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IMPROVING THE DESIGN OF ADAPTABLE BUILDINGS THOUGH EFFECTIVE FEEDBACK IN USE

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Abstract

For many years the issue of how to design buildings which can adapt to changing demands has posed a considerable challenge. This debate has had renewed significance given the emergence of the sustainability agenda and the need to extract additional value from built assets through life. Developing a better understanding of how buildings change over time is arguably crucial to informing architects concerned with extending the life of buildings. This paper critically reviews literature on adaptability, together with that relating to knowledge feedback and architectural practice, in order to construct a theoretical platform for understanding how knowledge of how buildings change can be used to inform design decisions. A pilot case study is used to illustrate the ways in which buildings change could be captured to inform adaptable designs in the future. The work reveals a lack of knowledge in how buildings change and how, if this was fed back to architects, it could support design decisions that might increase the life of many buildings.

Keywords: building appropriation, adaptability, design decisions, feedback, sustainability

INTRODUCTION

Designing for adaptability has had renewed significance since the emergence of the sustainability agenda and the need to extract additional value from built assets through life. Beadle et al. (2008) argue that "adaptable buildings have the ability to change use with market conditions, enabling them to have a longer useful life". Russell & Moffatt (2001) emphasise that the building stock is a key resource that needs to be managed correctly in order for it to be sustainable - as urban areas everywhere are experiencing problems related to poor use of buildings, and high flows of energy and materials. This is supported by Bijdendijk in (Leupen et al. 2005), who claims a sustainable building has two qualities: it can accommodate change (i.e. individual values) and holds preciousness (i.e. collective values) through its exterior and shared spaces. As Graham (2005) summarizes, "A sustainable building is not one that must last forever, but one that can easily adapt to change". Thus, the creation of a more sustainable environment can be augmented by adaptable design strategies that produce a level of building malleability, and which allow for a variety of changes to be accommodated. Thus, developing a better understanding of how buildings change over time is arguably crucial to informing architects concerned with extending the life of buildings.

The research examines the hypothesis that real accounts of change over time will provide designers with a more informed perspective towards designing for adaptability. It investigates the extent to which current feedback mechanisms provide an effective method for doing so and what new or revised mechanisms could be developed to address this need. In order to address these issues, the paper critically reviews literature on adaptability, feedback, and architectural practice, as links between the three could provide insights into improving the design of adaptable buildings by understanding what parameters are critical and how changes to them can be captured and implemented in future design decisions.

ADAPTABILITY

The section expresses an overarching understanding of adaptability, focusing on how buildings accommodate change and how this could be improved by reviewing the different parameters that allow buildings to better accommodate change. There are various definitions of adaptability, however, the overriding message of many of these reflects the ability of a building to respond to or accommodate change, whether this is specifically focused on user needs, or some wider reaching criteria, such as the state of the market (Schmidt III et al. 2010). The working definition of adaptability that will be used for this report is - *a building's ability to accommodate change throughout time, fundamentally extending its life*.

A distinction can be made between buildings that have been designed for adaptability and ones that have not. However, buildings that have stood the 'test of time' tend to be a mixture of the two, signifying that not all buildings designed for adaptability escape obsolescence and some buildings that were designed with no explicit consideration for adaptability can be adapted over time. Using a streetscape in New York City between 1865 and 1990, Brand (1994) highlights for every building that has stood the test of time there are seven that have not. This failure to survive is termed 'building obsolescence' and the cause of this can be wide ranging, including changes in legislation, technology, economic conditions or architectural style (Mansfield & Pinder 2008). Essentially the building has been unable to accommodate change rendering it no longer of use. From this, it is possible to see that there needs to be an understanding of what allows certain buildings to be adapted rather than demolished and vice versa. Understanding how buildings can or can't accommodate change will provide interesting lessons that could be fed back to help move beyond pre-described ideas of designing for adaptability, which have endured mixed success.

As a general perception in order to add adaptability into the design of a building there is a need to over specify mechanical and electrical plant sizing, floor area provision, structure, etc (e.g. Finch 2009, Ellison & Sayce 2007). This is combined with identifying physical aspects (e.g. durability of materials, span depth, floor to floor height) and specific technical solutions (e.g. moveable partitions, drop ceilings, raised floors) (Schmidt III et al. 2010, Fuster et al. 2009, Matsumura et al. 2006, Durmisevic & Brouwer 2002, Madden & Gibb 2008). In addition, understanding the configuration of a building and the interactions between its components can provide insight into how a building will endure change (Schmidt III et al. 2009). Layers provide a way of thinking about the building that link both time and the building's material form, conceiving components as different 'layers' of longevity. As Duffy (1990) clearly articulates, 'There isn't such a thing as a building… a building properly conceived is several layers of longevity of built components'. Brand (1994) expanded upon Duffy's (1990) layers concept to include the total building (Table 1). While the table below shows the differing lifespan of components ranging from daily to eternal, it does not make any correlation with different types of change a building may go through and how architects may start to understand them.

Layer	Description	Timescale
Site	Geographic setting of building	Eternal
Structure	The load bearing elements including foundations	30 – 300 years
Skin	The exterior surfaces that provide a weather protecting layer	20 years
Services	The working guts of a building – HVAC, electrical, plumbing, sprinklers etc	7 – 15 years
Space Plan	The internal layout – internal partitions, doors etc	3 – 30 years
Stuff	Furniture, equipment, personal positions of occupants	Daily

Table 1*: Building layers and time (adapted from Brand 1994)*

Schmidt III et al. (2010) expand the concept of layers by linking them to six different strategies or types of changes for thinking about adaptability (Table 2). This provides a more comprehensive idea of how buildings evolve over time, while not attempting to predict what may happen to buildings - it is simply linking different types of change with how often and to what parts they are likely to change.

Strategy	Type of change	Building layer(s)	Frequency of change
Adjustable	Change of task	Stuff	High
Versatile	Change of space	Stuff, Space	High
Refitable	Change of performance	Space, Services, Skin	Moderate
Convertible	Change of function	Space, Services, Skin	Moderate
Scalable	Change of size	Space, Services, Skin, Structure	Moderate/low
Moveable	Change of location	Structure, Site	Low

Table 2: *Adaptable strategies and layers (adapted from Schmidt III et al. 2010)*

The consideration of the proposed layers and strategies suggest a framework for which specific examples of changes accrued can fit into and may enhance design decisions towards a more adaptable designed solution. It is therefore crucial that this understanding of change over time is fed back to architects.

FEEDBACK

Leaman & Bordass (1993) suggest that "Good design seemingly creates opportunities out of apparent constraints; Bad design seems to deny opportunities". But how is it possible to tell what is good or bad design without feedback?

This section explores the literature pertaining to feedback and how this has been used to inform design decisions. A number of publications examining the evaluation of buildings

(Gorgolewski 2005, Preiser 2005), show how feedback could be integrated into every stage of a building's lifecycle, for example, through building log books, Sea trials, POEs or DQIs. However, in practice most architects and contractors have shown little interest in learning how their buildings actually perform in use (Bordass 2005).

According to Bordass & Leaman (2005) there are currently five different categories of feedback techniques ranging from a type of audit where quantitative methods are used to measure the buildings technical performance, to package and process techniques which incorporate both quantitative and qualitative methods. These methods include: an in-house team to support the clients moving in and solving any small problems that may become chronic irritants such as the Soft Landings approach (Bordass 2005); a design review (Cook 2007); and a workshop with all major stakeholders (Preiser 2005). It is important also to note that the methods can also be distinguished by who they're carried out by - between users or an expert (Bottom et al 1998). User feedback offers an occupants' subjective perception of the space, where as expert feedback is aimed at objectively quantifying building characteristics. These feedback techniques are meant to gain a holistic view of the building in use; however, they do not currently include techniques that explicitly document how buildings change over time.

An example of a technique from the audit category is the CIBSE TM22 (Bordass et al. 2001). This technique, mainly aimed at service engineers, is a method of surveying and reporting the energy use of a building at any time. Given the data collected, it can also calculate the anticipated savings due to a change in use, which is valuable for engineers, but offers less value to architects, who are unlikely to use it due to its specific role in telling engineers the performance data of the building.

An exemplar from the discussion category is the Learning from Experience (LfE) handbook (Bartholomew 2003). This technique uses interviews to review and reflect on projects. Intended for large construction organisations, it is excellent at transposing tacit knowledge gained on the project to the rest of the organisation. Its main focus is on the business case and where money can be saved. It does, however, ask three main questions that could be very useful for feeding back and documenting change to architects. These are: what happened; why did it happen; and, what can be done better? These provocations could be adapted to look at change within the building, e.g. what has changed? Why has it changed? How could this improve future design?

There are many different approaches within the questionnaire category, including the AUDE POE Guide and Building Use Studies, which are aimed at the client and the users' perception respectively. The majority of these approaches are limited by the fact that a questionnaire cannot explore the building in any depth; in order to gain any depth the questions would have to be qualitative in nature. One questionnaire method that offers some insight is the Design Quality Indicators (DQI) survey (Gann et al. 2003). This user focused technique starts off as a questionnaire, but also includes workshops to discuss the findings with the stakeholders in order to gain a fuller understanding of the meaning behind the data collected. The survey is designed so that these workshops can be conducted at any stage in the project from the preparation and briefing phase to the building-in-use phase. The two most important phases for this research are expected to be the design phase and the use phase, and these are also identified as key phases in the original DQI methodology, because in these phases all of the main stakeholders are brought together to discuss how improvements could be made, allowing for a much broader remit of subjects to be explored. During the design workshop, materiality and the needs of the user are the key focus. During the use phase workshop, the impact of the building design on the users is discussed and recorded, implicitly a workshop of this kind will produce some explanation of what has changed within the building and why. However, the DQI methodology does not attempt to understand these changes using a verified framework. Nor does it explicitly feed this knowledge back to the architect with the purpose of improving future design decisions. This could be due to the focus of the workshop relating to how to improve the users' environment, rather than how architects can improve future work.

One of the most successful feedback tools used in recent years is based on the PROBE studies (Derbyshire 2001). This tool is essentially an amalgamation of some of the approaches discussed above, mainly looking at user satisfaction, energy consumption and manageability (Blyth & Worthington 2000). What made this so successful was that it managed to publish all of its results in the public domain, meaning that the knowledge could be transferred further than just the participating companies. However, in the context of this work, because this tool is very much based in the engineering field, it is not expected to offer much insight regarding how architects design decision-making might be informed in pursuit of adaptable solutions.

The major problems with existing feedback techniques are that they are all based around two objectives; the technical performance of a building and the improvement of the users environment. They are also currently based around a single point in time, only DQIs are strategically set up to be implemented at different points in time. However, they are still based around a prescribed set of questions aimed at the user's perception none of which may be valued by architects, who instead of looking at the shortcomings of a completed building would much rather move on to the exciting task of a new assignment (Blyth & Worthington 2000). It is therefore important to understand how feedback mechanisms could match architectural values, and how this link could allow for an effective feedback tool that engages the enthusiasm of architects. It is also worth noting that in order for feedback techniques to be successful, champions of feedback need to make a more persuasive case to a broader range of stakeholders as well including clients, developers and occupants on the added value or real savings that can be gained from feedback (Zimmerman & Martin 2001).

ARCHITECTURAL PRACTICE

This section attempts to express the link between architectural practise and feedback pertaining to how buildings change. An architect's values are what set them apart from other professions when it comes to the concept of designing buildings (Cohen et al. 2005), and shape why architects design the way they do. These values can come from an architect's education or experience, and motivate the decisions and guide the behaviours of the designer. Broadly, values are defined as principles, standards, and qualities that guide actions. (Le Dantec & Do 2009).

Most architectural values are based in the visual arena (aesthetics, visual perception, beauty); this is hardly a surprise considering the nature of architectural work and what they are creating (Till 2009). The idea of timelessness or time standing still is also articulated; suggesting most architects ignore time to focus on the aesthetic fixation and immediate functional performance of buildings (Schmidt III et al. 2010). This is likely to create a fundamental barrier to the idea of learning from feedback in the conventional sense. However, it is not suggested that architects do not want to learn per se. This is backed up in their values, when Schön (1984) states that architects are always learning in the sense that architects learn by doing in order to build up their experiences, therefore they are continually learning through experience. This is supported with what is found in modern practice where architects engage in CPD (continuing professional development) events, lunch seminars, and evening training courses typically aimed at improving computer skills; knowledge of new materials/ regulations; or learning about architectural theories, practices and buildings. Ethics and a feeling of social responsibility are also mentioned (Till 2009), which shows that architects should be open to learning in order to improve the built environment.

Clearly, these values can have a significant impact on how architects design, so it is important to understand how these values develop, in order to conceive how best to affect design decisions. Architectural education is a very important concept to explore; it sets the foundation as to how architects learn both during education and in practice, providing insight into how value systems are shaped. Cuff (1991) insists that architectural education has, for a considerable amount of time, been very much based around learning how to be creative and thinking for yourself; while Lawson et al. (2003) adds that ‘knowing by doing’ is a readily accepted method of educating within architecture.

A strong criticism of the education system is that “adaptive use is the destiny of most buildings, but it is not taught in architectural schools” (Brand 1994). Most programs emphasis innovation and novelty (Glasser 2000), very little education goes into how to change existing buildings, so there is no knowledge taken forward from education into practice in this area (Kohler & Hassler 2002). Perhaps an answer as to why architectural education and practice are different lies in the fact that, within architectural education it is expressed that it must not mimic the real world in all aspects, as it serves a very important creative and exploratory purpose and if they weren’t taught this within education, architects would not be able to apply this conceptualisation in practise (UIA 2005). An additional argument for why education can’t directly mimic practice is that the complex web of social interactions that are played out by architects in practice may be hard to replicate in an educational environment (Demirbas & Demirkan 2003).

The above arguments seem to suggest that, intentional or not, there is a missing link between education and practice. It is understood that architectural education must be used as a time to expand creative knowledge; however, the content of that exploration could incorporate an improved understanding about how buildings change. This could still match the underlying problem solving nature of the education (UIA 2005) and might generate creative solutions to current adaptability issues.

Although the value system is shaped in education, it is also instilled within practice; therefore it is also important to examine the literature surrounding architectural practice. There are many problems in practice that not only act as a barrier to learning but can also reduce the quality of the buildings that are produced. A fundamental problem with project-catered organisations is often there is a need to work with new teams, including clients and contractors (Macmillan et al. 2002), which can reduce levels of trust, and the need to build a relationship becomes key, rather than learning, as would be typical of more mature relationships.

A more recent issue is the shift in power within the construction industry from architects to contractors (Kieran & Timberlake 2004). This often means that the architect is merely a subcontractor (Krygiel & Nies 2008), which could be a barrier to ‘architectural’ feedback; if the client only wants the architect to create the aesthetics of the building. With re-use and refurbishment of existing buildings becoming increasingly important to sustainability (Pearce 2004), and sustainability becoming increasingly important to clients, it could be argued that architects could regain this power if they had an increased understanding of how buildings can change over time.

A repetition of mistakes because of a lack of learning from past projects is a recurring theme within the literature (Bordass & Leaman 2005). Heylighen et al. (2007) argue that architects (and the building industry in general) have a tendency to disregard past projects in order to concentrate on future ones. This is also reinforced by the way contracts are framed and finished at the end of construction (Barlow & Koberle-Gaiser 2009). In order to incorporate a way to understand time and change in current architectural practice, it is important that lessons are learnt from the entire building stock and how it has changed, so that design decisions in pursuit of creating adaptable solutions can be better informed.

METHODOLOGY

The pilot case study served as a tool to inform and refine data collection plans (Yin 2004). The aim was to gain a holistic understanding of the building and to explore whether there were any lessons to be learnt and fed back to the architects. Qualitative data was collected for this preliminary exercise through semi-structured interviews with major stakeholders of the Nottingham science park; this included the architect, the building manager and developer.

The interviews covered a range of questions geared at uncovering stakeholder values and roles along with understanding what changes were planned for in the design process and what changes have already occurred in use. The questions were based around gaining information in relation to the six strategies presented earlier as they would be used to organise and analyse the different types of changes. Data from each interview was then coded and a thematic content analysis was conducted in relation to each of the adaptable strategies outlined in an attempt to answer the research question posed at the start of this paper - How might design decision-making in pursuit of adaptable solutions be informed?. Through analysis of the interviews the provocations presented at the end of each adaptable strategy are an initial attempt to glean lessons from the data.

CASE STUDY

Nottingham Science Park

The Nottingham Science Park is a speculative office development constructed by the developers Blueprint and designed by the architects Studio Egret West. It was completed in 2008 and is located on the outskirts of Nottingham in the area of Beeston opposite Nottingham University. The development offers a range of spatial sizes (1000 to 20,000 sq ft sized offices), fit out levels (shell & core to full lab spec), design (grade A office to bespoke solutions) and leases (flexible lease terms to suit individual requirements).

 

Figure 1: *Exterior perspective* ***Figure 2:*** *Internal layout*

Adaptable Strategies

Adjustable

Most of the rooms can be reconfigured as none of the furniture is fixed. However this could be a larger undertaking than first realised as when an office is fit out electrical plugs are positioned under the desk layouts through the raised floor. If this layout was to change the electrical plugs would have to be moved also. Another related issue is the fact that fresh air comes through ducts in the raised floor so these would have to be moved away from the underside of desks for user comfort. Both of these reduce the adjustability of the office space; however, it is still feasible compared to providing fixed furniture. *Could alternative electrical and ventilation solutions been provided to ease the shifting of furniture?*

One of the changes that have already occurred within the building is the addition of a carpet to the mezzanine floor as it was found that people walking on the hard floor caused too much noise for the adjacent meeting rooms. *What is the appropriate level of acoustics for the meeting room and other areas? Could the walls been detailed differently initially to accommodate the hard wood floors?*

Versatile

The science park is very flexible as stated by the owner, “We wanted a very flexible layout with a notion of a central hub with a series of pods going off it.” The park can be split from a series of small offices of around 1000 sq ft to the occupation of a full floor.

One interesting point which could hinder versatility is the management of how the offices are split up. For example if a company wanted to expand yet the management had put another office in the adjacent section it would not be possible to simply knock down the partition wall, the expanding company would have to be relocated or given a separate office. *Is it possible for the configuration of space to be designed so that the segregation of offices is optimal? Are there different operational processes that could improve the configuration of space?*

Refittable

The science park has a very high specification of services within it, these services have been designed so they can be divvyed up into different sections, which help with the versatile aspects of adaptability; however, it could also be argued that a major refit would be aided by the design as long as it was a similar configuration as to what is there now. The ability to add extra ventilation has already been brought into question when one of the clients requested a laboratory section to their space. This request was granted however the solution for adding additional ventilation was clearly not considered before the request as there is a ventilation tube now stuck through an open window. Reasons for this stem back to the envisaged uses of the building not including laboratories.. This request was however said to be easy in the sense that the raised floor could be removed to incorporate the additional loading strength. However another issue was the insurance implications for the building, the building itself could sustain this type of activity however the insurance was an issue as it was built predominately as an office building, this clearly wasn't thought about. *Are there any uses that would require extra services? What is the strategy for refitting the services of the building?*

The cladding could also be refitted easily as it uses a dry connection fitted to insulation, however when asked whether this was a consideration when writing the brief for this project the developer stated that it was "post rationalisation". The architect also added that it 'could' be very easy to re-clad the building, but didn't see this as a likely scenario. *As the skin of a building is envisioned to last approximately 20 years and the structure intended to last much longer (in regards to Brands layers) shouldn't there be a strategy to replace the cladding? Would an easily removable skin aid in the external maintenance of the building?*

Convertible

Convertible strategies involve changing the use of a building. In terms of the science park, it wasn't envisaged in the brief and would be very difficult for many reasons. Location would be a major reason as it is located next to another science park (opposite a university) and out of town, so there is very little demand from within the retail, accommodation, or entertainment sector. The structure itself probably could lend its self to residential in that it can be split into small sections, however there would be very limited local amenities. Planning constraints (e.g. zoning), building regulations (e.g. fire regulations), and zoning of services could also limit this. The structure could accommodate interactive classrooms with in it; however it wouldn't be able to accommodate a split level lecture theatre, so it wouldn't be ideal for an education building. In terms of other university uses, it could be converted into administrative space or a place for non laboratory research. *What functions could this building be equipped to change to with minimal effort? What is needed to accommodate a wider range of uses? What uses could the surrounding area support? Does the lack of public transport affect the diversity and livelihood of the location?*

Scalable

In terms of the scalability of this building, it is built to a set size and there is no plan to ever extend it. If the foundations were overdesigned it would be able to take an extra floor, however, the majority of the plant is on the roof meaning that it would be a major job to refit these elsewhere. *If the park is very successful how does it accommodate the additional space demand?* In terms of location and according to the master plan of the site there is a further plot that could be used to build a replica if the science park proved very successful. *Are there any planning restrictions on what can and can't be built on this site?*

Moveable

The movable strategy has no relevance to this project.

DISCUSSION

In pursuit of answering the research questions several points can be summarised from the work undertaken. It has been put forth that architects are much more interested in the aesthetics of a building rather than how it may change in the future, rendering adaptability (i.e. real appropriation/change) a still poorly understood topic by architects. Current feedback mechanisms are too focused on the building's performance characteristics and not on its physical reshaping. They do not match an architect's complex value system, which is why architects appear disinterested about learning from them. In addition, conventional education and design processes for architects don't value the building as a dynamic process, but as a static finished object.

The above points have lead to the assertion that there are no current mechanisms that communicate the changes in a building's life back to architects in a way that matches well with current values/processes. This argument has been positioned by the literature and exploratory case study by exploring how adaptability can be stratified in time as a series of strategies and layers, how current feedback mechanisms don't communicate changes in the built form, and how current mindsets and processes of stakeholders undermine attempts to feed knowledge back.

In the pursuit of adaptable solutions it remains critical that an effective feedback mechanism, which takes into account architects values and ways of working, be developed in order to better inform future design decisions. This method must support accessibility of explicit knowledge, rather than tacit knowledge, to ensure that any understanding of change has a tangible impact on the profession. The case study illustrates this by showing a number of provocations that, if thought about during the briefing/design stage, could have affected the composition of the building itself. They may not have changed the overall aesthetic of the building but may have improved the configuration and relationships of some elements. This mechanism could compliment other techniques that are currently implemented when a building is in use (e.g. DQIs) by adding an understanding of the changes that have occurred within the building through the adaptable strategies and framework. The next step in the research is to suggest a feedback technique that would best match architectural values.

CONCLUDING REMARKS

Developing a better understanding of how buildings change over time is arguably crucial to informing architects concerned with extending the life of buildings. It shouldn't be an attempt to predict what buildings may change into in the future as, "all buildings are predictions and all predictions are wrong" (Brand 1994), but rather an attempt to construct a platform for capturing and understanding how knowledge regarding the way buildings change can better be used to inform design decisions. This can be supported by understanding how buildings change - by defining different types of changes and how they relate to the different physical elements - by understanding the available methods for knowledge to be transferred from the operational phase of buildings back to the producers of buildings and by understanding the processes and values the producers hold.

Adaptability can no longer be seen as a 'one size fits all' solution and should be developed with the complexity it affords; lessons can and need to be learnt from the building stock in its entirety, which should only improve the design of adaptable buildings in the future.

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