	59.3
No	96	40.7
Total	*236*	*100*
Formal education on DfA concept		
Yes	73	30.9
No	163	69.1
Total	*236*	*100*
Professional development training on DfA concept		
Yes	56	23.7
No	180	76.3
Total	*236*	*100*
Willingness to participate in professional development training on DfA		
Yes	231	97.9
No	5	2.1
Total	*236*	*100*
Mode for professional development training		
Online course/webinar	146	61.9
Face-to-face course/seminar	90	38.1
Total	*236*	*100*

Source(s): Table created by authors

of DfA. While 61.9% of the respondents preferred such training to be conducted through an online course/webinar, 38.1% preferred a face-to-face course/seminar.

Although a moderate level of awareness of DfA was recorded among professionals, much awareness is still needed to drive the implementation of DfA practices in the GCI. Granheimer *et al.* (2022) mentioned that design professionals play a crucial role in developing future infrastructure, planning and design, as their services are invaluable in solving carbon reduction issues. As design professionals become more aware of the interconnection between environmental and social issues, there is a likelihood of greater demand for flexible structures to reduce their environmental effects while meeting changing needs (Dodo *et al.*, 2013). According to Munaro and Tavares (2023), providing education and training for design professionals is the key to enhancing their awareness and practice of DfA. When designers are educated on the importance and benefits of DfA practices that contribute to sustainable construction and circularity, the stakes concerning its application in their design practice are higher. Furthermore, when the construction industry becomes increasingly aware of carbon emissions (Lamptey *et al.*, 2021), it is crucial to provide design professionals with the necessary training on tools and techniques that enable buildings to adapt. This ensures that optimal solutions are achieved during the design phase, leading to waste reduction and, invariably, carbon reduction. Unfortunately, designers in GCI lack formal education and professional training on the principles of DfA, although they are somewhat aware of the ideology behind the concept. Therefore, increasing the awareness of DfA practices through formal education and training among design professionals will not only expose them to the benefits of DfA but will also imbibe in them the required competency to facilitate adaptable designs and buildings to curb the issues of building obsolescence and construction and demolition waste within the GCI.

4.3 Objective 2: Frequency of engagement of design for adaptability practices among design professionals in the Ghanaian construction industry

The second objective of this study sought to determine design professionals' frequency of engagement in DfA practices. On a five-point Likert scale ranging from "Never" to "Always," the engagement levels of design professionals with 20 DfA practices were analyzed using frequency distributions. The results in Table 3 show that more than 50% of the respondents often or always engage in all 20 DfA practices within the GCI. The top four DfA practices mostly considered were DP 5 (endorsing the use of durable elements in my design specification), DP 2 (creating designs that consider the structural durability of the building), DP 3 (outlaying the structure to have space-plan flexibility) and DP 4 (maintaining a balance of structural durability and space-plan flexibility in my designs). This means that design professionals in the GCI frequently engage in DfA practices. According to Pinder and Saker (2013), construction stakeholders, including design professionals, have demonstrated interest in building adaptability over the years. As a result, this interest may be a driving factor for their engagement in some DfA practices.

4.3.1 One-sample t-test of engagement in design for adaptability practices. A one-sample *t*-test was used to analyze the statistical significance of the 20 DfA practices and to ascertain whether the respondents considered their mean frequencies of engagement in the practices to be at least "often" based on a test value of 3.5 (Agyekum *et al.*, 2022; Botchway *et al.*, 2023; Pittri *et al.*, 2023; Amudjie *et al.*, 2023). As shown in Table 4, all 20 DfA practices had positive *t*-values (strength of test), indicating that their mean scores were above the hypothesized mean (3.50). The top five ranked DfA practices were *DP 5* (*T*-value = 13.880, mean score [MS] = 4.28), *DP 2* (*T*-value = 13.456, MS = 4.27), *DP 3* (*T*-value = 12.389, MS = 4.23), *DP 4* (*T*-value = 11.128, MS = 4.16) and *DP 1* (*T*-value = 9.195, MS = 4.08). From the

Table 3. Summary of analyses of frequency of engagement of DfA practices (frequencies)

		Frequency of engagement in design for adaptability (DfA) practices					
S/N	DfA practices	Never (%)	Rarely (%)	Sometimes (%)	Often (%)	Always (%)	Often and always (%)
DP 1*	Designing to ensure the functional resilience of buildings	2.1	4.2	18.2	33.9	41.5	*75.4*
DP 2*	Creating designs having in mind the structural durability of the building	1.3	3.0	11.9	35.6	48.3	*83.9*
DP 3*	Outlaying the structure to have space-plan flexibility	1.3	3.4	14.4	32.6	48.3	*80.9*
DP 4*	Keeping a balance of structural durability and space-plan flexibility in my designs	0.8	3.8	17.8	33.9	43.6	*77.5*
DP 5*	Endorsing the use of durable elements in my design specification	1.7	1.3	12.7	36.4	47.9	*84.3*
DP 6*	Recommending the use of flexible connection methods within the building	1.3	5.5	26.3	38.1	28.8	*66.9*
DP 7*	Designing with materials that can be easily dismantled	3.4	9.3	28.8	32.6	25.8	*58.4*
DP 8*	Creating a structural grid that allows for a modular building skin	2.5	5.9	21.2	30.5	39.8	*70.3*
DP 9*	Designing space plans based on standard material dimensions	0.8	9.7	25.4	37.7	26.3	*64.0*
DP 10*	Incorporating design measures that maintain comfortability and a healthy indoor environment	1.7	8.1	18.2	35.6	36.4	*72.0*
DP 11*	Creating designs using bioclimatic and biophilic principles	3.4	8.5	30.5	29.2	28.4	*57.6*
DP 12*	Organizing building layers (i.e. the site, structure, skin, services, space plan and stuff) according to their end-of-life span in my designs	1.7	11.9	25.8	31.8	28.8	*60.6*
DP 13*	Designing to ensure that building service systems are separated	2.5	9.7	25.4	34.3	28.0	*62.3*
DP 14*	Recommending the use of recyclable materials in my design specifications	3.0	11.4	30.1	28.4	27.1	*55.5*
DP 15*	Endorsing the reuse of materials in my designs	3.0	11.4	28.4	36.4	20.8	*57.2*
DP 16*	Creating designs to ensure the possibility of vertical expansions	4.7	9.7	29.2	34.7	21.6	*56.3*
DP 17*	Using building elements that can be reassembled in my design	3.8	15.3	28.4	30.5	22.0	*52.5*
DP 18*	Designing with a deconstruction plan in mind	5.1	11.0	28.0	27.1	28.8	*55.9*
DP 19*	Ensuring that components can be selectively disassembled	4.7	10.2	25.4	29.2	30.5	*59.7*
DP 20*	Creating designs that preserve the heritage of buildings	1.3	8.5	20.3	33.9	36.0	*69.9*

Note(s): *DfA practices which more than 50+% respondents frequently engage with often or always
Source(s): Table created by authors

Table 4. Summary of analyses of frequency of engagement of DfA practices (one-sample *t*-test)

	Summary of analyses of the frequency of engagement of DfA practices (one-sample *t*-test)					
		Cronbach's alpha = 0.919, test value = 3.50				
S/N	DfA practices	*T*-value	Mean	Std. deviation	Rank	*p*-value
DP 1	Designing to ensure the functional resilience of buildings	9.195	4.08	0.977	5th	0.000^t
DP 2	Creating designs having in mind the structural durability of the building	13.456	4.27	0.876	2nd	0.000^t
DP 3	Outlaying the structure to have space-plan flexibility	12.389	4.23	0.909	3rd	0.000^t
DP 4	Keeping a balance of structural durability and space-plan flexibility in my designs	11.128	4.16	0.907	4th	0.000^t
DP 5	Endorsing the use of durable elements in my design specification	13.880	4.28	0.858	1st	0.000^t
DP 6	Recommending the use of flexible connection methods within the building	6.196	3.88	0.935	9th	0.000^t
DP 7	Designing with materials that can be easily dismantled	2.635	3.68	1.062	15th	0.009^t
DP 8	Creating a structural grid that allows for a modular building skin	7.263	3.99	1.040	6th	0.000^t
DP 9	Designing space plans based on standard material dimensions	4.560	3.79	0.971	10th	0.000^t
DP 10	Incorporating design measures that maintain comfortability and a healthy indoor environment	7.138	3.97	1.012	7th	0.000^t
DP 11	Creating designs using bioclimatic and biophilic principles	2.971	3.71	1.074	13th	0.003^t
DP 12	Organizing building layers (i.e. the site, structure, skin, services, space plan and stuff) according to their end-of-life span in my designs	3.519	3.74	1.054	12th	0.001^t
DP 13	Designing to ensure that building service systems are separated	3.729	3.75	1.047	11th	0.000^t
DP 14	Recommending the use of recyclable materials in my design specifications	2.156	3.65	1.087	16th	0.032^t
DP 15	Endorsing the reuse of materials in my designs	1.577	3.61	1.032	18th	0.116
DP 16	Creating designs to ensure the possibility of vertical expansions	1.273	3.59	1.074	19th	0.204
DP 17	Using building elements that can be reassembled in my design	0.235	3.52	1.109	20th	0.815
DP 18	Designing with a deconstruction plan in mind	1.800	3.64	1.157	17th	0.073
DP 19	Ensuring that components can be selectively disassembled	2.791	3.71	1.143	14th	0.006t
DP 20	Creating designs that preserve the heritage of buildings	6.836	3.95	1.009	8th	0.000t

Note(s): ^{t}one sample *t*-test result is significant at 0.05 significance level, *p*-value < 0.05 (two-tailed)
Source(s): Table created by authors

same table, 4 of the 20 DfA practices had *p*-values higher than 0.05, indicating that there was no statistical significance in those practices. The findings show that the majority of design professionals within the GCI frequently engage in DfA practices. This solidifies the results revealed in the frequency table (*see* Table 3) concerning their high level of engagement in DfA practices. However, these findings can be attributed to the high level of awareness among design professionals. According to Kwofie *et al.* (2016), the success of construction projects depends on a strong professional knowledge base, skills and ability to make informed decisions by design professionals. Therefore, if design professionals exhibit a strong level of awareness of DfA practices, it is not surprising that they are also portraying high levels of engagement in their projects. By contrast, there is a likelihood that those who are seldom aware of DfA practices will not likely implement it. These findings concur with those of Pinder and Saker (2013) and Hamida *et al.* (2024) in that there is an increase in the awareness level regarding the concept of designing adaptable buildings. Kelly *et al.* (2011) also mentioned that developing a deeper grasp of adaptable buildings is essential for architects who focus on designing such buildings. Moreover, the findings challenge the assertion of Heidrich *et al.* (2017) and Watt *et al.* (2023), which purports a lack of awareness of the DfA concept among design professionals and other stakeholders in the construction industry.

4.3.2 Independent sample t-test for engagement in design for adaptability practices. An independent sample *t*-test was used to analyze statistically significant differences in the mean frequency of involvement among the 20 DfA practices based on the following clusters:

- Differences in the frequency of engagement of DfA practices based on the awareness of design professionals on the DfA concept.
- Differences in the frequency of engagement of DfA practices based on design professionals' formal education on DfA.
- Differences in the frequency of engagement of DfA practices based on the profession of the respondents.

Table 5 shows the results of the independent sample *t*-tests. This section of the study only includes DfA practices that yielded statistically significant results ($p \leq 0.05$ [two-tailed]). When comparing respondents who were aware of the DfA concept to those who were not aware, 2 out of the 20 DfA practices were shown to be statistically significant. These two practices were *DP 2 (creating designs having in mind the structural durability of the building)* and *DP 16 (creating designs to ensure the possibility of vertical expansions)*. Similarly, when comparing the group of respondents who had formal education on the DfA concept to the group with no formal education on DfA, the results showed that one out of the 20 DfA practices had a significant difference (i.e. *DP 16*). In the last section of Table 5, the findings revealed that only 2 out of the 20 DfA practices had a significant difference when their engagement levels among architects were compared with those of civil/structural engineers. These two practices include *DP 10 (incorporating design measures that maintain comfortability and a healthy indoor environment)* and *DP 11 (creating designs using bioclimatic and biophilic principles)*. It can be inferred from the findings that the profession of the respondents, their formal education and awareness levels of the DfA concept have limited or no influence on their frequency of engagement in DfA practices. This means that there might be other significant factors that drive the frequency of engagement in DfA practices in the GCI. Some studies have suggested that the development of tools and guidelines for DfA practices will influence its implementation among design professionals (Heidrich *et al.*, 2017; Askar *et al.*, 2022).

Table 5. Summary of the independent sample *t*-test on the frequency of engagement based on the awareness of the DfA practices

								95% confidence interval of the difference	
Independent sample t-test based on the awareness of respondents									
S/N	DfA practices	Design for adaptability awareness	N	Mean	SD	*t*-value	*p*-value sig. (two-tailed)	Lower	Upper
DP 2	Creating designs having in mind the structural durability of the building	Yes	140	4.39	0.836	2.545	0.012	0.066	0.518
		No	96	4.09	0.907				
DP 16	Creating designs to ensure the possibility of vertical expansions	Yes	140	3.71	1.083	2.055	0.041	0.012	0.569
		No	96	3.42	1.043				
Independent sample t-test based on education								95% confidence interval of the difference	
S/N	DfA practices	Design for adaptability receipt of formal education	N	Mean	SD	*t*-value	*p*-value sig. (two-tailed)	Lower	Upper
DP 16	Creating designs to ensure the possibility of vertical expansions	Yes	73	3.89	0.994	2.931	0.004	0.143	0.730
		No	163	3.45	1.084				
Independent sample t-test based on the profession of respondents								95% confidence interval of the difference	
S/N	DfA practices	Design for adaptability profession	N	Mean	SD	*t*-value	*p*-value sig. (two-tailed)	Lower	Upper
DP 10	Incorporating design measures that maintain comfortability and a healthy indoor environment	Architect	105	4.18	0.988	2.907	0.004	0.122	0.637
		Civil/structural engineer	131	3.80	1.003				
DP 11	Creating designs using bioclimatic and biophilic principles	Architect	105	3.90	0.966	2.555	0.011	0.081	0.629
		Civil/structural engineer	131	3.55	1.131				

Source(s): Table created by authors

4.3.3 One-way analysis of variance results for the engagement levels of design for adaptability practices. One-way ANOVA was used to determine statistically significant differences in the mean frequency of engagement in the 20 DfA practices across the two clusters:

(1) Experience in respondents' professions (categorized as 1–5 years, 6–10 years, 11–15 years, 16–20 years and over 20 years); and

(2) Type of firm respondents work with (categorized as consultancy firm, construction firm, engineering firm and freelancing).

Table 6 shows a summary of the results from the one-way ANOVA tests, which included DfA practices that yielded statistically significant results ($p \leq 0.05$ [two-tailed]) only. The one-way ANOVA test based on the respondents' type of firm (i.e. consultancy, construction, engineering and freelancing firms) showed that only 2 out of the 20 DfA practices had statistically significant differences. This suggests that the respondents' firm type does not influence the frequency of engagement in DfA practices. Likewise, in the same table, the findings revealed that 1 out of the 20 DfA practices were statistically different in terms of their engagement levels based on the respondents' years of experience (i.e. 1–5 years, 6–10 years, 11–15 years, 16–20 years and over 20 years). These findings suggest that the type of firm respondents work in, coupled with their years of experience in their profession, does not influence their frequency of engagement in DfA practices. In general, all the tests conducted on the engagement levels of the DfA practices reveal that the implementation of DfA practices does not depend on the social attributes of the design professionals (i.e. profession, awareness level and years of experience, among others); rather, there might be some external factors driving its implementation. Kamara *et al.* (2020) reveal such external factors to include "changes in legislation," "market forces" and "environmental conditions."

5. Conclusion

This study investigated the awareness and engagement levels of DfA practices among design professionals in GCI. Generally, the study concluded that design professionals in the GCI were moderately aware of the DfA concept, although the majority of them did not have any

Table 6. Summary analyses of one-way ANOVA for engagement levels of DfA practices

S/N	DfA practices		Sum of squares	df	Mean square	*F*	Sig.
One-way ANOVA based on types of firm							
DP 4	Keeping a balance of structural durability and space-plan flexibility in my designs	Between groups	7.165	3	2.388	2.979	0.032
		Within groups	186.034	232	0.802		
		Total	193.199	235			
DP 5	Endorsing the use of durable elements in my design specification	Between groups	5.763	3	1.921	2.663	0.049
		Within groups	167.335	232	0.721		
		Total	173.097	235			
One-way ANOVA based on years of experience							
DP 19	Ensuring that components can be selectively disassembled	Between groups	16.046	4	4.011	3.187	0.014
		Within groups	290.781	231	1.259		
		Total	306.826	235			

Source(s): Table created by authors

formal education or training of the concept. Nonetheless, enhancing awareness of the DfA concept through formal education and training sessions is beneficial for knowledge and skill acquisition. Design professionals also indicated a high engagement level of DfA practices in GCI. In determining the nexus between the awareness levels of the DfA concept and its frequency of engagement, it was concluded that the awareness of design professionals had a limited bearing on their frequency of engagement. Additionally, other factors such as profession, years of experience, type of firm they work in and formal education on the DfA concept do not influence their engagement level of the DfA practices in the GCI.

The results of this study have theoretical and practical implications. From a theoretical perspective, this study contributes to the limited literature on the concept of DfA and its implementation among design professionals emphasizing the current awareness level of the concept and the frequency of engagement of its practices. Therefore, theoretically, the study has the potential to expand existing frameworks of design thinking and adaptability. Also, the findings can theoretically contribute to the development of new models that integrate the principles of adaptability into design education and practice. Practically, this study contributes to the creation of awareness of DfA implementation among design professionals and its potential to reduce waste and carbon emissions. It also informs design professionals of DfA practices that can provide optimal design solutions to promote sustainable construction in construction projects. The findings can potentially inform the development of targeted training programs that fosters greater awareness and engagement in adaptable design practices. Also, the findings could guide organizations to implement best practices and strategies that prioritize resilience and sustainability and which can ultimately encourage effective and innovative design solutions that can better respond to environmental and societal changes. Although this study offers several benefits, it also acknowledges some shortcomings. First, the study specifically focused on design professionals in the GCI, namely, architects and civil/structural engineers. Other design engineers, similar to service engineers, were excluded from this study because of the sampling techniques used (i.e. purposive and snowball sampling). For instance, purposive sampling was based on the researcher's judgment of respondents deemed relevant to the study. Similarly, the referral method of selecting respondents under snowballing may result in overrepresentation or underrepresentation of the population. Hence, future research could be broadened to incorporate the perspectives of additional design experts, who were not considered in this study.

References

Agyefi-Mensah, S. (2013), "Functionality and adaptability of design solutions for public apartment buildings in Ghana: towards evidence-based design for sustainable lifespan building performance", PhD Thesis, Technische Universiteit Eindhoven, doi: 10.6100/IR762203.

Agyekum, K. and Amudjie, J. (2024), "Challenges to implementing circular economy: empirical evidence among built environment firms in Ghana", *International Journal of Construction Management*, Vol. 24 No. 3, pp. 281-297, doi: 10.1080/15623599.2023.2222993.

Agyekum, K., Goodier, C. and Oppon, J.A. (2022), "Key drivers for green building project financing in Ghana", *Engineering, Construction and Architectural Management*, Vol. 29 No. 8, pp. 3023-3050. doi: 10.1108/ECAM-02-2021-0131.

Agyekum, K., Amudjie, J., Pittri, H., Dompey, A.M.A. and Botchway, E.A. (2024), "Prioritizing the principles of circular economy among built environment professionals", *Built Environment Project and Asset Management*, Vol. 14 No. 5, pp. 734-750, doi: 10.1108/BEPAM-04-2023-0077.

Agyekum, K., Dompey, A.M.A., Pittri, H. and Botchway, E.A. (2023), "Design for maintainability (DfM) implementation among design professionals: empirical evidence from a developing country context", *International Journal of Building Pathology and Adaptation*, doi: 10.1108/IJBPA-06-2023-0078.

Aigwi, I.E., Nwadike, A.N., Le, A.T.H., Rotimi, F.E., Sorrell, T., Jafarzadeh, R. and Rotimi, J. (2022), "Prioritising optimal underutilised historical buildings for adaptive reuse: a performance-based MCDA framework validation in Auckland, New Zealand", *Smart and Sustainable Built Environment*, Vol. 11 No. 2, pp. 181-204, doi: 10.1108/SASBE-08-2021-0139.

Akinade, O., Oyedele, L., Oyedele, A., Delgado, J.M.D., Bilal, M., Akanbi, L., Ajayi, A. and Owolabi, H. (2020), "Design for deconstruction using a circular economy approach: barriers and strategies for improvement", *Production Planning and Control*, Vol. 31 No. 10, pp. 829-840, doi: 10.1080/09537287.2019.1695006.

Amudjie, J., Agyekum, K., Adinyira, E., Amos-Abanyie, S. and Kumah, V.M.A. (2023), "Awareness and practice of the principles of circular economy among built environment professionals", *Built Environment Project and Asset Management*, Vol. 13 No. 1, pp. 140-156, doi: 10.1108/BEPAM-11-2021-0135.

Anastasiades, K., Blom, J., Buyle, M. and Audenaert, A. (2020), "Translating the circular economy to bridge construction: lessons learnt from a critical literature review", *Renewable and Sustainable Energy Reviews*, Vol. 117, p. 109522, doi: 10.1016/j.rser.2019.109522.

Arfa, F.H., Zijlstra, H., Lubelli, B. and Quist, W. (2022), "Adaptive reuse of heritage buildings: from a literature review to a model of practice", *The Historic Environment: Policy and Practice*, Vol. 13 No. 2, pp. 148-170, doi: 10.1080/17567505.2022.2058551.

Asare, K.A., Ruikar, K.D., Zanni, M. and Soetanto, R. (2020), "BIM-based LCA and energy analysis for optimised sustainable building design in Ghana", *SN Applied Sciences*, Vol. 2 No. 11, pp. 1-20, doi: 10.1007/s42452-020-03682-2.

Askar, R., Bragança, L. and Gervásio, H. (2021), "Designing buildings for adaptability, flexibility, and durability", *Sustainable Urban Development: Topics, Trends and Solutions*, Bristol, UK, pp. 1-10. IOP Publishing, doi: 10.1088/978-0-7503-3971-1ch10.

Askar, R., Bragança, L. and Gervásio, H. (2022), "Design for adaptability (DfA)–frameworks and assessment models for enhanced circularity in buildings", *Applied System Innovation*, Vol. 5 No. 1, pp. 1-25, doi: 10.3390/asi5010024.

Asman, G.E., Kissi, E., Agyekum, K., Baiden, B.K. and Badu, E. (2019), "Critical components of environmentally sustainable buildings design practices of office buildings in Ghana", *Journal of Building Engineering*, Vol. 26 No. 2019, p. 100925, doi: 10.1016/j.jobe.2019.100925.

Atombo, C., Cudjoe, J., Dzantor, K. and Agbo, A.A. (2015), "Integration of sustainable construction in project management: a case study in Ghana", *International Journal of Construction Engineering and Management*, Vol. 4 No. 1, pp. 13-25, doi: 10.5923/j.ijcem.20150401.02.

Baker, H., Moncaster, A. and Al-Tabbaa, A. (2017), "Decision-making for the demolition or adaptation of buildings", *Proceedings of the Institution of Civil Engineers - Forensic Engineering*, Vol. 170 No. 3, pp. 144-156, doi: 10.1680/jfoen.16.00026.

Botchway, E.A., Agyekum, K., Kotei-Martin, J.N. and Afram, S.O. (2023), "Utilization of simulation tools for building performance assessment among design professionals", *International Journal of Building Pathology and Adaptation*, doi: 10.1108/IJBPA-01-2023-0006.

BRE Global (2017), "BREEAM international non-domestic refurbishment 2015", *Technical Manual: SD225 1.4*, Building Research Establishment, Watford, UK, available at: www.erfgoedenergieloket.be/wp-content/uploads/2018/12/BREEAM-International-Non-Domestic-Refurbishment-2015.pdf (accessed 07 February 2024).

Bryman, A. (2016), *Social Research Methods*, 5th ed., Oxford University Press, Oxford, UK.

Celadyn, M. (2019), "Interior architectural design for adaptive reuse in application of environmental sustainability principles", *Sustainability*, Vol. 11 No. 14, p. 3820, doi: 10.3390/su11143820.

Chirisa, I., Bandauko, E., Mazhindu, E., Kwangwama, N.A. and Chikowore, G. (2016), "Building resilient infrastructure in the face of climate change in African cities: scope, potentiality and challenges", *Development Southern Africa*, Vol. 33 No. 1, pp. 113-127, doi: 10.1080/0376835X.2015.1113122.

Conejos, S., Langston, C. and Smith, J. (2014), "Designing for better building adaptability: a comparison of adaptSTAR and ARP models", *Habitat International*, Vol. 41, pp. 85-91, doi: 10.1016/j.habitatint.2013.07.002.

Creswell, J.W. (2009), *Research Design: Qualitative, Quantitative and Mixed Methods Approach*, 3rd ed., Sage Publishing, Los Angeles.

Dams, B., Maskell, D., Shea, A., Allen, S., Driesser, M., Kretschmann, T., Walker, P. and Emmitt, S. (2021), "A circular construction evaluation framework to promote designing for disassembly and adaptability", *Journal of Cleaner Production*, Vol. 316, p. 128122, doi: 10.1016/j.jclepro.2021.128122.

Dodo, Y.A., Raji, A.U., Bornoma, A.H., Yahaya, A., Qureshi, S. and Najad, P.G. (2013), "Policies for adaptability in retrofitting office building", *International Journal of Scientific and Research Publications*, Vol. 3 No. 4, pp. 791-792, available at: www.researchgate.net/profile/Abdulazeez-Umar-Raji/publication/269577047_Policies_for_Adaptability_in_Retrofitting_Office_Building/links/54a8f9ca0cf257a6360be47b/Policies-for-Adaptability-in-Retrofitting-Office-Building.pdf (accessed 09 February 2024).

European Commission (2020), "Circular economy: principles for buildings design", available at: ec.europa.eu/docsroom/documents/39984 (accessed 18 April 2024).

Foster, G. (2020), "Circular economy strategies for adaptive reuse of cultural heritage buildings to reduce environmental impacts", *Resources, Conservation and Recycling*, Vol. 152, p. 104507, doi: 10.1016/j.resconrec.2019.104507.

Frempong-Jnr, E.Y., Ametepey, S.O. and Cobbina, J.E. (2023), "Impact of stakeholder management on efficient construction waste management", *Smart and Sustainable Built Environment*, Vol. 12 No. 3, pp. 607-634, doi: 10.1108/SASBE-08-2021-0147.

Geraedts, R. (2016), "FLEX 4.0, a practical instrument to assess the adaptive capacity of buildings", *Energy Procedia*, Vol. 96, pp. 568-579, doi: 10.1016/j.egypro.2016.09.102.

Gosling, J., Sassi, P., Naim, M. and Lark, R. (2013), "Adaptable buildings: a systems approach", *Sustainable Cities and Society*, Vol. 7, pp. 44-51, doi: 10.1016/j.scs.2012.11.002.

Granheimer, K., Eriksson, P.E. and Karrbom Gustavsson, T. (2022), "Adaptability in public procurement of engineering services promoting carbon reduction: an organizational control perspective", *Sustainability*, Vol. 14 No. 10, p. 5958, doi: 10.3390/su14105958.

Habraken, N. (1961), *Supports: An Alternative to Mass Housing*, *English Language*, The Architectural Press, London. ISBN 9781003014713.

Hamida, M.B., Jylhä, T., Remøy, H. and Gruis, V. (2023), "Circular building adaptability and its determinants–a literature review", *International Journal of Building Pathology and Adaptation*, Vol. 41 No. 6, pp. 47-69, doi: 10.1108/ijbpa-11-2021-0150.

Hamida, M.B., Remøy, H., Gruis, V. and van Laar, B. (2024), "Towards promoting circular building adaptability in adaptive reuse projects: a co-developed framework", *Smart and Sustainable Built Environment*, doi: 10.1108/SASBE-03-2024-0087.

Hart, J., Adams, K., Giesekam, J., Tingley, D.D. and Pomponi, F. (2019), "Barriers and drivers in a circular economy: the case of the built environment", *Procedia Cirp*, Vol. 80, pp. 619-624, doi: 10.1016/j.procir.2018.12.015.

Heidrich, O., Kamara, J., Maltese, S., Re Cecconi, F. and Dejaco, M.C. (2017), "A critical review of the developments in building adaptability", *International Journal of Building Pathology and Adaptation*, Vol. 35 No. 4, pp. 284-303, doi: 10.1108/IJBPA-03-2017-0018.

Herthogs, P., Debacker, W., Tunçer, B., De Weerdt, Y. and De Temmerman, N. (2019), "Quantifying the generality and adaptability of building layouts using weighted graphs: the SAGA method", *Buildings*, Vol. 9 No. 4, p. 92, doi: 10.3390/buildings9040092.

Huang, L., Hamza, N., Lan, B. and Zahi, D. (2016), "Climate-responsive design of traditional dwellings in the cold-arid regions of Tibet and a field investigation of indoor environments in winter", *Energy and Buildings*, Vol. 128, pp. 697-712, doi: 10.1016/j.enbuild.2016.07.006.

IPCC (2014), "Summary for policymakers", in Field, C.B., Barros, V.R., Dokken, D.J., Mach, K.J., Mastrandrea, M.D., Bilir, T.E., Chatterjee, M., Ebi, K.L., Estrada, Y.O., Genova, R.C., Girma, B., Kissel, E.S., Levy, A.N., Maccracken, S., Mastrandrea, P.R. and White, A.N.D.L.L. (Eds), *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, Cambridge, United Kingdom and New York, NY, pp. 1-32, available at: www.researchgate.net/publication/272150376_Climate_change_2014_impacts_adaptation_and_vulnerability_-_IPCC_WGII_AR5_summary_for_policymakers (accessed 9 April 2024).

Kamara, J.M., Heidrich, O., Tafaro, V.E., Maltese, S., Dejaco, M.C. and Re Cecconi, F. (2020), "Change factors and the adaptability of buildings", *Sustainability*, Vol. 12 No. 16, p. 6585, doi: 10.3390/su12166585.

Kanters, J. (2020), "Circular building design: an analysis of barriers and drivers for a circular building sector", *Buildings*, Vol. 10 No. 4, p. 77, doi: 10.3390/buildings10040077.

Kelly, G., Schmidt, R., Dainty, A. and Story, V. (2011), "Improving the design of adaptable buildings though effective feedback in use", *Proceedings of 2011 CIB Management and Innovation for a Sustainable Built Environment international conference*, *Amsterdam*, *Netherlands*, available at: www.irbnet.de/daten/iconda/CIB22014.pdf (accessed 9 February 2024).

Koranteng, C., Simons, B. and Awume, J. (2019), "Evolution of spatial configurations in Ghana's housing development: the case of private apartment buildings in Ghana", *African Journal of Applied Research*, Vol. 5 No. 2, pp. 12-23, available at: https://ajaronline.com/index.php/AJAR/article/view/322 (accessed 9 February 2024).

Kotei-Martin, J.N., Agyekum, K., Salgin, B., Pittri, H., Botchway, E.A., Gasue, R. and Aklashie, S. (2025), "Challenges to the implementation of design for adaptability among design professionals in Ghana", *International Journal of Building Pathology and Adaptation*, doi: 10.1108/IJBPA-09-2024-0189.

Kwak, S.G. and Park, S.H. (2019), "Normality test in clinical research", *Journal of Rheumatic Diseases*, Vol. 26 No. 1, pp. 5-11, doi: 10.4078/jrd.2019.26.1.5.

Kwofie, T.E., Amos-Abanyie, S. and Afram, S.O. (2016), "Principal component analysis of professional competencies of architects in the Ghanaian construction industry", *Engineering, Construction and Architectural Management*, Vol. 23 No. 5, pp. 571-587, doi: 10.1108/ECAM-08-2014-0108.

Lamptey, T., Owusu-Manu, D.-G., Acheampong, A., Adesi, M. and Ghansah, F.A. (2021), "A framework for the adoption of green business models in the Ghanaian construction industry", *Smart and Sustainable Built Environment*, Vol. 10 No. 3, pp. 536-553, doi: 10.1108/SASBE-08-2020-0130.

Manu, P., Poghosyan, A., Agyei, G., Mahamadu, A.M. and Dziekonski, K. (2021), "Design for safety in construction in Sub-Saharan Africa: a study of architects in Ghana", *International Journal of Construction Management*, Vol. 21 No. 4, pp. 382-394, doi: 10.1080/15623599.2018.1541704.

McFarland, D., Ross, B., Naser, M.Z., Blok, R. and Teuffel, P. (2021b), "Quantitative evaluation of the relationship between physical parameters and building demolition or adaptation outcomes", *Architecture, Structures and Construction*, Vol. 3 No. 4, pp. 1-14, doi: 10.1007/s44150-021-00014-9.

McFarland, D.E., Ross, B.E. and Albright, D. (2021a), "Quantifying adaptability of college campus buildings", in Littlewood, J., Howlett, R.J. and Jain, L.C. (Eds), *Sustainability in Energy and Buildings 2020, Smart Innovation, Systems and Technologies*, Vol. 203, pp. 75-87. Springer Singapore, doi: 10.1007/978-981-15-8783-2_6.

Mehr, S.Y. and Wilkinson, S. (2021), "A model for assessing adaptability in heritage buildings", *International Journal of Conservation Science*, Vol. 12 No. 1, pp. 87-104, available at: https://opus.lib.uts.edu.au/bitstream/10453/172632/2/IJCS-21-06_YazdaniMehr%20%26%20Wilkinson.pdf (accessed 06 February 2024).

Melton, P. (2020), "Buildings that last: design for adaptability, deconstruction and reuse", The American Institute of Architects, available at: https://content.aia.org/sites/default/files/2020-03/ADR-Guide-final_0.pdf (accessed 12 October 2023).

Mlote, D.S., Budig, M. and Cheah, L. (2024), "Adaptability of buildings: a systematic review of current research", *Frontiers in Built Environment*, Vol. 10, p. 1376759, doi: 10.3389/fbuil.2024.1376759.

Munaro, M.R. and Tavares, S.F. (2023), "Design for adaptability and disassembly: guidelines for building deconstruction", *Construction Innovation*, doi: 10.1108/CI-10-2022-0266.

Negash, Y.T., Hassan, A.M., Tseng, M.L., Wu, K.J. and Ali, M.H. (2021), "Sustainable construction and demolition waste management in Somaliland: regulatory barriers lead to technical and environmental barriers", *Journal of Cleaner Production*, Vol. 297, p. 126717, doi: 10.1016/j.jclepro.2021.126717.

Newhart, M. and Patten, M.L. (2023), *Understanding Research Methods: An Overview of the Essentials*, Routledge, ISBN 978-0-367-55118-6.

Oppong, R.A. and Masahudu, M. (2014), "Exploration of building adaptations and retrofitting challenges in Ghana: the case of selected rural bank projects", *Structural Survey*, Vol. 32 No. 5, pp. 349-364, doi: 10.1108/SS-12-2013-0041.

Pinder, J.R.S. III. and Saker, J. (2013), "Stakeholder perspectives on developing more adaptable buildings", *Construction Management and Economics*, Vol. 31 No. 5, pp. 440-459, doi: 10.1080/01446193.2013.798007.

Pittri, H., Agyekum, K., Ayebeng Botchway, E., Opoku, A. and Bimpli, I. (2023), "Design for deconstruction (DfD) implementation among design professionals: empirical evidence from Ghana", *International Journal of Construction Management*, Vol. 24 No. 13, pp. 1387-1397, doi: 10.1080/15623599.2023.2174663.

Pittri, H., Agyekum, K., Botchway, E.A., Alencastro, J., Oladinrin, O.T. and Dompey, A.M.A. (2024), "Drivers for design for deconstruction (DfD) implementation among design professionals", *Smart and Sustainable Built Environment*, Vol. 13 No. 5, pp. 1134-1154, doi: 10.1108/SASBE05-2023-0117.

Pranskūnienė, R. and Zabulionienė, E. (2023), "Towards heritage transformation perspectives", *Sustainability*, Vol. 15 No. 7, p. 6135, doi: 10.3390/su15076135.

Queirós, A., Faria, D. and Almeida, F. (2017), "Strengths and limitations of qualitative and quantitative research methods", *European Journal of Education Studies*, Vol. 3 No. 9, pp. 369-386, doi: 10.5281/zenodo.887089.

Rockow, Z.R., Ross, B.E. and Becker, A.K. (2021), "Comparison of building adaptation projects and design for adaptability strategies", *Journal of Architectural Engineering*, Vol. 27 No. 3, p. 4021022, doi: 10.1061/(ASCE)AE.1943-5568.0000481.

Roopa, S. and Rani, M.S. (2012), "Questionnaire designing for a survey", *The Journal of Indian Orthodontic Society*, Vol. 46 No. 4_suppl1, pp. 273-277, doi: 10.5005/jp-journals-10021-1104.

Ross, B.E., Chen, D.A., Conejos, S. and Khademi, A. (2016), "Enabling adaptable buildings: results of a preliminary expert survey", *Procedia Engineering*, Vol. 145, pp. 420-427, doi: 10.1016/j.proeng.2016.04.009.

Sreejesh, S., Mohapatra, S. and Anusree, M.R. (2014), "Questionnaire design", *Business Research Methods*, pp. 143-159, Springer, Cham, doi: 10.1007/978-3-319-00539-3_5.

Tleuken, A., Torgautov, B., Zhanabayev, A., Turkyilmaz, A., Mustafa, M. and Karaca, F. (2022), "Design for deconstruction and disassembly: barriers, opportunities, and practices in developing economies of Central Asia", *Procedia CIRP*, Vol. 106, pp. 15-20, doi: 10.1016/j.procir.2022.02.148.

Tsang, S., Royse, C.F. and Terkawi, A.S. (2017), "Guidelines for developing, translating, and validating a questionnaire in perioperative and pain medicine", *Saudi Journal of Anaesthesia*, Vol. 11 No. 5, pp. S80-S89, doi: 10.4103/sja.SJA_203_17.

Vafaie, F., Remøy, H. and Gruis, V. (2023), "Adaptive reuse of heritage buildings; a systematic literature review of success factors", *Habitat International*, Vol. 142, p. 102926, doi: 10.1016/j.habitatint.2023.102926.

Watt, H., Davison, B., Hodgson, P. and Kitching, C. (2023), "What should an adaptable building look like?", *Resources, Conservation and Recycling Advances*, Vol. 18, p. 200158, doi: 10.1016/j.rcradv.2023.200158.

Zhao, Q., Gao, W., Su, Y., Wang, T. and Wang, J. (2023), "How can C&D waste recycling do a carbon emission contribution for construction industry in Japan city?", *Energy and Buildings*, Vol. 298, p. 113538, doi: 10.1016/j.enbuild.2023.113538.

Further reading

Boadu, E.F., Wang, C.C. and Sunindijo, R.Y. (2020), "Characteristics of the construction industry in developing countries and its implications for health and safety: an exploratory study in Ghana", *International Journal of Environmental Research and Public Health*, Vol. 17 No. 11, p. 4110, doi: 10.3390/ijerph17114110.

Brand, S. (1994), *How Buildings Learn: What Happens After They're Built*, 1st ed., Viking Press, New York, NY. ISBN 978-0140139969.

Davidson-Shivers, G.V., Rasmussen, K.L. and Lowenthal, P.R. (2018), "Web-based learning: design, implementation and evaluation", available at: https://link.springer.com/book/10.1007/978-3-319-67840-5 (accessed 9 February 2024).

Honold, C., Leistner, S., Roth, D., Binz, H. and Sobek, W. (2019), "Method toolbox for the multidisciplinary planning and development of adaptive buildings", *Proceedings of the Design Society: International Conference on Engineering Design*, Vol. 1 No. 1, pp. 169-178, doi: 10.1017/dsi.2019.20.

Manewa, A., Siriwardena, M., Ross, A. and Madanayake, U. (2016), "Adaptable buildings for sustainable built environment", *Built Environment Project and Asset Management*, Vol. 6No No. 2, pp. 139-158, doi: 10.1108/bepam-10-2014-0053.

Corresponding author
Hayford Pittri can be contacted at: hayfordp09@gmail.com

Appendix 1

Table A1. Summary of respondents' demographic information

Demographic information	Frequency	%
Occupation		
Architect	105	44.5
Civil/ structural engineer	131	55.5
Type of firm worked in		
Consultancy firm	126	53.4
Construction firm	52	22.0
Engineering firm	31	13.1
Freelance	27	11.4
Years of experience		
1–5 years	55	23.3
6–10 years	76	32.2
11–15 years	21	8.9
16–20 years	41	17.4
Over 20 years	43	18.2
Professional bodies		
Ghana Institute of Architects (GIA)	88	37.3
Ghana Institution of engineering (GhIE)	139	58.9
Institution of Engineering and Technology, Ghana (IET Ghana)	9	3.8

Source(s): Table created by authors

Appendix 2

QUESTIONNAIRES FOR SURVEY

DESIGN PROFESSIONALS’ AWARENESS AND ENGAGEMENT IN DESIGN FOR ADAPTABILITY (DfA) PRACTICES

PART ONE: GENERAL BACKGROUND INFORMATION ON RESPONDENT

Please provide possible answers to the following questions by ticking (√) in the appropriate boxes provided and/or filling in the blank spaces where necessary.

1. Please indicate your occupation in the Ghanaian construction industry.
   [ ] Architect
   [ ] Civil/Structural Engineer
2. Which type of firm do you work in?
   [ ] Consultancy firm
   [ ] Construction firm
   [ ] Engineering firm
   [ ] Freelance
3. Indicate the number of years you have been working within the construction industry.
   [ ] 1-5 years
   [ ] 6-10 years
   [ ] 11-15 years
   [ ] 16-20 years
   [ ] Over 20 years
4. Which of these professional bodies do you belong to?
   [ ] Ghana Institute of Architects (GIA)
   [ ] Ghana Institution of Engineering (GhIE)
   [ ] Institution of Engineering and Technology Ghana (IET Ghana)

PART TWO: AWARENESS LEVEL OF DESIGN FOR ADAPTABILITY

Please provide possible answers to the following questions by ticking (√) in the appropriate boxes provided and/or filling in the blank spaces where necessary.

1. Were you familiar with the concept of design for adaptability (DfA) prior to this survey?

[ ] Yes

[ ] No

2. Did you undertake any course on design for adaptability as part of your formal education?

[ ] Yes

[ ] No

3. Have you ever participated in any professional development training on design for adaptability?

[ ] Yes

[ ] No

4. Are you willing to participate in any professional development training on design for adaptability?

[ ] Yes

[ ] No

5. **If yes**, what will be your preferred means of professional development training?

[ ] Online course/webinar

[ ] Face-to-face course/Seminar

PART THREE: FREQUENCY OF ENGAGEMENT OF DESIGN FOR ADAPTABILITY PRACTICES

In order to determine the design professionals' frequency of engagement with DfA practices, it is very important to indicate your response against the following variables/practices. Kindly indicate your level of engagement per experience using the following Likert scale. **1 – Never; 2 – Rarely; 3 –Sometimes; 4 – Often; 5 – Always**. Please answer by ticking (√) in the space provided.

SN	DESIGN FOR ADAPTABILITY (DFA) PRACTICES	1	2	3	4	5
1.	I design to ensure the functional resilience of buildings.					
2.	I create designs having in mind the structural durability of the building.					
3.	I lay out the structure to have space-plan flexibility					
4.	I keep a balance of structural durability and space-plan flexibility in my designs					
5.	I endorse the use of durable elements in my design specification					
6.	I recommend the use of flexible connection methods within the building					
7.	I design with materials that can be easily dismantled					
8.	I create a structural grid that allows for a modular building skin					
9.	I design space plans based on standard material dimensions					
10.	I incorporate design measures that maintain comfortability and a healthy indoor environment					
11.	I create designs using bioclimatic and biophilic principles					
12.	I organize building layers (i.e., the site, structure, skin, services, space plan and stuff) according to their end-of-life span in my designs					
13.	I design to ensure that building service systems are separated					
14.	I recommend the use of recyclable materials in my design specifications					
15.	I endorse the reuse of materials in my designs					
16.	I create designs to ensure the possibility of vertical expansions					
17.	I use building elements that can be reassembled in my design					
18.	I design having in mind a deconstruction plan					
19.	I ensure that components can be selectively disassembled					
20.	I create designs that preserve the heritage of buildings					