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Structuring the Environmental Experience Design Research Framework through Selected Aged Care Facility Data Analyses in Victoria

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Received: 4 September 2017; Accepted: 23 November 2017; Published: 25 November 2017

Abstract: Humans relate to the living environment physically and psychologically. Environmental psychology has a rich developed history while experience design emerged recently in the industrial design domain. Nonetheless, these approaches have barely been merged, understood or implemented in architectural design practices. This study explored the correlation between experience design and environmental psychology. Moreover, it conducted literature reviews on theories about emotion, user experience design, experience design and environmental psychology, followed by the analyses of spatial settings and environmental quality data of a selected aged care facility in Victoria, Australia, as a case study. Accordingly, this study led to proposing a research framework on environmental experience design (EXD). It can be defined as a deliberate attempt that affiliates experience design and environmental psychology with creation of the built environment that should accommodate user needs and demands. The EXD research framework proposed in this study was tailored for transforming related design functions into the solutions that contribute to improving the built environment for user health and wellbeing.

Keywords: environmental experience design; user experience design; function analysis; environmental psychology; indoor environmental quality; aged care facilities; architectural design; EXD research framework matrix

1. Introduction

Architectural design encompasses a complex thought process that leads to realising the configurations and spaces with due consideration of market needs and demands. The growth of ageing population is on the hike. However, many existing aged care facilities today barely accommodate the concept of age-friendliness. The personalisation in the design development may need to be taken into account. Design decision makers, such as architects, are responsible for creating the physical and psychological comfortable built environment. Psychological comfort is subject to human emotion. Crozier defines emotion as "conceptions of meaningful responses to life experience" [1]. He also mentions that "it is a person's experience of the world rather than the world's objective properties that counts" [1]. Furthermore, McCarthy and Wright annotate that "emotions are qualities of particular experiences" [2,3]. In some manners, these statements support the importance of design for built environment that needs to accommodate proper user experiences.

It is worth noting that the "experience design" has been devised in the industrial design domain, originated from "user experience design" which focuses on the design of end-user product interfaces [4]. Experience design aims to achieve physical and psychological spatial needs and demands from user perspectives [4]. The term of user experience design was coined by Norman attempting to refine the interface between humans and facilities in order to emphasise the essentials of human interaction design [5]. A synergic theory expounded by O'Sullivan and Spangler is concerned with involvement and creation of an environment establishing connections on the level of emotion or value to users [6]. "It is now about creating experiences beyond just products and services, about creating relationships with individuals, creating an environment that connects on an emotional or value level to the customer" [4]. Pine and Gilmore's statement clarifies that the most successful experience design may have "sweet spots" regarding both passive and active participation of end-users and absorptive and immersive connection in its consistent context [7]. Hassenzah describes that "experience design ... requires a broadened perspective, with the fulfillment of psychological needs (values), which in turn creates meaning and emotion, as the prime design objective" [4]. Berridge defines experience design as "a new emerging paradigm, a call for inclusion: it calls for an integrative practice of design" [8]. It is a new term, making an effort on exploring the connection between the concept of experience and the practice of design. However, "the design of experience is not any newer than the recognition of experience . . . it is really combination of many previous disciplines" [8].

Architectural design involves interdisciplinary and human-centric decision-making processes; however, experience design has barely been applied to architectural practices. Kellert et al. indicate that the sense of gratification within a building is "an experience of architectural pleasure that resonated as both new and unfathomably familiar" [9]. The ambition of experience design is to orchestrate human experiences with functionality, purposefulness, engagement, stimulation and memory [10]. Experience design applied to the built environment may bring up potentials to improve the understanding of association between residents and their physical settings. Exploring experience design, when implemented in the built environment, articulates a paradigm which emphasises the necessity of enhancing and restoring human experiences [11]. In this respect, this application may help replace the technology-driven decision-making approach by the human-centric one. Frumkin provides empirical evidences on how humans respond psychologically to the built environment [12]. It may acknowledge that the research on environmental psychology provides insights on how human-centric experience design engages with architectural practices. Gifford defines environmental psychology as "a study of transactions between individuals and their physical settings" [13]. Furthermore, Nagar also proposes a similar definition, arguing environmental psychology is "the study of the interrelationships between the physical environment and human behaviour" [14].

Human emotion to some extent correlates to user experience; architecturally, it may contribute to generating the notion of experience design linked to environmental psychology (Figure 1). This paper aims to develop knowledge of the experience design and to propose a research framework that enhances the interrelationship between residents and the built environment. It uses a selected aged care facility in Victoria, Australia, as a case study to document and analyse the spatial settings and physical environmental conditions. The following sections identify the present circumstances for further analyses.

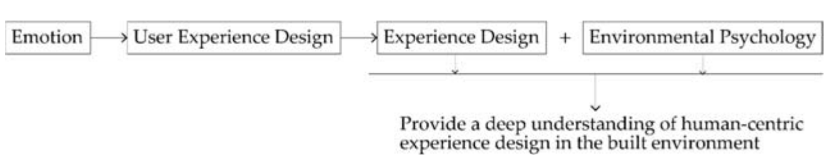

Figure 1. Structure of the literature review.

2. Review on Residential Aged Care Facilities in Australia

Residential aged care facilities cater for the elderly who cannot live independently in their own homes. These facilities were designed as a "miniaturised acute-care hospital" in the post-war era [15]. In 1980s, as reflected in the *Guidelines for the Provision of Nursing Home Facilities* published by the Australian government in 1983, residents were named as "patients" and their rooms were defined as "wards". Multi-bedded rooms were recommended with shared toilets and bathrooms. Operational efficiency and effective surveillance were promoted instead of personal privacy and dignity [16]. Collective living and rigid routines affected the individuality and personal identity of residents [17]. The institutionality of residential aged care facilities was criticised by Carboni as the "negation of home" with the "sense of placelessness" due to the loss of intimacy between the individual and the environment [18]. According to Maslow, there are at least five sets of human needs, ranging physiological, safety, love/belonging, esteem and self-actualisation [19]. Apart from the fundamental physical needs, personal safety and security, it is crucial for people to have the sense of belonging and to be accepted and respected by others to build up their self-esteem and confidence against loneliness, isolation and depression. Due to various impairments, it is common for the elderly to experience stress and frustration, so they are vulnerable to environmental impacts [20]. The design of aged care facilities should not merely provide the residents a comfortable and safe place to live, but also facilitate social interaction among them and enable them to exercise their residual abilities towards self-actualisation without much difficulty.

Individual needs of the elderly were emphasised by Kidd in *The Image of Home: Alternative Design for Nursing Homes*, published by the Centre for Applied Research on the Future at the University of Melbourne in 1987. According to Kidd, "every effort should be made to restore, retain, regain or develop independence, choice and decision making" amongst residents [21]. The physical setting may need to offer a variety of communal areas for interacting with others and personalisation of private spaces according to individual preferences. Similar ideas were incorporated by Kidd in the subsequent *Hostel Design Guidelines* published by the Commonwealth Department of Community Services and Health in 1988. Based on this guideline, residential aged care facilities should reflect a truly domestic character to avoid the risk of disorientation within the buildings and to provide a stimulating environment for both social encounters and personal retreat. The importance of single bedroom provision was also emphasised for enabling residents to personalise their individual accommodation [22]. The proportion of single bedroom in a residential aged care facility has been significantly increased from one per ten residents according to the guidelines in 1983 to at least 75% according to the *Aged Care Residential Services Generic Brief* published by the Victorian Government in 2000 [23].

3. The Case Study

In Victoria, there are 750 government-funded nursing homes and 131 privately operated supported residential services (SRS) [24,25]. Most of the facilities cater for English-speaking residents or a specific cultural group. Adare SRS is unique in terms of having residents with multi-cultural backgrounds, so it was selected as the site for investigation.

3.1. Spatial Design Setting

Adare SRS is located in Wantirna South, approximately 35 km to the south-east of Melbourne's Central Business District. It was built in the year of 2000 and can accommodate 45 residents. As of August 2017, about one-third of residents are English-speaking, while the remaining speak Cantonese, Mandarin, Shanghainese and other Chinese dialects. Room numbers are labelled from 1 to 39, 60 to 63, 65 and 66 to avoid unlucky numbers according to Chinese traditional belief. Apart from Rooms 16 and 17 which are connected together to accommodate an aged couple, the remainders are single bedrooms with ensuite (Figure 2). Bedrooms are located on both sides of three major corridors. The longer corridor (Corridor 1: Rooms 1 to 21) and the shorter corridor (Corridor 2: Rooms 22 to 31) run north–south, whereas the third corridor (Corridor 3: Rooms 32 to 66, together with kitchen and laundry) run east–west. The communal spaces (living lounges and dining areas) link these three corridors together with gardens on both sides of the living lounges.

Compared with the *Aged Care Residential Services Generic Brief* published in 2000, Adare SRS has a very high percentage of singe bedrooms, which can provide privacy for each resident. Residents are allowed and even encouraged to bring their own furniture and decorative fixtures to their individual rooms which can foster their sense of identity (Figure 3). The inclusion of personal fixtures and items in the rooms, including chairs, photos, paintings and other artefacts, can reinforce residents' residual memory capacities and arouse their reflection upon their past experiences. This is helpful to personalise the institutional setting and create a familiar environment for them to live. The display of personal objects may stimulate social interaction and conversation among residents and may enable the staff to improve the understanding of the residents about their stories and preferences.

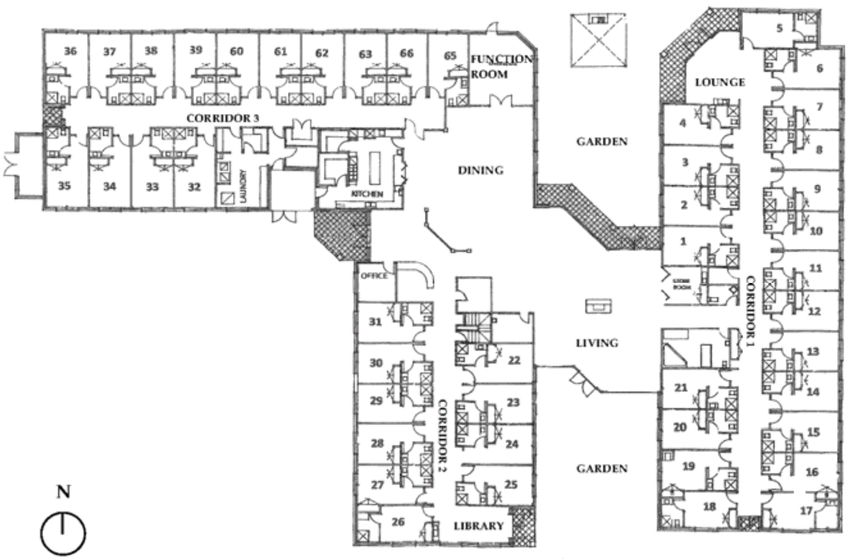

Figure 2. Floor plan of Adare supported residential services (SRS).

Figure 3. Residents' rooms with personal furniture and decorative fixtures.

Various communal spaces are provided at Adare SRS to cater for different types of social encounters among residents depending on their choices. Couches in the living area are arranged in clusters and small family-sized tables for four to six residents are provided in dining area (Figure 4). Besides living and dining area, there are a small library and a small lounge at the end of Corridors 2 and 3, respectively (Figure 5, Left Panel). A private function room is provided next to the dining area for family gathering or other activities which can be booked in advance by residents and their family members to suit their needs (Figure 5, Right Panel).

Figure 4. Living area (**left**); and dining area (**right**).

Figure 5. Lounge (**left**); and private function room (**right**).

Outdoor gardens are located on both sides of the communal living area (Figure 6). Doors opening to the gardens are unlocked during the daytime which can facilitate residents to go outside as one of their choices. In fact, a well-designed garden is a therapeutic environment for the elderly as it can provide visual, tactile, olfactory and auditory stimulation through the combination of natural landscape, fragrance, sunlight, wind and birds.

Figure 6. Outdoor gardens.

There is no air-conditioner at Adare SRS. During summer time, evaporative coolers at communal areas can be switched on and there is a ceiling fan in each resident's room for cooling purpose. During winter time, wall-mounted hydraulic heaters at both communal areas and residents' rooms can be turned on to keep the interior space warm. Residents can open windows in their rooms for natural ventilation and adjust window curtains to control the amount of sunlight into their rooms.

3.2. Indoor Environmental Quality Data Collection and Analysis

Indoor environmental quality measurements were conducted over a one-week period from 29 May to 4 June 2017. For the analysis in this paper, we consider the data collected on five weekdays. The collected data can represent conditions in winter season because the three most important factors that influencing indoor environmental quality—climate condition, elderly activity pattern, and building operation, differs little across winter days. The investigation focusing on summer season is warranted in future studies. Sampling was performed with 2-min time resolution. Two sets of instruments were concurrently deployed at Adare SRS. One set of instruments was located in Bedroom 21 and the second monitoring station was operated in the dining area. The dining hall is selected as the sampling location for public spaces because it is the most used communal area and it share space with living area.

Real-time, size-resolved optical particle counters (OPC, model 9306, TSI Inc., Shoreview, MN, USA) were employed to measure concentrations of airborne particles at Adare SRS. These particle counters have a detectable minimum particle diameter of 0.3 μm. Number concentrations were reported in six size bins based on optical diameter (0.3–0.5, 0.5–1.0, 1.0–2.5, 2.5–5.0, 5.0–10.0, and >10 μm). Particle sampling was performed with 2-min time resolution. This study focuses on the data covering the diameter range 0.3–2.5 μm ($PM_{0.3–2.5}$) and 0.3–10 μm ($PM_{0.3–10.0}$).

Real-time measurements of dry bulb temperature, radiant temperature, relative humidity, and carbon dioxide (CO_2) concentration were made by means of indoor air quality monitor (HuxConnect, Hux Pty. Ltd., Melbourne, Australia). Measurements were recorded with 5-min time resolution.

In addition to the indoor measurements, one additional set of instruments was operated at a local outdoor monitoring site to record the outdoor particle levels, dry bulb temperature, and relative humidity on a continuous basis. Over 30,000 data points were generated from the one-week monitoring campaign. For each indoor air quality index of interested, the distribution patterns were comparable across monitoring days.

(1) CO_2 concentrations

The elevated concentration of CO_2 has been associated with negative impacts on human cognition and decision-making [26,27]. ANSI/ASHRAE Standard 62.1-2016 recommends that indoor CO_2 concentration should be below 1000 ppm [28]. As illustrated in Figure 7, The CO_2 concentrations measured at both bedroom and communal space were kept below 1000 ppm throughout the whole monitoring period. It is worth noting that the 1000 ppm is the concentration threshold preferred by healthy adults. The guideline on CO_2 exposure limit for elderly group has not been established.

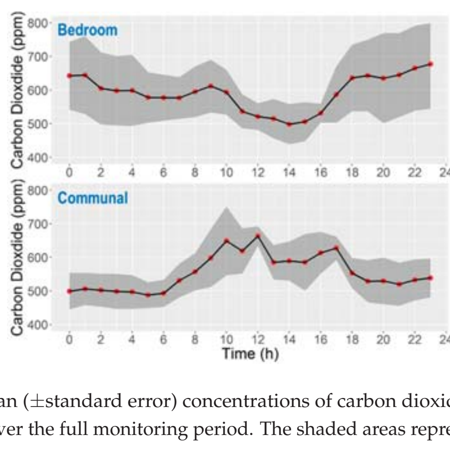

Figure 7. Daily 1-h mean (±standard error) concentrations of carbon dioxide measured at bedroom and communal space over the full monitoring period. The shaded areas represent variability of results as ±standard error.

It is worth noting that the CO_2 distribution pattern varied between bedroom and lounge space. The peak phase shifted from nighttime periods in bedroom to daytime periods in communal spaces. One can gain insight about the time diary of the elderly residents from CO_2 data. CO_2 is a major type of human metabolic emissions, which would in turn be associated with the number of occupants, duration of residency, and intensity of activity performed. Figure 6 indicated that the elderly residents spent most of their daytime periods in communal areas rather than bedrooms.

(2) Thermal comfort

As illustrated in Figure 8, the outdoor hourly mean dry bulb temperature ranged from 10.8 °C to 14.9 °C, with an average across the five weekdays of 12.5 °C. The temperature profile measured at bedroom was maintained between 20 °C and 23 °C. The temperatures of communal space were comparable with values recorded at the bedroom, but one can observe significant peaks during afternoon periods.

Compared to outdoor relative humidity (RH) profile, the indoor values fluctuated in a narrow range. The daily 1-h mean RH of the bedroom ranged from 44% to 51%, with an average across the five monitoring days of 48%. The values recorded at communal area ranged from 50% to 55%, with an average of 52%.

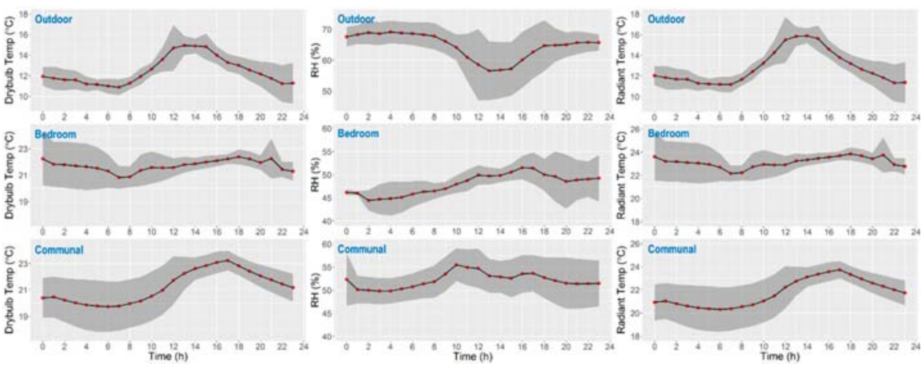

Figure 8. Daily 1-h mean (±standard error): dry bulb temperature (**left**); relative humidity (**middle**); and radiant temperature (**right**) measured at outdoor, bedroom and communal space over the full monitoring period. The shaded areas represent variability of results as ±standard error.

The Thermal Comfort Tool developed by the Center for the Built Environment (CBE) at the University of California, Berkeley, was applied to examine if Adare SRS provides a comfortable thermal environment for the elderly residents [29]. The PMV model was selected because: (i) the elderly have limited ability to control their thermal comfort; and (ii) the indoor air speed is negligible in experimental period because the house relies on air infiltration/exfiltration for ventilation purpose on winter days. As illustrated in Figure 7, the mean radiant temperatures followed the dry bulb temperature profiles through the monitoring period. The weekly average values, 23.1 °C and 21.8 °C for bedroom and communal space, respectively, were used to estimate the thermal condition. There is no discernible air flow in indoor environment. The low air flow can be attributable to the fact that windows and doors are usually kept closed in winter days and house relies on air infiltration/exfiltration for ventilation purpose. The elderly residents are usually in sedentary status (metabolic rate = 1 met) and wearing winter clothes (clothing level = 1 clo) during the monitoring period.

Although the thermal condition of both bedroom and communal space are in the lower range of thermal comfort zone defined by ANSI/ASHRAE Standard 55-2013 [30] (Figure 9), a warmer environment is recommended. This is because: (i) the standard comfort zone is the thermal condition preferred by healthy adults, rather than vulnerable elderly residents; and (ii) previous studies indicate that the 20–24 °C comfort zone is not warm enough for older adults and older adults generally prefer a warmer environment than younger subjects [31,32].

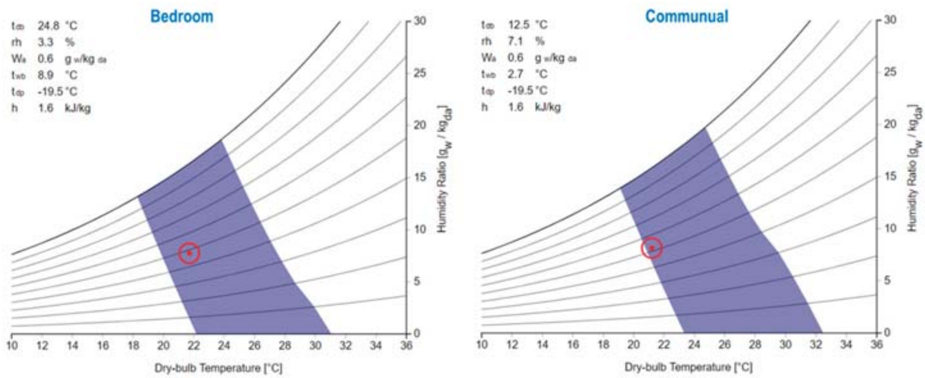

Figure 9. Thermal condition of: the bedroom (**left**); and the communal space (**right**) in psychometric chart. The shaded areas represent comfort zone boundary. The averaged values for the monitoring period were used in this estimation.

(3) Concentrations of particulate matters

Previous studies suggest association of particulate matter (PM) and its compounds with health problems in the elderly such as the acute respiratory inflammation, pneumonia, asthma chronic obstructive pulmonary disease, autonomic cardiac dysfunction, renal and cognitive deficit, and cardiovascular and respiratory mortality [33–36]. For both $PM_{0.3–2.5}$ and $PM_{0.3–10.0}$, the indoor concentrations were lower than outdoor levels (Figure 10). This implies that the building envelope can protect the elderly residents against outdoor PM pollutants. One can observe elevated $PM_{0.3–10.0}$ concentration measured at communal area during day times, which is consistent with CO_2 concentration profile.

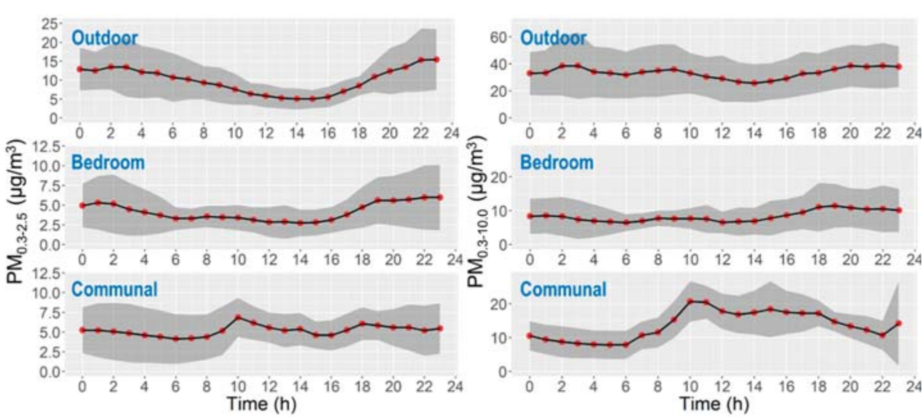

Figure 10. Daily 1-h mean (±standard error): $PM_{0.3–2.5}$ (**left**); and $PM_{0.3–10.0}$ (**right**) concentrations measured at outdoor, bedroom and communal space over the full monitoring period. The shaded areas represent variability of results as ±standard error.

Menders and his colleagues investigated a wide of range of indoor environmental quality parameters (including CO_2 and particle concentrations, thermal condition parameters) of elderly care centers in GERIE study (Geriatric study on health effects of air quality in nursing homes) [37–40]. The aged care residents were exposed to higher level of CO_2, but warmer temperature in this case study than GERIE project. The elevated CO_2 concentrations and temperature can be attributable to the reduced indoor-outdoor air exchange in winter season. The particle concentrations reported in previous studies are two to three times higher than the values we observed in this work. The low air exchange rate and better air quality outdoors probably contribute to the reduction of particle concentrations.

This section explored spatial and environmental conditions of a selected aged care facility. The temperature, relative humidity and air contaminants were monitored to examine if the minimum standard of indoor-environmental quality had been met. Nonetheless, the objective monitoring outcomes themselves do not necessarily reflect users' subjective comfort or environmental experiences. There is a clear need to address subjectivity. A question arises: How can the environmental data collected contribute to improving spatial settings of aged care facilities? Based on the need, the following section will analyse the subjectivity and propose the environmental experience design research framework.

4. Environmental Experience Design Research Framework

Due to the growth of global ageing population, increasing attentions have been drawn to accommodate the needs of the elderly's experience design [41]. Lawton initially raises the significance of the "reciprocal relationship between the elderly and their environment" [42,43]. Elf et al. also indicate the importance of the built environment that fulfils modern care vision embracing "autonomy, relatedness and competence" [44,45]. Nonetheless, Holahan and Moore et al. criticise the lack of theoretical research framework on person-environment nexuses in environmental psychology [46,47]. The gap may be filled by combining theories and practices around emotion, user experience design, experience design and environmental psychology—those that were briefed in the previous sections. In this study, the integrated research approach will be termed "environmental experience design" (EXD) which aims to provide a framework to identify design objectives, to analyse user perception and to propose design strategies. In the EXD research framework, both objective physical parameters (e.g., environmental quality data) and subjective user perception (e.g., human emotion) are brought into account for the development of spatial design strategies. As a case study, this paper intends to explore the proposed research framework through the application to a selected aged care facility located in Victoria. Based on the literature review of theories related to this study, the following sections unveil relevant design objectives towards the establishment of the EXD research framework.

4.1. Environmental Experience Design of Freedom

The current care model of the selected Adare SRS enables the residents to enjoy their freedom with minimum restrictions. Lawton and Nahemow summarise that origins of the elderly's stress are mainly due to the lack of "convenience to services, friends, and relatives, characteristics of structure and availability of social services" [42]. However, all these stated concerns may be solved with the notion of providing freedom. Parmelee and Lawton suggest that one of the aspects of human-environment relations in the elderly's late life depends on "the dialectic of autonomy" [48]. Autonomy is defined as "a state in which the person is, or feels, capable of pursuing life goals by the use of his or her own resources" which indicates "freedom of choice, action, and self-regulation of one's life space—in other words, the perception of and capacity for effective independent action" [48]. Nevertheless, "freedom of choice, action and self-regulation" are intertwined. As Dubos argues, "people want to experience the sensory, emotional, and spiritual satisfactions that can be obtained only from an intimate interplay, indeed from an identification with the places which [they] live" [49]. However, the mere consideration of the experience of freedom with accessibility to social infrastructure seems to be inadequate, architectural design also plays an important role of realising the true freedom. Open floor planning could be considered as a fundamental design approach to maximising the use of limited spaces while minimising partitions. Movable partitions may also enhance the space use efficiency and flexibility. Unnecessary level changes on the floors may reduce or eliminate physical and visual barriers associated with the elderly movements (e.g., with a wheelchair, wheeled walker, scooter and mobile hoist) and other daily life activities including social networking. Van Steenwinkel et al. advocate that this open spatial articulation enables more social interactions amongst residents, but also affords "spatial generosity" through combining "surface area, room to maneuver and variety of places" [50].

4.2. Environmental Experience Design of Connection to Natural Environment

The natural environment is a source of "interest, fascination and affection" and it may serve as a medium which directly or indirectly influences human psychology in the built environment [51]. Human relationship with nature may also be considered as the important part of environmental experience design. In such case, direct experience may involve the built environment connecting with self-sustaining natural elements including daylight, vegetations, animals and ecosystems, while indirect experience may refer to partial natural elements, such as potted plants and fountains, symbolic-represented natural features through images, photos and metaphors. Salingaros and Masden argue that "we instinctively crave physical and biological connection to the world. The human perceptual mechanisms through which these processes establish our relationship and response to both architecture and the built environment" [52]. Kellert uses the term "building for life" to highlight the significance of the re-establishment of the positive relationship between occupants and nature in the built environment [53]. Such positive relationship may be reinforced through various architectural design approaches, such as allowing daylight access, natural sound transmission and botanic fragrance perception for the sake of fulfilling the inherent need of humans to connect with nature [54].

4.3. Environmental Experience Design of Belongingness

Strong physical and psychological needs are retained to call places as homes regardless of propensity of mobility [55]. However, the feeling of "placelessness" may exist in the elderly's emotions [56,57]. Against the sense of placelessness, Relph emphasises the importance of maintaining the sense of "placeness" which can be "sources of safety and identity for individuals and for groups of people" [57]. Salingaros and Masden share the similar view of connecting to the built environment by having "a deep sense belonging to it" [52]. As far as architectural design approach is concerned, a welcoming environment may need to create and provide a sense of "placeness", which implies that the architectural space needs to be vibrant and flexible to respond to the elderly's changing needs, interests and abilities.

4.4. Environmental Experience Design of Individual Dignity

Designing environmental experience of individual dignity may enhance the elderly's sense of control in the built environment given and help them feel secured and comfortable physically and psychologically. Andrews and Philips argue that to provide a healthy living environment is vital to understand how the elderly establish their feelings of self-esteem in the aged-care facility [58]. Kitwood also points out a notion regarding "the uniqueness of each person, subjectivity, and relatedness", however, "treating human beings consistently as persons is so rare in everyday life" [59]. Architecturally, environmental experience design of individual dignity may be performed as non-hierarchical, manageable and controllable spaces.

The aforementioned physical and psychological parameters such as freedom, connection to natural environment, belongingness and individual dignity were considered as general environmental experience design objectives (Table 1). In the table, the user experiences and associated spatial design strategies and/or solutions were enumerated.

Table 1. The general environmental experience design objectives.

Selected EXD Objectives	Analysed User Experiences	Potential Spatial Design Strategies and/or Solutions
Freedom	Feeling in control of their own actions rather than being controlled by others	Open floor planning Movable partitions Level difference avoidance
Connection to natural environment	Feeling connected with nature in the built environment	Direct and indirect experiences of natural environment in relation to health and well-being
Belongingness	Feeling an intimate contact with the place they live in	Vibrant and flexible spaces to correspond with the elderly's changing needs, interests and abilities
Individual dignity	Feeling being respected by others	Non-hierarchical, manageable and controllable spaces

4.5. The Environmental Experience Design Research Framework

The aim of structuring this EXD framework is to meet physical and psychological needs and demands from user perspectives. To achieve it, the methodology of function analysis system is introduced. Such methodology is important to identify "the performance of a user function" and refine the design procedure to "fulfil a user requirement" [60]. It determines by asking what functions that users need and how designers satisfy these. Consequently, the Function Analysis System Technique (FAST) diagram is applied for taking project functions and arranging them in a logical order [60]. It aids in clarifying problems objectively through visualising and understanding logical relationships between related functions. Such FAST diagram may help to explore the elderly users' physical and psychological needs and demands. As an example, it was generated to explore functions that relate to the elderly users' physical and psychological activation for their health and wellbeing (Figure 11).

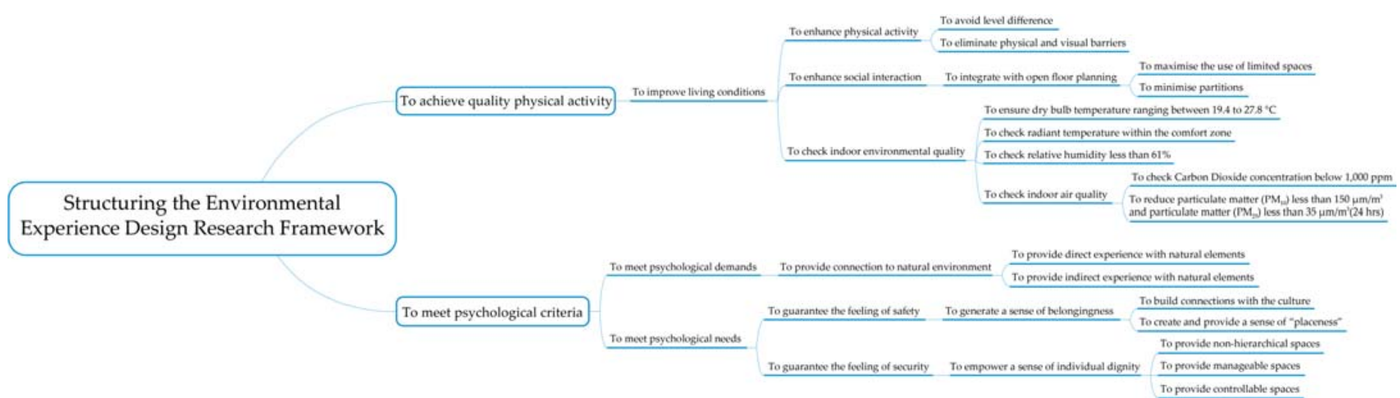

Figure 11. Environmental experience design function analysis system technique (FAST) diagram example.

The function analysis results may need to be converted into a medium that provides a design guideline to which stakeholders involved in design development can apply. Accordingly, in this study, an EXD research framework matrix was proposed, encompassing related design criteria, design settings, objectives, design elements, opportunities and design solutions. For the demonstration purpose, an EXD research framework matrix for the design improvement of aged care facilities was developed based on the previous function analysis results (Table 2). The EXD matrix serves as a diagnostic tool to recap the effective functions and transform them into design solutions that can be applied to upgrading new and existing buildings according to users' physical and psychological needs and demands.

Table 2. Environmental experience design diagnostic matrix.

Design Criteria	Design Settings	Objectives	Design Elements	Opportunities	Design Solutions
Physical Activation Criteria	Natural setting	Natural variability	Sounds	Providing pleasing effects	Euphonic sounds increase
				Providing soothing effects	Chaotic sounds reduction
			Touch responses	Interaction with vegetation	Garden walking pathways
				Interaction with animals	Freedom of feeding pets
			Smell responses	Olfactory stimuli	Different scented plants
			Ageing and changing	The rhythm of life	Seasonal plants assembly
		Natural harmony	Complex order	Rich sensory information	Different types of flowers and trees gardening
			Patterned wholes	Intriguing balance between boring and overwhelming	Symmetric and fractal geometries of integrated pavements
		Naturalness	Outdoor gardens	Ecological connectivity	Communal spaces in the garden
			Garden crafts	Culture and ecology integration	The elderly engaged gardening
	Built environment setting	Spatial adaptability	Present spatial needs	Achieving the elderly's satisfactions	Calming colours of wall and ceiling paintings
					Natural textured material of floorings
					Two layered curtains: gauze and fabric curtains
					Freedom of bringing personal belongings
					Lockable interior doors
					Keep gardens open
		Spatial flexibility	Future spatial needs	Pliable temporal limitation	Moveable partitions
		Spatial durability	Ease of maintenance spaces	Cleanness guarantee	Flooring with vinyl
		Spatial arrangement	Spatial requirement	Friendly, comfortable and welcoming living conditions	Kitchen adheres to dining areas
					Communicative living rooms
					Bedrooms with private bathroom
					Multi-activity rooms
					Corridors with hand rails
					Clinic and therapy areas
					A nurse's station
			Spatial relationship		Kitchen next to dining room
					Nurses station away from dining room
					Nurses station away from reception and entrance
					Nurses station away from high-care residents' bedrooms
					Nurses station away from clinic and therapy areas
					Nurses station away from staff office
					Low-care elderly's bedrooms next to activity rooms
			Spatial layout		Using bubble diagrams
		Indoor environmental quality	Dry bulb temperature	Elderly wellbeing, comfort and health	Direct heat exposure avoidance: 19.4 to 27.8 °C
			Radiant temperature		Shading provision: within the comfort zone
			Relative humidity		Fresh air ventilation: less than 61%
			Indoor air quality		Fresh air ventilation: CO2 concentration below 1,000 ppm
					Particulate matter (PM_{10}) less than 150 μm/m^3 (in 24 hrs)
					Particulate matter (PM_{10}) less than 35 μm/m^3 (in 24 hrs)
Psychological Activation Criteria	Psychological demands	Emotional wellness	Anxiety reduction	Harmful effects on health andthe overall quality of life	Respect the elderly's personal choices and decisions
			Angry reduction		
			Depression reduction		
		Passive participation	Activating physical walking	Increase engagement and participation	Low-care elderly's bedrooms in a distance to living rooms
			Visual connection to activity rooms		Lay-outing the low-care elderly's bedrooms be adjacent to activity rooms
	Psychological needs	Security	Empowering a sense of individual dignity	Being free from injury	Non-hierarchical spaces
					Manageable spaces
					Controllable spaces
		Safety	Generating a sense of belongingness	Being protected from risk	Locating residential care facilities in the neighbourhood
					Rooms have visual connections with outdoor
					Stimulating the elderly to bring vernacular objects
					Stimulating the elderly engaged gardening
					A space with the passage of time
		Active participation	Barrier-free spatial conditions	Physical activity stimulation	Level difference avoidance
					Slip-resistant and firm flooring surfaces
					Physical and visual barriers elimination
					Wide interior doors, corridors and turning spaces associated with the elderly movements
			Open floor planning	Social interaction	Maximising the use of limited spaces
					Minimising partitions
			Multi-activity rooms' design	Restorative activity	Evoking and developing the elderly's interests

5. Conclusions

This study led to the creation of a new terminology "environmental experience design" (EXD) and the research framework through literature reviews of theories on emotion, user experience design, experience design and environmental psychology, as well as studies on existing spatial settings and indoor environmental quality of an aged care facility selected in Victoria, Australia. Through the case study of a selected aged care facility (i.e., Adare SRS), various physical environmental data (including dry bulb temperature, radiant temperature, relative humidity and indoor air quality) have been collected and analysed. However, the objective outcomes from monitoring itself do not necessarily reflect users' subjective comfort or environmental experiences; therefore, human subjective environmental experiences should be examined further. Accordingly, the EXD approach was proposed considered an attempt that affiliates experience design and environmental psychology with the creation of the built environment that requires to accommodate user needs and demands. The EXD explores design essentials beyond physical data-driven interpretations. In this paper, the above-mentioned EXD objectives provided a base for further execution of related function analysis and matrix development. Using the Adare SRS case, the Function Assessment System Technique (FAST) diagram and the EXD diagnostic matrix for the elderly users' physical and psychological activation were demonstrated. The EXD matrix served as a diagnostic tool to recap the effective functions and transform them into design solutions. It can be applied to upgrading new and existing buildings according to users' physical and psychological needs and demands.

The quality of space needs to be evaluated by users themselves. In this paper, the EXD research framework matrix was developed with due consideration of the elderly users' behavioural patterns observed; however, their direct opinions over spaces were not collected. Therefore, the questionnaires about their post-EXD solutions and potential outcomes should be gathered and analysed. The EXD approach can also be applied to any other spatial design decisions under various environmental conditions. Therefore, the application to different architectural topologies and environmental conditions should be conducted.

Acknowledgments: The authors would like to thank the Adare SRS for providing access to the facility for research activities and the Thrive Research Hub for providing measuring devices for collecting physical environmental data.

Author Contributions: The first author led overall research activities and contributed to structuring the proposed environmental experience design diagnostic framework. The second author conducted spatial data collation of an aged care facility selected. The third author dealt with the indoor environmental quality assessment. The fourth author contributed to the total editorial coordination and arrangement.

Conflicts of Interest: The authors declare no conflict of interest.

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