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Developing an integrated design model incorporating technology philosophy for the design of healthcare environments: A case analysis of facilities for psychogeriatric and psychiatric care in The Netherlands

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ABSTRACT

The design of healthcare facilities is a complex and dynamic process, which involves many stakeholders each with their own set of needs. In the context of healthcare facilities, this complexity exists at the intersection of technology and society because the very design of these buildings forces us to consider the technology–human interface directly in terms of living-space, ethics and social priorities. In order to grasp this complexity, current healthcare design models need mechanisms to help prioritize the needs of the stakeholders. Assistance in this process can be derived by incorporating elements of technology philosophy into existing design models. In this article, we develop and examine the Inclusive and Integrated Health Facilities Design model (In2Health Design model) and its foundations. This model brings together three existing approaches: (i) the International Classification of Functioning, Disability and Health, (ii) the Model of Integrated Building Design, and (iii) the ontology by Dooyeweerd. The model can be used to analyze the needs of the various stakeholders, in relationship to the required performances of a building as delivered by various building systems. The applicability of the In2Health Design model is illustrated by two case studies concerning (i) the evaluation of the indoor environment for older people with dementia and (ii) the design process of the redevelopment of an existing hospital for psychiatric patients.

1. Introduction

The design of buildings is a complex and dynamic process. In the context of healthcare facilities, this complexity exists at the intersection of technology and society because the very design of these buildings forces us to consider the technology–human interface directly in terms of living-space, ethics and social priorities. The overall complexity is strongly increased when the design process concerns buildings for specific user groups with non-standard requirements. For example, the design of a psychiatric hospital or long-term facility for older adults with dementia requires an interdisciplinary dialogue involving many medical disciplines, care professionals, and patient associations. In addition, the design of the building should also take into account the standard requirements of an adequate operation and cost-effective maintenance. It is a challenge for the architects and consulting engineers to capture these needs in a single design. The complexity of such design processes is enlarged due to (i) the increased

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insight of the medical disciplines and care professionals during the design process into the requirements, resulting in changes in the desired performances, and (ii) the increased insight of the architect and the designers in the characteristics of the specific user group and the translation of these characteristics into a suitable design. For these reasons, it is of utmost importance to gain an in-depth insight in the complexity and dynamics of such processes.

The complexity of the built environment becomes particularly evident when concerning the *evidence-based* design of healthcare facilities [1,2]. The domain of healthcare follows – as much as possible – the principle of evidence-based practice, meaning that treatment and interventions should be supported by scientific evidence. Thus, ideally, the design of buildings in which care or medical treatment and interventions take place should also be in compliance with evidence-based practice. Discussions about the importance of the built environment for healthcare delivery extend at least as far back as Hippocrates (around 400 BC) and Florence Nightingale [3]. Huisman et al. [2] have shown that there are numerous design solutions which positively impact or support a number of stakeholders, including patients, staff and relatives. The needs of these different stakeholders add complexity to the desired design criteria. Zimring and Bosch ([4], p. 148) state that effective evidence-based design, which they describe as "*a practice that can genuinely contribute to the wide range of complex decisions involved with health care design*", requires full-bodied research efforts and a large amount of valid information that can be applied in practice.

To date, there is not such a unified theoretical foundation to support the compilation of research findings in the field of evidence-based design for healthcare facilities. This discussion is gaining additional urgency as the building sector is dealing with the consequences of the aging of society, where new approaches are needed to building adequate housing for our older citizens, living both in the community as in institutional settings. Various researchers have proposed theoretical or conceptual frameworks linking different built environment characteristics to health outcomes or to capture the current domain of evidence-based design in healthcare [5–7]. These models all capture a different part of the complexity and, thus, reflect a part of reality. Durmisevic and Ciftcioglu acknowledge this complexity ([6], p. 101): "[*N*]*ew knowledge in evidence-based design adds continuously to complexity (the "information explosion"), and it becomes impossible to consider all aspects (design features) at the same time, much less their impact on final building performance*."

According to Durmisevic and Ciftcioglu [6], there is no adequate methodology to deal with different environmental aspects in a holistic way. Moreover, there is a lack of knowledge on the cumulative effect of various environmental aspects on health, and there is no adequate tool for the efficient knowledge management and modeling of evidence-based building data based on individual studies. Existing studies do not address the built environment in its entirety, as they are conducted by researchers from healthcare to building sciences, but address separate aspects [5]. In addition, there are a lot of additional questions about the integration of the specific user group characteristics and their non-standard requirements in the design process. These challenges call for an integrated building approach that optimizes values for all stakeholders involved in the building process over the building's lifespan. Such an approach would incorporate existing frameworks known in building sciences and healthcare.

The aim of this study is to develop a universal, inclusive and integrated model that does justice to the complexity of design processes in healthcare and the needs of involved stakeholders. It should incorporate the fundamentals of philosophy and theory, which are missing from current models. We develop this model through a succession of steps:

(a) Case study analysis;

(b) Evaluation of the International Classification of Functioning, Disability and Health (ICF) of the World Health Organization [8], and the Model of Integrated Building Design (MIBD) by Rutten [9] from the perspective of the case studies;

(c) Philosophical exploration of complexity and the ontology by Dooyeweerd [10];

(d) Refining the combination of ICF and MIBD by incorporating a philosophical foundation.

2. Case study analysis

The complexity of designing healthcare environments is illustrated by two case studies. The first case study is the design of appropriate housing for older people with dementia, in which they can continue living in the community (Fig. 1) [11–16]. The second case study is the design of a new psychiatric hospital in Maastricht, the Netherlands (Fig. 2). The description of this case was taken partly from Klijn [17] and through direct observations gathered from 2004 to 2007.

2.1. Case 1: designing for older people with dementia

Persons with dementia have special needs regarding their housing conditions. Contrary to popular belief, loss of

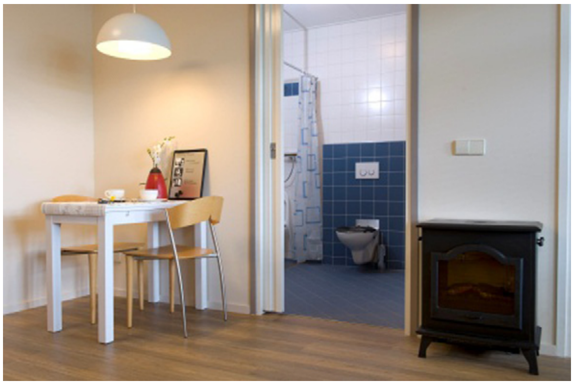

Fig. 1. Inside a demonstration dwelling for persons with dementia in Woerden, the Netherlands [16]: view of the kitchen area, the decorative hearth and the bathroom.

Fig. 2. The new Vijverdal hospital for psychiatric care, Maastricht, The Netherlands.

memory is not the only deficit in dementia. Impairment in activities of daily life and behavioral problems are common symptoms. All these symptoms impact daily living and the way dwellings should be designed in order to be supportive and take away hindrances.

Apart from a wide range of home modifications that can be used to assist persons with dementia and their caregivers, certain aspects of interior designing need to be considered, such as the choice of repetitive patterns and colors. Another aspect relevant to people with dementia is the indoor environment, comprising sounds, temperature, lighting and smells. People with dementia may have an altered sensitivity for indoor environmental conditions. Dementia, therefore, creates demands for the design of the home's physical indoor environment and relevant building services. Moreover, there are the needs of a spouse and professional caregivers visiting the person with dementia at home. One example of the complexity of design solutions is related to high indoor temperatures, for instance, temperatures exceeding 25 °C during a heat wave. Such temperatures impact thermal comfort in a negative way, possibly leading to the expression of problem behavior such as wandering and arousal, and may cause dehydration. Moreover, high temperatures and their effects can be strenuous for caregivers.

Apart from the person with dementia, there are numerous other stakeholders as partners, relatives, professional caregivers, housing organizations and care organizations, who all have specific needs concerning the built environment. The needs and requirements are often similar in character, as all parties want a good quality of care, although these needs and requirements can be totally different from a cost perspective. In addition, there are numerous questions which are so complex in character that they cannot be answered easily. For instance, to what extent do we fully understand how older people with dementia perceive the esthetics of the home environment and how to design assistive devices for people with dementia whose cognitive functions deteriorate? The health and care-related needs of the stakeholders and the performances that a building needs to fulfill form a heterogeneous range of design challenges and design options, for which no suitable models or classifications exist, to date. This implies that a new model may be helpful in identifying the complex needs of future residents of care homes and the staff based on asking critical questions. For instance, what is the effect of perceptual dysfunction of an older person with dementia on the various requirements we need to set to the various dimensions and systems of a building? A perceptual dysfunction may imply problems with vision (people require more light, less visual clutter, more contrast, avoiding hazardous situations), problems with hearing (people require a reduction of background noise, limiting reverberation sounds), and loss of smell (leading to safety issues as one cannot smell gas or tainted foods, or one's own body odor).

2.2. Case 2: designing a hospital for psychiatric patients

The 'old' psychiatric hospital Vijverdal was built in 1969. Its design was based on the view of a Community Mental Hospital in the 1960s. The architecture was seen as a significant social factor with the potential of having a positive influence on the behavior of patients. The idea that psychiatric patients had to be cared for in an outbuilding in the woods far from society was abandoned. It was believed that the hospital had to be geared to patients from the city and should have an urban character. It had to be a 'small society' that prepared the patients for a return to the 'real society'. These starting points led to two important architectural decisions. Firstly, the clinic and the treatment center would be housed in an apartment building of nine stories. The underlying idea was that an apartment building would be the best reflection of the living conditions in the urbanized Netherlands. Secondly, the various functions in everyday social life would have to be realized in this complex. Therefore, around the clinic and treatment center various facilities were designed: from shop to hair-dresser, from swimming pool to gym hall and from coffee shop to recreational space. In the press the new design was called 'revolutionary' because the classical idea of separate smaller buildings in the woods had been relinquished.

In the course of the time, however, the idea of a Community Mental Hospital was more and more criticized. It became steadily clearer that taking care of a psychiatric patient should not be concentrated in the hospital as a 'small society' but should be done as long as possible in the home situation as a 'real society'. Also, the goal of a hospital as an open community had been set too high. As a result, the architecture of the hospital did not fit in with the newly developed vision of care-giving. The functional giant would have to be replaced by accessible, patient-friendly sections on a smaller scale. In the late 1990s it was decided that a new hospital had to be built. Consequently, this new hospital was put into use in 2007.

The idea that patients had to be treated as long as possible in their home environment implied that hospital was populated with patients who suffered from a severe mental illness. As a consequence, the hospital could not be designed for the 'average psychiatric patient' but had to fit the mental mood and the social behavior of the individual patient. These considerations had a strong influence on the design. It was decided that the units should consist of no more than ten to twelve beds. Every patient would have a single room of twelve to fifteen square meters with its own toilet, shower and wash basin. In addition, every unit would have its own lounge, smoking room and outdoor space. In practice, this design appeared to be a good balance between 'individual space' and 'group space'.

The Vijverdal case shows that designing a hospital for psychiatric patients is a difficult job. It requires (a) a view on the psychiatric patient, the treatment, and the return to society, and (b) this view has to be 'translated' in the design. Two risks arise from this approach. Firstly, when the view of the psychiatric patient and the treatment is wrong then a wrong design develops. This was the case with the 'old' Vijverdal. Secondly, when the view on the psychiatric patient and the treatment is adequate, then this view can be 'translated' in the wrong way into the design. To prevent such a wrong translation, one needs to have a deep insight into the psychiatric disorder on the one hand and the influence of design on the experience of psychiatric patients on the other. In the following sections, we will highlight two items: the design of a unit and the esthetical appearance. Moreover, we will also discuss the need for models to guide the design process of healthcare facilities, using architecture for persons with dementia from the first case study as a topic.

3. Present models: the framework of ICF and MIBD

Van Hoof [11] (Fig. 3) presented a framework combining the International Classification of Functioning, Disability and Health (ICF) of the World Health Organization [8], and the Model of Integrated Building Design by Rutten [9] for the design and evaluation of a building. The two case studies have demonstrated the complexity encountered in the design of buildings and situations that can be used to evaluate the framework.

3.1. MIBD

The MIBD is an integrated model. It covers three different types of complexity: (1) building system, (2) performance and (3) value-domain. Firstly, the building system represents the technological complexity of the building system itself. It includes the six systems of Brand [18]: stuff, space plan, services, skin, structure, and site. Each system has a specific set of functions (which can be seen as solutions) that contribute to the optimization of a certain value for the (different) stakeholders. The success of the final design is the result of how well the needs of the stakeholders are met by the building systems. Stakeholders' demands and system supplies set the prerequisite for building design performances.

Secondly, the performance represents the desired building performance for the different stakeholders. The demands of the different stakeholders are reflected in the specified performances like safety, security, production support, reliability, and esthetics, the compliance with laws, energy, water use, changeability, and costs. These demands set the prerequisite for building design performances. Finally, the MIBD distinguishes different value-domains. It distinguishes six different types of values: basic, local, functional, economic, ecological, and strategic values. Each of these values is related to at least one important stakeholder: the individual, organization, community, global community, potential users, and owner.

In conclusion, the MIBD is an integrated model that addresses different types of complexity that has to be covered in the design process. However, the application of this model to long-term housing for persons with dementia and a hospital for psychiatric patients appears to be a challenge. How can designers cope with the complex behavioral patterns of older persons with dementia in the design of Brand's systems? How can designers translate the experience of psychiatric patients to the performances of Brand's systems? And how can designers account for the large number of stakeholders and how can designers balance their interests? In other words, the two case studies pose a challenge to using the MIBD in such a way to do justice to the context of healthcare.

3.2. ICF

The International Classification of Functioning, Disability and Health is a classification of and health and health-related domains [8]. It distinguishes between bodily functions and structures (impairments), activities (limitations), and participation (restrictions). The activities are further classified into personal and environmental factors. The ICF in itself is a pragmatic approach from the domain of healthcare, and its overall aim is to provide a unified and standard language and framework for the description of health and health-related states. Each component of ICF can be expressed in both positive and negative terms. From the health point of view, one's function can be impaired, activities limited and participation restricted. This means that the ICF focuses on complexity from the perspective of illness and health. For example, in the case of housing for people with dementia, you deal with somatic illnesses and a psychiatric disorder, and their accompanying cognitive limitations and social restrictions.

ICF captures those aspects of human functions and structures, activities, and participation that have to be translated into performances and building structures. For instance, a person with dementia, who experiences problems carrying out a certain activity of daily living as toileting independently, may need certain home modifications to facilitate this process. However, the ICF does not guide a designer through the world of impairments, limitations, and restrictions. It also does not give the designer a clue for relating this world to his or her own world of functional specifications and technological structures. Therefore, it is difficult to connect this classification to the two case studies.

3.3. Connection

At first glance, it may seem obvious to combine the MIBD and the ICF in order to arrive at a framework accounting for the full complexity of designing housing for older adults with dementia and hospitals for psychiatric hospitals. The combined framework seems to address all relevant themes of the built environment in the context of

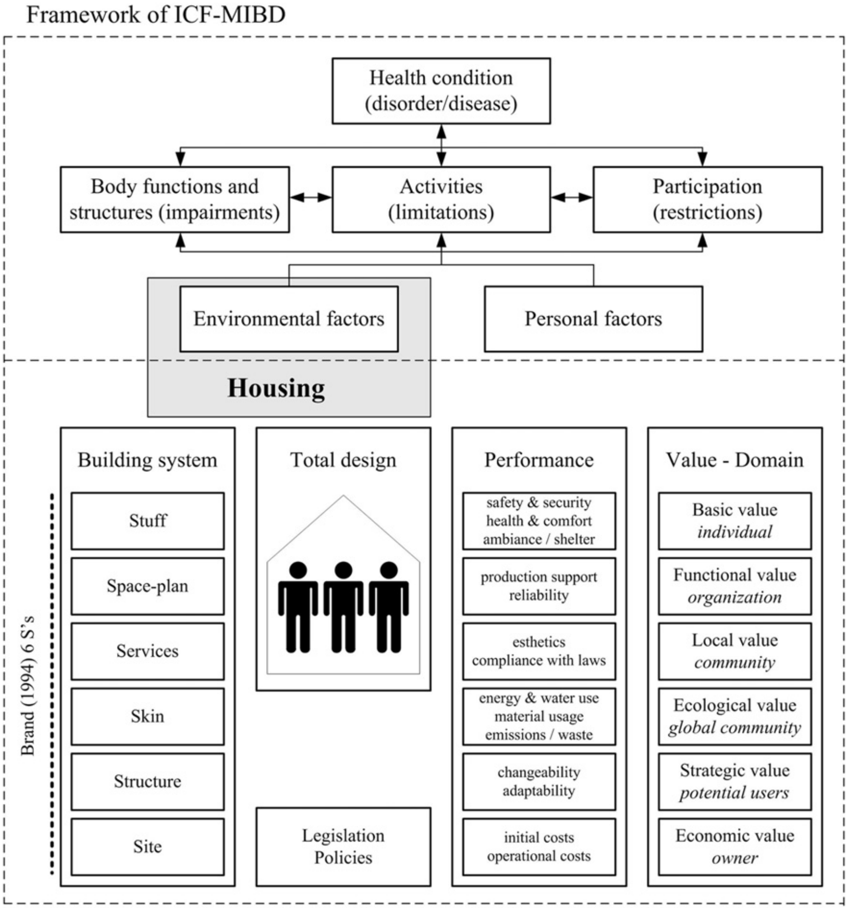

Fig. 3. The integration of the MIBD and ICF as proposed by van Hoof [11].

healthcare [11]. For example, the basic values of the individual in the MIBD can be further elaborated from the bodily functions and structures of the individual of the ICF. In addition, the limitations and the restrictions of the citizen or patient as elaborated in the ICF can be related to the performance functions of the MIBD. Furthermore, the economic aspects of the MIBD (initial costs, operational costs) cover the financial aspects of healthcare organizations. Finally, the MIBD addresses legislation and politics [9]. These topics are very important in healthcare. However, these two models alone do not enable designers to deal effectively with the realities of healthcare practice.

In this regard, serious questions arise. The first question is whether the combined model fully covers the complexities of homes for older adults with dementia and hospitals for psychiatric patients. How do we know that the combined model is complete? Is it possible that there are hidden performances, values, and themes? Another question is how the illness and health characteristics of a person can be related to the performance of the design. Do both models really fit so that dementia and psychiatric disorders can be guiding the design of a building structure? Finally, the combined model does not give any assistance for balancing conflicting interests between stakeholders. As a consequence, we have to dig further in the "normative state" of technological designs in relationship to different stakeholders. As such, that is a very broad topic, since various kinds of norms play a role in technology and the design thereof, in particular the normative features related to the notion of function. This means that we need a realistic philosophically driven model that helps define "normal".

How to cope with these questions? These questions go back to the inherent complexity of healthcare practice in reality. That means, these questions can only be answered on the basis of an ontological and ethical framework that does justice to the somatic, psychological, and social aspects of older adults with dementia and psychiatric patients (ICF), the various functions and building structures of homes and hospitals, and the different values of stakeholders (MIBD). As a consequence, we need a philosophical framework to (re-)describe the needs and functioning of older adults with dementia and psychiatric patients, to (re-)analyze the complexity of building designs, and to (re-) identify normative moments in stakeholder interests. Such a framework is elaborated in the following section. Based on this framework we can integrate, elaborate and refine the combination of MIBD and ICF: the Inclusive and Integrated Health Facilities Design model (In2Health Design model). It is through this philosophically constructed framework that healthcare facilities arise in the intersection of technology and society.

4. Philosophical analysis of complexity

In this section we present a philosophical analysis of complexity to lay a foundation for the Inclusive and Integrated Health Facilities Design model (In2Health Design model). We believe that such a model – due to its philosophical underpinnings – has the potential to transcend the limitations of the combination of ICF-MIBD and to offer a truly integrated model for building design in healthcare. A similar approach supported electrical engineers in managing the complexity of the design of smart grids that integrate both micro grids (local systems) and super grids (international systems) [19]. This complexity is even larger for the design of healthcare facilities, therefore we need to define and map out the complexity.

4.1. Three types of complexity

What types of complexity are relevant in designing buildings for healthcare? What is the relationship between humans with an affected health status like older adults with dementia and psychiatric patients on the one side and technological artifacts like homes and hospitals on the other side? These types of questions are continuously discussed in the philosophy of technology context. In this field, two different approaches can be distinguished. In the analytical tradition the nature and character of technical artifacts are analyzed in detail. In this tradition, attention is given to the complexity of design itself and the normative aspects that play a role in the design process. In the critical tradition, the role of technology in society is analyzed. In particular, questions are asked about the influence of technological artifacts on the quality of life, the freedom of people, and the natural environment. Both traditions in the philosophy of technology are required to understand the complexity of the design process.

Verkerk et al. [20] have given an introduction to both the analytical as well as the critical traditions of the philosophy of technology in connection to design. They show that in the design process three types of complexity have to be distinguished: dimensional complexity, technological complexity and stakeholder complexity. 'Dimensional complexity' refers to the different dimensions of a building that a designer has to take into account, for instance, spatial, technical, social, economic, juridical, and esthetical dimensions. 'Technological complexity' refers to the various technologies that have to be integrated into the same building, for instance, building technology, electrical technology, Information-technology, etcetera. 'Stakeholder complexity' refers to the diversity of stakeholders whose interests are at stake, such as patients, caregivers, nurses, owners, insurers, and bankers. These types of complexity can be seen as different cross sections in the design process that have to be managed in close coherence.

4.2. Wholes, dimensions and identity

In order to understand the nature of the dimensional, technological and stakeholder complexity we have to introduce some basic philosophical concepts. These concepts have been taken from the ontology developed by the Dutch philosopher Herman Dooyeweerd [10]. This ontology has been elaborated for technological artifacts by Verkerk et al. [20] and Schuurman [21].

Dooyeweerd makes a distinction between 'wholes' and 'dimensions'. A 'whole' is a total with its own identity. It is also referred to as an 'entity'. Examples of wholes are human beings and animals, trees and bushes, stones and grains of sand. All these 'wholes' are present in the natural environment and have their own identity. Humans, animals, trees and bushes are a part of the living world and stones and grains of sand are not. Humans can enjoy art and think rationally, and animals cannot. Animals have emotions and actively perceive their environment, and trees and bushes do not. Technological artifacts are also wholes. Examples are televisions, cars, houses, hospitals, and churches. These technological artifacts also have different identities. Televisions are mainly used for recreation, cars for social activities and business, houses for social living, hospitals for curing and caring, and churches for religious rituals. So, our first conclusion is that there are different kinds of wholes and that every whole has its own identity.

Dooyeweerd shows that 'wholes' function in a number of different aspects or dimensions (theory of modal aspects). For example, a human being needs food (biological dimension), has feelings (psychical dimension), interacts with other people (social dimension), exchanges goods with another person (economical dimension), enjoys art (esthetical dimension), shows ethical behavior (moral dimension), and does or does not believe in God (spiritual or religious dimension). According to Dooyeweerd, all these dimensions have their own nature or character: each dimension has its own dynamics and shows its own mechanisms. In addition, each dimension can be described with specific laws or norms. For example, the norms for social interaction are quite different from the standards of enjoying art. The biological laws that determine the digestion of food are quite different from the norms for moral behavior. The standards for the spiritual aspect are quite different from those of the economic aspect. In other words, every dimension has its own set of distinct norms (Table 1).

Technological artifacts are also 'wholes' that function in a number of different aspects or dimensions. For example, a hospital functions in the spatial dimension (it has a specific shape) and in the physical dimension (it consists of materials with specific properties). A hospital functions in the economic dimension (investment money, operating costs) and in the esthetical dimension (its architectural beauty). It also functions in the juridical dimension (a hospital has an owner) and in the spiritual dimension (giving hope and trust).

The basic concepts of wholes, dimensions and identity will be used to investigate the nature and character of the three different complexities: dimensional complexity,

Table 1
The fifteen dimensions by Dooyeweerd [10] and their relationship to building for people with dementia and psychiatric disorders.

Dimensions	Character or nature	Examples
1 Numerical (arithmetic)	Discrete quantity	This dimension refers to numbers that can be found in elevators, clocks, telephones, prizes in a canteen, etcetera. What if numbers lose their meaning, for instance, due to dementia?
2 Spatial	Extent, size, shape	This dimension refers to the shape of a building, spatial layout of corridors and location of wards. How do psychiatric patients perceive and experience the shape and the space of rooms and common rooms in a psychiatric hospital? What is the influence of the design on the psychiatric mood of the patient? How can one define a healing environment for patients with bipolar disorders or schizophrenia? How important is an outdoor space for closed wards? For example, in the new psychiatric hospital Vijverdal many corridors had windows at the end in order to prevent the feeling of being locked up. In addition, every ward had its own outdoor facility.
3 Kinematic	Movement	The kinematic dimension refers, for example, to the physical movements of the patient. Research has shown that walking is very important for psychic functioning and healthy aging. So how can we design spaces which prevent falls, and which support mobility and walking around? How can we cope with impaired mobility? Do we need circular corridors for wandering?
4 Physical	Energy, physical properties, interaction between materials	The physical dimension refers amongst others to the indoor environment like drafts, temperature, light, daylight access. What is the influence of these aspects on people with dementia and psychiatric patients? Which colors used on the ceilings and walls reduce stimuli and emanate rest and peace? For instance, there exists anecdotal evidence that a ‘cold’ blue color may have a negative influence on the behavior of psychiatric patients.
5 Biotic (biological)	Organic life, vegetative existence	The biotic dimension refers to the somatic functioning of patients. Research has shown that the somatic functioning of people with dementia and psychiatric patients is strongly influenced by the built environment. For example, high intensity lighting slows down cognitive decline and improves circadian rhythmicity in persons with dementia. Furthermore, cooling systems are important to protect older persons against the detrimental effects of hot summers and dehydration. Being in touch with nature supports one’s biological functioning and is part of the so-called healing environment (also found for the spatial, physical and sensitive dimensions).
6 Sensitive	Feeling, sensing, sensory functioning	This dimension refers to the sensory functions and the feelings of patients. What feelings and emotions do patients with dementia have? How do psychiatric patients sense reality, for instance, when they have a psychosis? In this field a balance has to be found between too few stimuli that may induce inactivity and too many stimuli that may induce hyperactivity. Inside a separation room the number of stimuli has to be as low as possible.
7 Logical (analytical)	Logical reasoning, analytical abilities, valuable distinctions	This dimension in related with the cognitive functioning of older adults with dementia and psychiatric patients, which is (quite) different from that of healthy adults. People may not be able to make plans or do things in a certain order. Also, they cannot maintain their own daily rhythm. To which level can design support the cognitive functioning of older adults with dementia? What is the ideal and logical flow of spaces or a building’s lay-out? For example, clues for orientation are needed in rooms and corridors. Repetitive patterns on wall papers may cause confusion.
8 Formative	Power, control, influence	This dimension is about the power that patients have over their own life. Particularly, in homes for older adults with dementia and hospitals for psychiatric patients, questions about control and influence are very important. On the one hand, the built environment limits the freedom of its residents. For instance, in the closed wards patients are not allowed to open and close the exits. On the other hand, exits have to be designed in such a way that a certain level of autonomy is supported. For example, when going to the bathroom at night, night-time orientation lights may illuminate the corridor. At the same time, automatic switches may induce panic when patients look for the light switch when leaving the bathroom.

(*continued on next page*)

Table 1 (*continued*)

Dimensions	Character or nature	Examples
9 Informatory (lingual)	Meaning of words, symbols or events	This dimension deals with the meaning of words and symbols for patients. How do older adults understand words and pictograms throughout the different phases of dementia? How can religious symbols be used in spiritual care? How can one design memory lanes that give meaning to things from the past? And what about the meaning of personal items like furniture, table-mats, and paintings?
10 Social	Social interaction, connectedness of people	This dimension refers to the social life of psychiatric patients and older adults with dementia. Designers need to have knowledge about the influence of dementia and psychiatric disorders on the social interaction between patients, between patients and their family, and between patients and professional caregivers. This type of information is essential when designing spaces and gardens. In many cases, multiple spaces may be needed to prevent negative social interactions and to stimulate a safe environment.
11 Economic	Scarcity, stewardship	The economic dimension refers to the economic and financial aspects of healthcare. In all Western countries the costs of healthcare strongly increase. Therefore, the development of financially sustainable healthcare is very important. The design of both the infrastructure as well as the organization should minimize costs for the state, insurers and the patients.
12 Esthetical	Harmony, beauty	The esthetical dimension is about the appreciation of harmony and beauty. Is the interior design pleasing and beautiful? What is the esthetical perception of psychiatric patients or older persons with dementia? What is sustainable esthetics for these groups?
13 Juridical	Justice	The juridical dimension deals with justice in a broad sense and legislation in a narrow sense. How can one protect the privacy of the residents in a psychiatric hospital or long-term care facility? How do the juridical rules influence the design of isolation cells? How can one guarantee access to care for people with limited financial means? What about the liability in case of incidents and accidents, such as fires?
14 Ethical (moral)	Love, care	The ethical or moral dimension refers to caring for nature and man. The whole design of the building should support and facilitate care. Staff should have an overview of the situation on the work floor. The design of a healing environment should support the well-being of the patient. Wandering detection and automated access control may also support care. Patients should have the possibility to withdraw, as long as it does not interfere with the provision of care.
15 Creedal (religious, spiritual, pistical)	Transcendental security, trustworthiness, belief,	This dimension is about the religious or spiritual experience of patients. How can one support the basic beliefs of patients by the building? What type of religious symbols is important? How can one express spirituality? A well-known example is the cross in the reception and the chapel for Sunday mass for people with a Catholic background. Another important element is to design the chapel in such a way that rituals can be experienced that fit to the cognitive state of the patients. A quite different perspective is that a building should express the idea of trust: they are safe and trustworthy.

technological complexity, and stakeholder complexity. We will show that an analysis of these three complexities is a prerequisite for designing buildings in general and for designing homes for older adults with dementia and hospitals for psychiatric patients more specifically.

4.3. Dimensional complexity

Dooyeweerd showed that in total about fifteen different dimensions are present. These vary from arithmetic, spatial, kinematic, and physical to esthetic, moral and religious. A list of all dimensions is given in Table 1 and Fig. 4. Intentionally, we used the word ‘about’ because Dooyeweerd wants to keep the options open for further philosophical and disciplinary research that discover new aspects or show that some aspects are superfluous because they are covered by another one.

Dooyeweerd showed that every whole functions in fifteen different dimensions. This holds not only for humans but also for technological artifacts. Humans are subject to the laws of the arithmetic, spatial, kinematic, and physical sciences. They have the choice to act in agreement with or to reject esthetical, moral and religious norms. It has to be remarked that psychiatric disorders and dementia may seriously affect esthetical experience, moral consciousness, and spiritual devotion. Technological

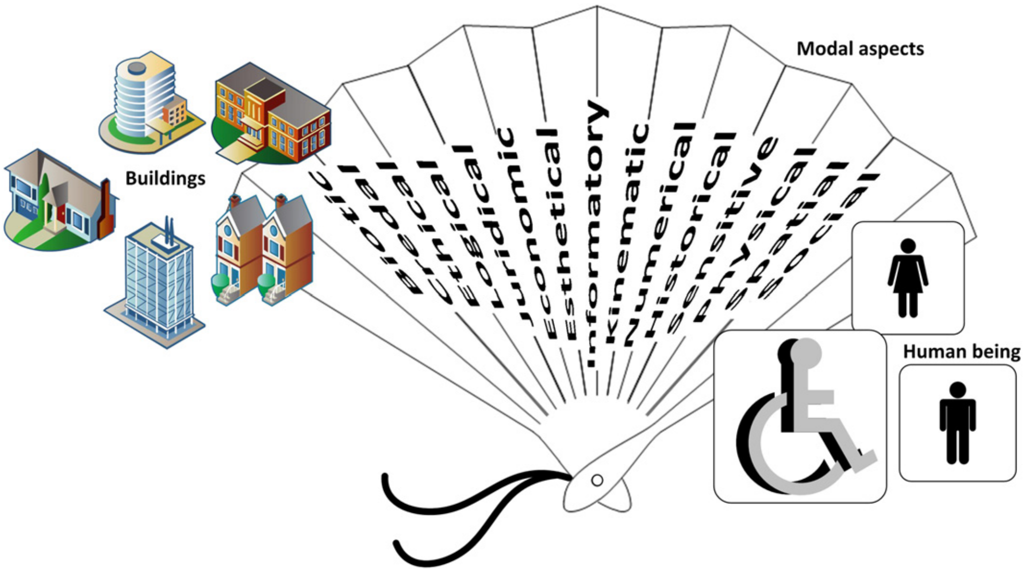

Fig. 4. Conceptual combination of the ontology of Dooyeweerd, the MIBD and ICF. The 15 modal dimensions are represented as a fan, linking buildings (MIBD) to the impaired or diseased human being (ICF).

artifacts are also subject to the laws of the arithmetical, spatial, kinetic and physical sciences. However, the other eleven dimensions function in relationship to humans.

The relationship of human beings or a technological artifact and their different dimensions can be explained using three metaphors. The first is that of the diamond ('whole') with a number of different facets (dimensions). The diamond expresses itself in different facets but these facets cannot exist outside a diamond. The same holds for a human being or technological artifact: we can distinguish fifteen different dimensions but there are no dimensions apart of the human being or the technological artifact. The second metaphor that can be used to understand the relationship between a whole and its dimensions is that of a beam of light which is broken by a prism. When white light ('whole') is broken by a prism (scientific study) different colors (dimensions) become visible. This also holds true for the example for healthcare facilities. A scientific study of a home for older adults with dementia or a psychiatric hospital will reveal a lot of different 'colors' or 'dimensions'. Some of these colors are vivid and are well-known. Others are pale and require a scientific study in order to be identified and understood. The third metaphor to be mentioned is that of the slats of a fan (Fig. 4). A fan consists of a number of different slats. A fan, however, can only function at its best when the whole fan is opened and all slats can perform their true function. Mutatis mutandis, a building can only perform at its best when all dimensions can perform their true function. These three metaphors emphasize that all different dimensions of technological artifacts, like housing for people with dementia and psychiatric hospitals have to be developed well during the building design process. These metaphors challenge us to investigate the precise meaning of every dimension for a specific design. In other words, it compels engineers to ask questions.

What type of questions should an engineer ask given this model? We will give some examples with respect to the biotic and social dimensions of healthcare facilities. An important aspect of designing buildings is the lighting system. To design such a system for housing for people with dementia we need to know more about the influence of lighting on the behavior and well-being of these patients. For example, van Hoof et al. [15] showed the importance of light and lighting for dementia care. High intensity lighting, administered on a certain time and of a certain quality and quantity, helps persons with dementia to improve their circadian rhythmicity without any adverse health effects. In addition, the eyesight of people with dementia is changing due to biological aging. So, we need light with a certain frequency and intensity to support persons with dementia who have declining vision [15,22]. Finally, lighting is important to decrease or lessen the symptoms of depression [23]. That means a detailed insight into the biological dimensions of lighting and dementia is required to design the lighting system of homes for persons with dementia [24].

How should we design the space of the ward in a psychiatric hospital? This question arose in designing the space for psychogeriatric care. To answer this question we need to have more insight into how psychiatric patients interact with each other and how they experience social relationships. Should the design consider the space as a room that supports the social interactions between residents or patients? Or as a room in which each individual can find his or her own way? In discussing these questions it appeared that these persons have such severe mental problems that the space had to support the care process of every individual, had to give every person the feeling of a sheltered life, and had to minimize the stimuli given by other resident patients. As a consequence, the whole ward and the common rooms were designed in such a way that the patients were not urged to interact socially and had the opportunity to withdraw. These examples all relate to the social dimension of a psychiatric hospital.

Both examples show that one needs to have detailed insight in the functioning of the residence or patients in order to start asking the right questions, to find the relevant answers and to design appropriate solutions. There are usually more questions than answers when it comes to healthcare facilities so the model or framework should prompt engineers to ask questions in certain areas.

Table 1 gives an overview of the fifteen different dimensions, their specific core characteristics, and an elaboration for housing in the relationship to healthcare facilities as illustrated in the two cases in this article. Basically, this table shows that every dimension of human functioning can be reflected in the different dimensions of the design of the building. The table also provides a step-by-step plan for asking the right questions during the design process.

Table 1 and Fig. 4 show that the first challenge of a designer is to understand the influence of the psychiatric disorder and dementia on the fifteen different functions of man. The second important step is to understand how this deepened insight in the functioning of the psychiatric patients and older adults with dementia can be 'translated' in the design of the hospital or long-term care facility. Fig. 4 clearly shows that the theory of modal aspects of Dooyeweerd is used as a philosophical framework bridging the characteristics of users and the design criteria of buildings.

4.4. Different technological systems

The second type of complexity is technological complexity. All buildings, albeit a home or an office building, exist through a physical integration of various technological systems. Each of these systems, in turn, has its own characteristics and functionalities. Brick and concrete slabs contribute to a spatial structure. Electricity systems provide power and form the engine of a building. The information and communications (ICT)-infrastructure of the building forms the intelligence of the building and implies the transportation of data, the interpretation of records, and making decisions. Elevators and stairs can be used for the transportation of occupants. All these technologies have a different function and are an integral part of designing a modern building.

It is a challenge for the designer (a) to analyze the character and nature of different technologies and sub-technologies, (b) to categorize them in a systematic way, and (c) to tune them to the different stakeholders?' In the analysis of the different technologies and sub technologies the theory of modal dimensions can be helpful. For example, these technologies are characterized by the physical dimension, the space-plan by the spatial dimension and the ICT-services by the formative dimension. The categorization of the different technologies and sub-technologies has to be done in a meaningful way from the perspective of the designer. In the MIBD the technologies are categorized as follows: stuff (furniture), space-plan (architectural lay-out), services (ICT infrastructure, building services, lighting), skin (windows and façade systems), structure (trusses, concrete slabs), and site [18]. However, these six systems as defined by Brand [18] may not be sufficient for healthcare applications and should also include assistive technologies and smart home systems. The Design Brief Working Group of NHS Estates [25] have included a number of different S's in their report, namely, shell, services, scenery, settings, site, skin, and systems. Apart from the six S's, the design process could also be conducted based on the concept of the seven A's: awareness, accessibility, affordability, appropriateness, adequacy, acceptability, and availability [26]. These seven A's are implicitly included in the value domains of the framework. For the design and evaluation of healthcare environments these seven A's may be a good addition, as they can be approached on different levels. In the end, no categorization may be complete or fully inclusive. Finally, the analyzed and categorized technologies and sub technologies have to be tuned to the needs of the users and the interests of the other stakeholders.

4.5. Different stakeholders

In the design of new building a number of different stakeholders are involved. These stakeholders all have their own needs and own interests that have to be taken in account as much as possible in order to design and construct a building that fulfills their requirements.

The design of healthcare facilities involves a large amount of different stakeholders. Primary occupants (residents and patients), family members, healthcare professionals and physicians, people living in the neighborhood, public bodies, insurance companies, banks and a plethora of other stakeholders can be identified. When the needs of the relevant stakeholders are not very outspoken or largely unknown, as is the case with persons with dementia or psychiatric patients, these needs cannot easily be translated into design options and subsequent design solutions. Hence, there is a need for a tool to grasp the complexity and steer the process of selecting and integrating design solutions.

The interests of the different stakeholders can be analyzed in more detail by using the theory of modal dimensions. For example, let us analyze three different stakeholders of a psychiatric hospital: patients, owners, and public bodies. The most important dimension for a psychiatric hospital is the moral dimension: caring or curing the patient. That means, from his or her perspective, the hospital has to be designed in such a way that the healing process is facilitated as much as possible. In other words, all technologies and dimensions of the design have to contribute as much as possible to the health of the patient. The most important interest of the owner is economic. The building has to be a sustainable investment and the return of investment has to be satisfactory. That means, for all technologies and all aspects of the building design the contribution to economic sustainability has to be asked. The most important interest of the public bodies is to be juridically qualified. The building has to comply with building regulations, safety regulations, healthcare regulations, and so on. These regulations will influence all technologies and all dimensions of the design.

What does this analysis imply? Does it mean that for the patients the economic considerations do not play a role? Surely, the price of the beds is important for the patient and his or her insurer. When the price becomes too high these beds will not become available for healthcare. However, the first priority of the patient is that the building supports care. Does it mean that for owners moral considerations are not important? Of course, they are important. More than that, many investors are socially motivated to invest in healthcare. However, when the investment would be too risky then they cannot complete the transaction because they have their own responsibility to their shareholders. Does it mean that the public bodies are not interested in care and return on investment? Absolutely, they are. After all, they work for the public interest. But they have one main responsibility: to ensure that the building will meet all the local and national regulations.

This analysis shows that the different stakeholders have different interests and these different interests can be prioritized. The challenge for the designer is to design the building in such a way that the interests of all stakeholders will be satisfactorily met.

What about conflicting interests? Whose interests will tip the scales? For example, whose experience of esthetics will dominate the design? Historically, the architects set the standard for the esthetical appearance of the building. Despite the fierce discussions in the field about esthetics, they determine what is beautiful and what not. At the time, owners believed that esthetical wonders would increase the economic sustainability of their investment. In the Vijverdal case, however, the esthetical appearance of the new building was discussed in view of the needs of the patients. It was argued that the design could not be too exciting in order to prevent a relapse of the patient. It was also mentioned that daylight would be available everywhere and light colors had to be used to prevent a negative influence on the mood of a patient. Also, it was stated that stakeholders like the employees and the neighbors had to like the design. The last requirement was that the design had to be timeless. In other words, the esthetical experience of the building had to be sustainable.

In the Vijverdal case all relevant stakeholders agreed with the proposed esthetical requirements and the designer took them as a starting point. However, a conflict can easily arise about the esthetical quality between patient associations, designers and owners. For example, a designer can hold the opinion that the wishes of the patient associations limit his or her creativity. Or the owner can state that his or her esthetical experience has to settle the matter. Then one should ask the question "Whose interest takes priority?" In the case of a healthcare facility the patient associations would have a high priority because the esthetics of the building has to contribute to the healing process first and foremost given the primary modal function of the facility. In addition, the patients live in the building all day and the designer and the owner does not. The owner also has an important interest. Namely, the esthetical appearance has to contribute to the economic sustainability of the building. However, economic sustainability is supported by a healing design, a design that is appreciated by patients, employees and neighbors, and a design that is esthetical. In other words, the wish of the owner can be 'reformulated' in the relationship to the other stakeholders. Finally, we have to address the interests of the designer. The designer has to serve patients, employees, neighbors and owners. His or her challenge is to design a beautiful building that meets the requirements of the various stakeholders. There is no justified interest like 'freedom of design'.

This analysis illustrates that conflicting interests, must be discussed and prioritized from the perspective of the needs of the different stakeholders. A detailed analysis shows that some interests are justified and others not. For example, 'freedom of design' is not a justified interest of an architect. This analysis also shows that conflicting interests are not always 'conflicting'. At first sight, the interests of patients and owners may be conflicting. Our analysis, however, shows that they reflect two different 'conditions' that an architect has to fulfill in the esthetical design. We do believe that some conflicting interests cannot be solved in this way. In that case there are two options. In a worst case scenario the powerful stakeholder (for instance, owner, architect) will settle the matter. In a best case scenario, the values involved will be analyzed and weighed in view of the stakes of the different stakeholders (the methodology demonstrated above).

5. Refined model

In this paper we try to integrate three existing frameworks in an inclusive and integrated model to exploit the richness and strengths of each of the approaches.

5.1. Simplified representation

The In2Health Design model we propose based on this high-level analysis encompasses a number of interacting domains. Fig. 5 gives a simplified representation of the new framework in the form of interacting domains: dimensions of design, technological systems, and stakeholder needs. The arrows in the figure indicate the mutual interaction and the dynamics of the design process. For example, the

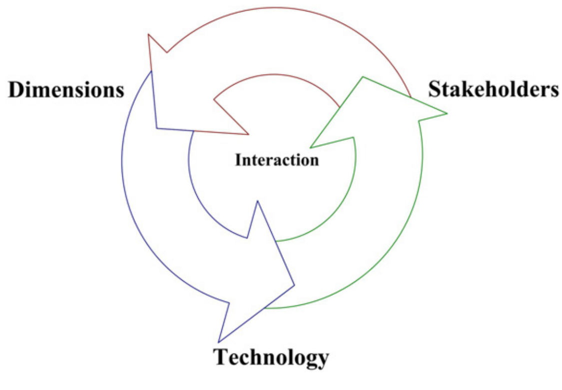

Fig. 5. The complex and iterative interaction between dimensions, technology and stakeholders. The interaction is also based on values, ideals and presuppositions.

development of new technologies like electronic prevention of wandering offers the designer more freedom in designing long term care facilities for older adults with dementia. Likewise, new insights in dementia will result in a deeper understanding of the different dimensions of design and will challenge us to use technology to develop new solutions.

5.2. Detailed representation

The refined model as presented in Fig. 5 invites the designer to ask questions about dimensions, technologies and stakeholders. The general question is: what is the importance of this specific dimension for a certain stakeholder? Because there are fifteen dimensions, five to ten different technologies, and five to fifteen stakeholders, the analysis is extremely complex. Therefore, we have to reduce this complexity to provide a useful framework.

In the detailed representation we would take our starting point as the interests of the various stakeholders. In Section 4.5 we found that each stakeholder has a specific justified interest. This justified interest has an influence on the different dimensions of the design of the facility. More specifically: the dimensions of every technology and sub technology. Let us take as an example the interests of the patient in his or her relationship to the different dimensions of the technology services. Table 2 gives an example of the analysis that has to be done. The analysis starts with the specific interest of the stakeholder, in this example, older adults with dementia. This means that the needs of caregivers or maintenance workers are excluded. The rows represent the different aspects and the columns the different sub technologies of services. For every cell the question has to be asked: how does this dimension of this specific technology support the caring process for the patient? This table invites the designer to ask questions about the specific condition of the patient (that can change over time) and the implication for the design, which can also change over time depending on the actual condition of the patient. For instance, the investigations of Van Hoof et al. [15] showed that lighting has an influence on the physical, biotic, sensitive, and social functioning of the older person with dementia. Examples include unwanted behavioral symptoms as agitation and restless behavior, difficulty locating thresholds and thus increasing the risk of falls. Future research may show that more dimensions are influenced by lighting. At this moment we know that humidity influences mainly the biotic functioning of the patient (to prevent dehydration) and the temperature the biotic and sensitive functioning of the patient. Maybe, future research will show that humidity and temperature influence even more dimensions.

In summary, the tool depicted in Table 2 helps to ask questions and to make an inventory of all the requirements of a certain technology and its sub technologies in order to support the care for the patient. This analysis also has to be done for all relevant stakeholders. The owner, for example, has the main interest of economic sustainability for the facility. Expectations are that the 'green cells' for this stakeholder will concentrate around the dimensions 'formative' (control of the services), 'economic' (investments and running costs), and 'creedal' (trustworthy system). This type of analysis gives a broad insight in the justified interests of the different stakeholders with respect to the different services. A comparable analysis has to be done for all technologies and its sub-technologies. Table 2 can also help steer discussions with experts. One should realize that this analysis was carried out based on the perspective of the stakeholder, not from the perspective of the building or building system itself.

Table 2
Example analysis of dimensions concerning building services and the indoor environment from the perspective of the stakeholder. Input taken from van Hoof et al. [14,15]. Lighting, humidity and temperature influence the physical functioning of a person with dementia, but in this example, is particularly evident through the biotic dimension.

Stakeholder: Patient / patient associations (older adults with dementia)
Justified interest of these stakeholders: good care (moral dimension)
Challenge for the designer: all technologies support the care for older adults with dementia
Building system: services

Dimensions	Sub-technology 'lighting'	Sub-technology 'humidity'	Sub-technology 'temperature'
numerical			
spatial	■		
kinematic			
physical			
biotic	■	■	■
sensitive	■	■	■
logical			
formative			
informatory			
social	■		■
economic			
esthetical	■		
juridical			
ethical			■
creedal			

6. Conclusion

This paper illustrated the need for a framework that combines insights from healthcare, construction and philosophy in order to capture the complexity of the design process of healthcare facilities. The design of these facilities exists at the intersection of technology and society because of the confluence of these factors in this framework. The Inclusive and Integrated Health Facilities Design model (In2Health Design model), which combines insights from three existing approaches, can be applied for the stakeholder-based design of healthcare facilities. The model is inclusive because it accounts for the needs of all the stakeholders. It also helps to prioritize the needs of the most important stakeholders by analyzing these needs. The model is integrated because it accounts for different dimensions that play a role in designing buildings for healthcare. The model helps to gather knowledge on the cumulative effects of various environmental aspects on health. The In2Health Design Model can help to identify conflicting interests and provides a method to analyze conflicting interests and to find solutions. With the In2Health Design model, designers are provided with a tool that helps them translate the various needs of stakeholders into an inclusive and integrated design that serves all stakeholders.

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