CARDIFF UNIVERSITY

A MIXED-METHODS EXPLORATION OF NON-TECHNICAL BARRIERS IN COLLABORATION

FOR BUILDING PERFORMANCE SIMULATION USE IN ARCHITECTURAL DECISION-MAKING

A THESIS SUBMITTED TO THE WELSH SCHOOL OF ARCHITECTURE, CARDIFF UNIVERSITY

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BY

SARA ALSAADANI

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I lovingly dedicate this thesis to my family.

I would be lost without you.

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The doctoral journey is often described as ‘independent research,’ yet I would have never been able to reach the finish line without the help and support of the most wonderful network of colleagues, family and friends, to whom I am indebted with my deepest gratitude.

My dear parents have considered me their lifelong investment and have showered me with never-ending love and support for as long as I can remember. Without their moral and financial support, and their belief in me, my dream of doing a PhD would have never become a reality.

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ABSTRACT

It is widely proposed that building performance simulation (BPS) software holds massive potential for architects; enabling them to empirically assess the impacts of design decisions based on energy-efficiency and performance. However, migration of BPS into the architectural world has been superseded with barriers. The majority of barriers identified in the literature are of a technical nature; related to limitations in software and difficulties experienced by architects when they attempt to use BPS tools. Instead, many architects rely on the services of specialists in BPS (BPS specialists), and collaborate with them to inform design decision-making.

It is proposed in this thesis that alongside technical barriers, there may be additional non-technical barriers which arise when architects and BPS specialists collaborate. The aim of this thesis is therefore to extract these potential non-technical barriers and explore how they may threaten to reduce the potential for BPS to inform design decision-making. To fulfil this aim, a pragmatic mixed-methods approach from the social sciences is devised; consisting of both qualitative and quantitative instruments.

The main findings of this thesis have been arrived at by integrating the outcomes of both qualitative and quantitative stages, and consist of some non-technical barriers specific to the England and Wales context. These include architects' negative attitudes toward BPS, architects perceiving the primary purpose of BPS to be for compliance, trust dynamics and stereotyping between architects and BPS specialists and ineffective communication between the two groups. These findings illustrate that non-technical barriers do exist, and can be extracted using the proposed methods. Novel additions to the body of knowledge made by this contribution include the findings themselves and the methodological approach used to arrive at these findings, highlighting the usefulness of social science research methods for future BPS research.

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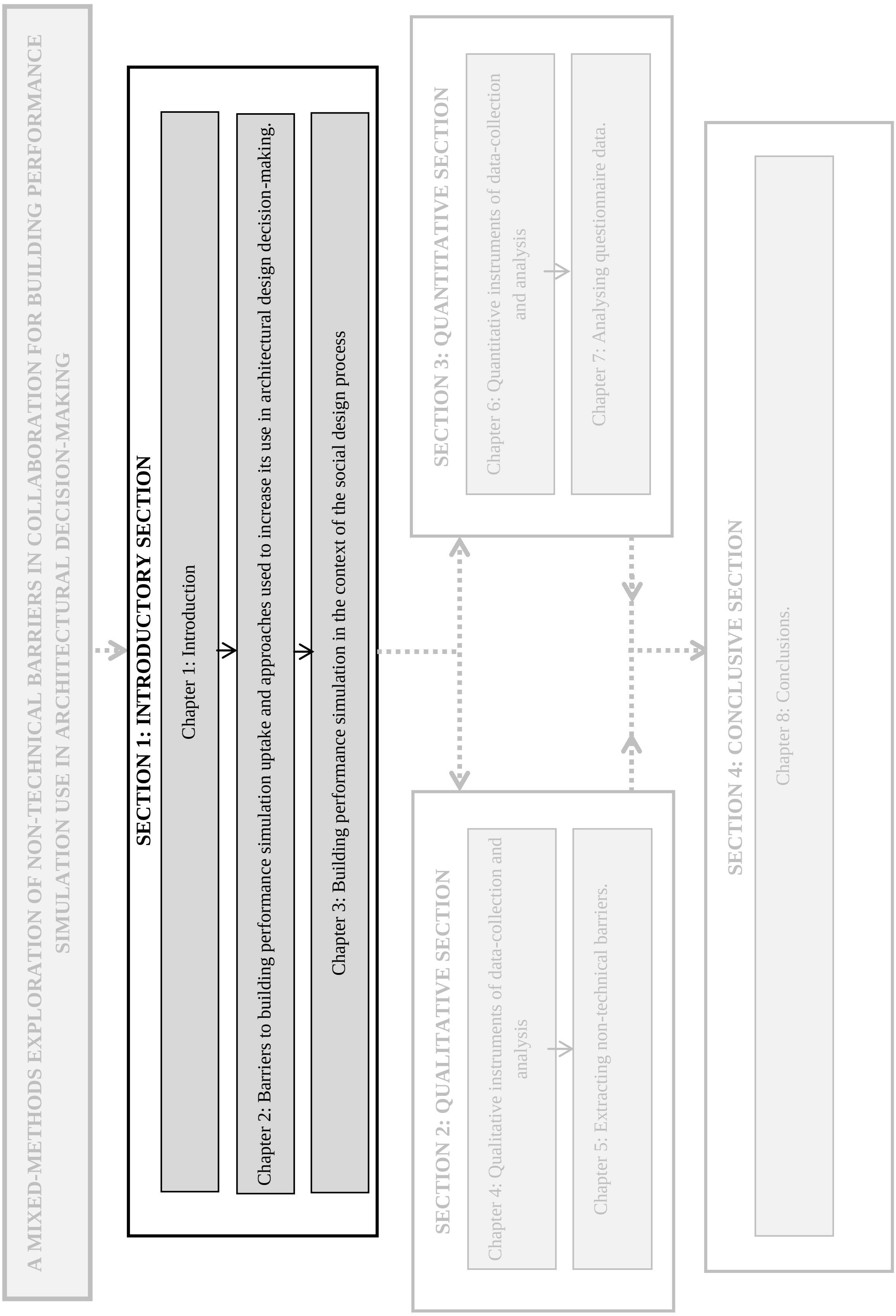
LIST OF ABBREVIATIONS

BPS	Building Performance Simulation
HVAC	Heating, Ventilation and Air Conditioning
GUI	Graphical User Interface
IES	Integrated Environmental Systems
GA	Genetic Algorithms
IPV	Integrated Performance based View
I²PV	Integrated, Intelligent Performance View
I³PV	Integrated, Interactive and Intelligent Performance View
CoED	Collaboration Enhancing among Design participants
IFCs	Industry Foundation Classes
gbXML	Green Building XML
DeST	Designer's Simulation Toolkit
DAI	Design Analysis Interface
IAI	International Alliance for Interoperability
RIBA	Royal Institute of British Architects
ARB	Architects Registration Board
CIBSE	Chartered Institute of Building Services Engineers
EPBD	Energy Performance of Buildings Directive
DSM	Dynamic Simulation Modelling
M&E	Mechanical and Electrical
SBEM	Simplified Building Energy Model
SAP	Standard Assessment Procedure
NCM	National Calculation Methodology
IBPSA	International Building Performance Simulation Association
PASW	Predictive Analysis Software

SPSS	Statistical Package for the Social Sciences
KMO	Kaiser-Meyer-Olkin measure of sampling adequacy
PCA	Principal Components Analysis
FA	Factor Analysis
ANOVA	Analysis of Variance
HSD	Honestly Significant Difference

SECTION 1; INTRODUCTORY SECTION



1. INTRODUCTION

"It is a strange paradox that we live in an information age and yet information is never in the hands of those who need it to make informed decisions" – Clarke (2001).

1.1 BACKGROUND

Contemporary societies, as we now know them, are characterised as post-industrial (Bell 1976). The first key tenet of post-industrialism is that advances in most sectors and industries have become principally driven by scientific and empirical investigations of basic phenomena occurring within the natural world. The results of these investigations are then rationally applied to solve scientific and technological problems.

The architectural industry is no exception to this rule. Moreover, because architecture is vastly contended to mirror attributes of the society in which it is immersed (Kroner 1997; Jencks 2006; Smith and Bugni 2006), for post-industrialism to have oriented the architectural milieu in new directions influenced by technology was an evolutionary matter. The direction of interest in this research is the 'energy' direction; which has ultimately altered architecture's main accountability to users' emotive and psychological requirements, to additionally include the physical and rational demands necessitated by energy-efficiency.

The second key tenet of post-industrialism as defined by Bell (1976) is that political action is also driven by science policies. This has also been strongly witnessed in the architectural discipline; and has had a resounding effect. Since the oil crisis of the 1970s, a plethora of policies, drivers and regulations on both local and international scales in much of the developed world have been released, in an active and swift response to reduce buildings' energy-consumption. However, energy reductions could not be made at the price of users' comfort which; as identified earlier, architecture has always been primarily accountable for. Rather, architectural designs today strive to reach a tight equilibrium between comfort conditions associated with better living standards and optimised energy-consumption.

Such an optimum balance cannot be achieved without accurate quantification. Moreover, these optimised standards need to be predicted during the building's design stages, i.e. pre-construction. However, quantifiably assessing a building's performance is a *"non-trivial task,"* due to the *"myriad of physical interactions"* in the building's thermodynamic and performative domains; including air-movement, daylighting and radiation exchanges amongst others (Clarke 2001). Traditional design methods are visibly limited in this respect. Rough guidelines, abstract rules of thumb or design intuition cannot be used to predict the impacts of such simultaneous and dynamic interactions on energy-consumption. Even disparate hand-calculations of performance assume static conditions and therefore do not suffice this requirement (Hansen and Lamberts 2011).

1.2 PROPOSED MIGRATION OF BUILDING PERFORMANCE SIMULATION IN THE ARCHITECTURAL WORLD

In the 1990s, it was proposed that powerful building performance simulation (BPS) tools could be used in the architectural industry to inform building design decision-making (Augenbroe 2001; Attia et al. 2009). These tools are inherently powerful for their recourse to underlying theories from a variety of knowledge-domains; ranging from mathematics and physical sciences to biophysical, behavioural and computational sciences (Hensen and Lamberts 2011). This inherent power means that BPS software can be used to construct complex mathematical models which accurately represent all potential transient energy flows within buildings; as well internal interactions between each of these energy flows (Clarke 2001).

This power had been demonstrated, fully-exploited and had become widely utilised throughout the 1980s in the HVAC industry. Uses and successes of BPS were further propelled in the HVAC industry by the advent of personal computing (Clarke 2001); and have since become widely utilised in the fields of HVAC design and building services. It was therefore envisaged that this power and preceding successes could further be exploited by empirically navigating architects' design decision-making between the early stages of the design process through to the detailed design stages. By using BPS calculations, architects could realise more energy-efficient design solutions, while providing comfortable internal conditions to the users. Moreover, various design possibilities could be simulated and their performances compared side-by-side. In short, it was seen that *"simulation represent*[ed] *a paradigm shift of vast potential"* for architects; and that it would *"give rise to a* ***cheaper, better*** *and* ***quicker*** *design process"* (Clarke 2001).

Although this seems like a utopian idea, at the time of writing of this thesis, these ambitious aspirations have yet to be fulfilled. Unlike the fluidity of using BPS in the HVAC industry, a fluid integration of BPS in the architectural design process has been far less steadfast. Poor uptake and integration of BPS within the architectural design process is repetitively cited in the literature as a largely unresolved problem (Morbitzer 2003, Zhu et al. 2007; Attia et al. 2009, Bombardekar and Poerschke 2009; Venancio et al. 2011a; Bleil De Souza 2009 to name a few); despite over two decades of active experimentation in this research area.

Based on a review of recent BPS literature concentrating on integrating BPS in the architectural design process; presented in detail in chapter 2, it appears that identified barriers to utilising BPS for architectural decision-making fall into four categories.

1. Differences in nature between architectural problem-solving and BPS problem-solving, which make it difficult for architects to use BPS in early stage decision-making (Bleil De Souza 2012; Pratt and Bosworth 2011).

2. Barriers pertaining to the nature of the architectural profession particularly;

    - Architects' poor comprehension of building physics, which is required for them to utilise BPS tools and interpret the outputs (Soebarto 2005; MacDonald et al. 2005; Stasinopoulos 2005; Bleil De Souza 2012; Reinhart et al. 2012). For the purpose of this research, this is being considered a technical barrier; as a knowledge of building physics is required to use the software and understand the outputs.

    - That architects often postpone employment of BPS software after fixation of most design decisions, rather than using them as 'what-if' tools to inform a wider range of design possibilities (Mourshed et al. 2003a; Zhu et al. 2007; Bleil De Souza and Knight 2007; Yezioro et al. 2011; Hensen and Lambets 2011).

3. Characteristics of BPS tools which render them inadequate for architectural use particularly;

    - Complexities related to data-input and output (Attia and De Herde 2011; Guglielmetti et al. 2011; See et al. 2011; Capeluto 2011).

- Poor graphical user interfaces (Clarke 2001; Guglielmetti et al. 2011; See et al. 2011; Capeluto 2011).

- That the tools are resource-consuming with particular respect to time and cost (Bazjanac et al. 2011; MacDonald et al. 2005; Hitchcock and Wong 2011).

- That a high amount of specialisation is required to run them and be able to interpret their outputs; coupled with a steep learning curve (Reichard and Papamichael 2005).

It is important to note that the afore-listed barriers are predominantly of a technical nature; concerned with difficulties experienced in using the software, or incongruences between architects' problem-solving methods and problem-solving methods architects would need to follow if they are to fully-exploit the potential of BPS software. Moreover, in response to the predominantly technical nature of barriers identified; an array of computational solutions has also been proposed; which are presented in the literature review. The vast majority of these solutions tend to be software-level developments; mainly new simplified tools or interfaces which claim to 'speak' architects' language.

On the other hand, it has been broadly recognised in previous research (e.g. MacDonald et al. 2005; Prazeres and Clarke 2003; Prazeres et al. 2007 and 2009; Bleiberg and Shaviv 2007; Bombardekar and Poerschke 2009) that architects needing to assess the performance of their design proposals seldom undertake BPS themselves. **In most practical project environments today, architects instead rely on collaborations with specialists in the building performance simulation field (hereon described as BPS specialists[1]) to conduct BPS for them.** These collaborations are inherently multi-disciplinary; merging between practitioners from disparate social and professional groups to work together in a single environment. It is only natural therefore that each of these social groups recurs to different worldviews; based on their educational routes.

[1] The phrase 'BPS specialists' is used throughout this thesis to describe building practitioners who use BPS software throughout their day-to-day working process, and collaborate with architects to assist them in design decision-making based on interpretations of BPS calculation outputs. These may be building services engineers, mechanical engineers, building physicists etc.

Difference in worldview further denotes differences in professional aims, objectives, professional languages and understandings.

1.3 RESEARCH HYPOTHESIS AND AIM

This research consequently departs from an alternate position to the existing. It is hypothesised in this thesis that, alongside the software-related barriers widely-cited in the literature, there may be additional **non-technical barriers arising during collaborations between architects and BPS specialists,** which further reduce the potential for BPS to inform architectural decision-making. In this thesis non-technical barriers are defined as those which **do not** arise from BPS software, and are not related to limitations in the tools and/or interfaces.

The aim of the research conducted in this thesis is therefore **to extract and explore non-technical barriers which arise when a collaborative approach between architects and BPS specialists is undertaken; as a route to using BPS to inform architectural design decision-making.**

The scope of this research is limited to the UK context, particularly England and Wales. This is because educational paradigms of architects and BPS specialists in the UK may vary significantly from those in other countries, as well as social and cultural traditions which may affect the barriers arising in collaboration. Furthermore, regulatory requirements in England and Wales[2] addressing the matter of buildings' energy consumption differ from regulatory requirements in other parts of the UK. As identified earlier in section 1.1, legislation has been a significant driver for the architectural industry to optimise energy-consumption; which has therefore been taken into account in this research.

To achieve the aim of this research, a pragmatic mixed-methods approach comprised of two empirical stages has been devised. This pragmatic approach utilises both qualitative and quantitative research instruments from the social sciences. Qualitative instruments allow the extraction of potential non-technical barriers, and how they may be reducing the potential for BPS to inform design decision-making is explored. Quantitative instruments are then used to confirm the existence of these non-technical barriers amongst the wider populations of architects and BPS specialists in England and Wales.

[2] Approved Document Part L of the building regulations (Conservation of Fuel and Power).

Inferences derived qualitatively and results obtained quantitatively are triangulated at the end of the research to form conclusive research findings.

1.4 THESIS OUTLINE

This thesis consists of four sections (figure 1.1). The structure of the thesis is also illustrated in this diagram.

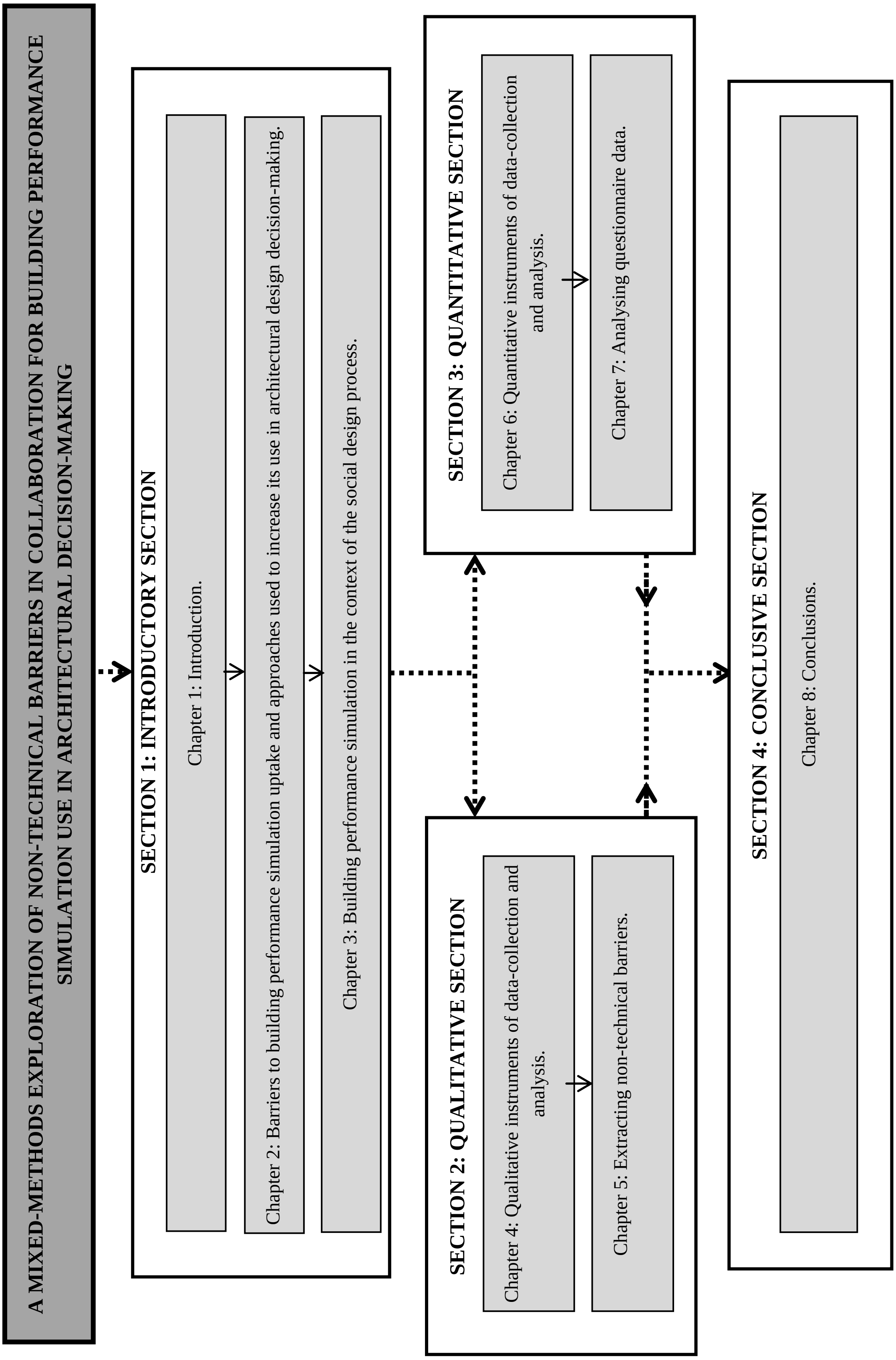


Fig. 1. 1 Outline and structure of this thesis.

Section 1 of this thesis consists of three chapters. Following from this introduction a review of the literature is conducted in chapter 2. This is focused on barriers which have been recognised in previous work hindering use of BPS in architectural decision-making, and the ways in which these barriers have been addressed in previous research initiatives; particularly over the last decade. In chapter 3, the need to discuss BPS in the context of the social design process is presented and the overarching research question of this thesis is identified. The pragmatic mixed-methods approach used to answer this research question is then proposed.

Section 2 of the thesis is focused on ***qualitative methods*** of data-collection and analysis; used in the first empirical stage. Chapter 4 discusses qualitative data-collection (semi-structured interviews) and analysis methods (thematic content analysis) used in this empirical stage. In chapter 5; these methods are applied to extract potential non-technical barriers and to explore how they may be reducing the potential for BPS to inform design decision-making.

Section 3 of the thesis is concentrated on ***quantitative methods*** of data-collection and analysis; used in the second empirical stage. In chapter 6, data-collection using self-completion questionnaires distributed to a sample of architects and a sample of BPS specialists is discussed. This chapter also presents key statistical tests which were used in the analysis of this questionnaire data. The results of the statistical analysis are presented in chapter 7.

Section 4 consists of one chapter; the final conclusive chapter of the research. Here, inferences made during the qualitative stage and results obtained from the quantitative stage are triangulated to form conclusive research findings. Arriving at these findings enables the overarching research question of the thesis to be answered. The pragmatic mixed-methods research design used to answer the research question is reflected upon, and avenues for further work are suggested to conclude the research.

1.5 SIGNIFICANCE AND LIMITATIONS OF THE RESEARCH

The focus of this research is limited by the exploration of non-technical barriers. Barriers discussed are those which arise from interpersonal interaction between professionals who belong to different social groups within the building industry. Barriers to BPS uptake as a consequence of limitations or discrepancies in previously written software and/or interfaces are not the concern of this research; as these have been widely explored in previously published research as the literature review will demonstrate.

This thesis does not intend to examine the use of a particular simulation domain for architectural decision-making; such as thermal simulation, lighting, solar or all of them combined. Instead, BPS is explored as the encompassing concept of using quantitative measurements of performance to inform architectural design decisions; a concept which is enabled by drawing together two groups of professionals into a single social setting.

Finally, it is believed that this work contributes to the existing body knowledge in the BPS research field in the following ways:

- To the best of the researcher's knowledge at the time of writing, the topic of investigation; examining non-technical barriers which arise when architects and BPS specialists collaborate, has not been examined in the past[3]. This makes the present contribution the first to propose that non-technical barriers, alongside widely-cited technical problems, may be hindering BPS integration, and the first empirical piece of work aimed at extracting these non-technical barriers and exploring their pertinence.

- Correspondingly, the main contribution of this research to the BPS field is in the use of social science methods; and the application of these methods to explore the problem of BPS integration in architectural design from an alternate vantage point to the existing. Moreover, the pragmatic mixed-methods research design used to carry out this investigation; by recurring to both social constructionist and positivist philosophies and integrating outcomes based on both, is a research approach which has not been employed in previous BPS research.

- Based on originality in the chosen research approach, some of the forthcoming research outcomes constitute contributions to the body of knowledge; which have not been recognised as potential barriers hindering BPS use to inform design decision-making. These are highlighted in the

[3] Collaboration has been explored in the BPS field with respect to interoperability; which is reviewed in the following chapter.

body of this thesis; as and when they appear. However, the ability to identify these non-technical barriers points toward the success of the method; and opens a new window of exploration in future research in the BPS domain using social science methodologies.

2. BARRIERS TO BUILDING PERFORMANCE SIMULATION UPTAKE AND APPROACHES USED TO INCREASE ITS USE IN ARCHITECTURAL DESIGN DECISION-MAKING (LITERATURE REVIEW)

“Though not all of us are going to be model builders, we all are becoming model consumers, ***regardless of whether we know it (or like it).”*** –Sterman (1991).

2.1 INTRODUCTION

In this chapter, **literature describing migration of building performance simulations (BPS) into the architectural world is critically reviewed.** Barriers preventing BPS integration in the architectural design process and its use to inform architects’ decision-making which are widely-cited in the literature are identified. Propositions used and solution-approaches undertaken to improve the role of BPS in informing design decision-making are critically examined. The review of these propositions is particularly focused on those put forward over the previous decade; as the pace of development in this research area makes it irrelevant to review propositions from before the year 2000.

This critical examination reveals that most efforts to enhance BPS integration in the architectural world have been tool-based propositions aimed at architectural use; many of which are based on inaccurate assumptions of architectural praxis. The examination further leads to the identification of a gap in the BPS body of knowledge pertaining to understanding the ‘human’ side of BPS; which has only been tentatively-questioned. It is finally concluded that there is a need to re-visit the BPS terrain from a social perspective; with a particular focus on collaborations between architects and BPS specialists.

2.2 BARRIERS IN THE USE OF BPS TO INFORM ARCHITECTURAL DECISION- MAKING

In this section, barriers preventing BPS integration and use to inform architectural decision design decision-making are reviewed. These identified obstacles are categorised into three inter-related groups; as illustrated in figure 2.1.

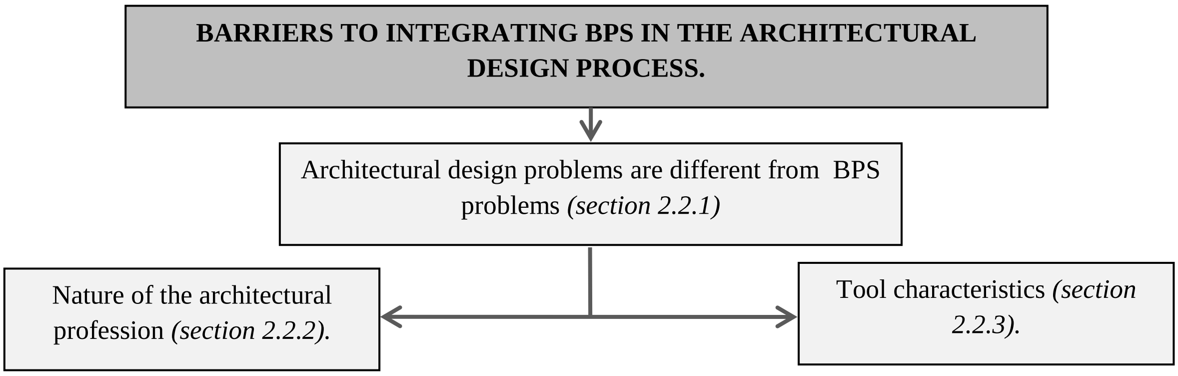


Fig. 2.1. Barriers surveyed in the literature.

2.2.1 ARCHITECTURAL DESIGN PROBLEMS ARE DIFFERENT FROM BPS PROBLEMS

One of the underlying obstacles to BPS integration in architecture is in the differences between architectural design and BPS problem-solving methods (Bleil De Souza 2008 and 2012; Pratt and Bosworth 2011). These differences are often categorised using Rittel and Webber's 'well-defined, ill-defined and wicked' problem-classification (Rittel and Webber 1973).

Architectural design problems: Architectural design problems are described as 'ill-defined' (Cross 2001; Eastman 2001) or 'wicked' (Coyne 2005; Bleil De Souza 2008). This is because at the onset the problem-space often lacks concrete definition and is information-poor. Early design decisions are based on rules of thumb, geometrical design principles, precedents or the designer's intuition. Aims of the problem are not clear at the start and the boundaries are invariably loose; it is only as the solution progresses towards solidity that the problem can be retrospectively defined. Information required for BPS; including boundaries, constraints and numerical requirements, only become available at later design stages.

Adding BPS to architectural design problem-solving: Advocates of a simulation-based design process argue that the afore-described procedure is inadequate for energy-efficient design (Pratt and Bosworth 2011). Decisions consolidated during these early stages, when the problem is ill-defined, will have the most impact on performance and energy-efficiency. Therefore it is unanimously agreed that BPS is best used early for calculations to effectively inform these critical decisions (Ellis and Mathews 2001;

Donn 2001; Massen et al. 2003; Ochoa and Capeluto 2009; Attia and De Herde 2011 and Hensen and Lamberts, 2011 to cite a few who explicitly express this). **Nevertheless, BPS is more congruent with well-defined problems** (Bleil De Souza 2008 and 2012); which are information-rich from the start with a clear definition of boundaries, conditions and aims. However, much of this information is unavailable during early design stages, and if BPS is used much of this input data needs to be falsely assumed.

2.2.2 NATURE OF THE ARCHITECTURAL PROFESSION

2.2.2.1 Inadequate architectural knowledge

It is widely-cited in the literature that many practising architects do not have adequate knowledge of building physics and heat transfer processes; as this material is not always covered in architectural curricula in support of BPS (Soebarto 2005; MacDonalds et al. 2005; Stasinopoulos 2005; Bleil De Souza 2009; Reinhart et al. 2012 to cite a few). This is often coupled with a poor desire to learn what has not traditionally fallen under the typical architectural remit. Palme (2011) concluded that despite having a general interest in sustainable design, architects and architecture students do not always have an equal desire to learn building physics which would empower them to use BPS.

Poor knowledge of building physics is a pertinent barrier reducing the potential for thermal simulation tools in particular to inform architects' design decision-making. Without this knowledge, it becomes difficult for architects to observe the building from the thermodynamic lens necessary for them to understand heat and mass transfer processes occurring between the outside and building interior.

2.2.2.2 The way BPS is currently used in the architectural profession

BPS software are descriptive 'what-if' tools (Sterman 1991) and should be used to evaluate the impacts of design-decisions in various situations. A comparative procedure testing the 'what-ifs' of different design-scenarios is likely to reap the most benefits. **However, in most architectural practices reported on in the literature, BPS is side-lined as an after-thought conducted only once all design decisions have been fixated** (Mourshed et al. 2003; Zhu et al. 2007; Bleil De Souza and Knight 2007; Yezioro et al. 2011; Hensen and Lamberts 2011).

2.2.3 TOOL-CHARACTERISTICS

A number of BPS tool characteristics have been quoted in the literature as reasons deeming them unsuitable for architectural use.

2.2.3.1 Data-complexity

Dynamic BPS software is often comprised of powerful calculation engines. However, these have been disregarded in the literature as hostile for architectural use (Attia and De Herde 2011) due to the high complexities associated with data input and output, alongside the afore-described poor foundational building physics knowledge of most architects.

Data-input: Large amounts of data must be defined and described as input parameters (Zimmerman 2005; Laine et al. 2007); much of which is not available at the early stages[1]. Moreover, many of these input parameters require non-architectural data to be described, such as HVAC, lighting, electricity and their schedules of use (Punjabi and Miranda 2005; Yezioro et al 2011).

Data-output: In correlation with the complexity of data input comes the difficulties of interpreting outputs. Outputs of hourly simulation runs are usually produced as a plethora of alpha-numeric files which cannot be meaningfully interpreted by architects. According to the comprehensive review of BPS outputs in Bleil De Souza (2009); most BPS tools for architectural use incorporate either output interface data display systems, or output interface design advice systems. Output interface data display systems convert the raw or processed outputs into tables and graphs. Output interface design advice systems consist of environments which allow the comparison of alternative design-scenarios. **Nevertheless, although information-rich, outputs do not always reflect as adequate design feedback** (Attia and De Herde 2011).

2.2.3.2 Poor user interfaces and visualisation techniques

One of the shortcomings of much existent BPS software **is the lack of a comprehensive graphical user interface (GUI) which communicates effectively with architects** (Guglielmetti et al. 2011; See et al. 2011; Capeluto 2011). This is

[1] Due to the ill-defined nature of architectural problem-solving which is information-poor in the early stages.

particularly notable in freeware software which comes with basic user interfaces. This reduces available access to the power instilled within the software and makes its adoption by architects less widespread.

The general justification to this shortcoming is that software developers tend to be scientists and academics; whose interests are primarily technically-oriented. They therefore focus on embedded calculation methodologies, and software capabilities to accurately represent spatio-temporal complexities, rather than presentation (Punjabi and Miranda 2005; Srivistav et al. 2009; Mahdavi 2011a). However, being visually-oriented people (Punjabi and Miranda 2005), for architects rich quantitative data may hold little importance if they cannot fully make sense of it. They need a means of communicating with the software in a congruent visual format.

2.2.3.3 Time-consuming and cost-intensive

BPS is time-consuming for several reasons. Manual data input can be tedious and labour-intensive (Bazjanac et al. 2011). Running the simulation can be time-consuming; although this is dependent on the degree of simplifications made by the modeller at the time of data-input[2]. Finally, much time must also be invested in interpreting data-outputs, which have been indicated previously as illegible for architects and often require translation.

Moreover, many commercially-available BPS tools are marketed as flagship products and have a high price tag attached (MacDonald et al. 2005; Hitchcock and Wong 2011). Examples can be seen in the licensing of commercial packages such as IES (Integrated Environmental Solutions 2012) or commercial interfaces such as DesignBuilder (DesignBuilder Software 2012). Consequently, BPS is often restricted to iconic projects with a suitable budget to allow tool-licensing (Hetherington et al. 2011). Alternatively, some architectural practices may employ specialists to run simulations in-house, or may even have in-house packages. **One can therefore assume that effective BPS uptake in architectural practices is determined by affordability and restricted to a niche market.**

[2] The more detailed, the slower the computational process.

2.2.3.4 High degrees of specialisation required

A combination of the afore-described barriers[3] means that when architects are faced with the dilemma of learning a BPS package, the learning curve seems enormously steep (Reichard and Papamichael 2005). **Consequently, BPS is nowadays mostly carried out by specialists; who have adequate time, technical knowledge and expertise required to operate the tools** (Macdonald et al. 2005; Attia et al. 2009; Reither and Butler 2008; Venancio et al. 2011a).

2.3 HOW THESE BARRIERS HAVE BEEN ADDRESSED IN RECENT PROPOSITIONS

Solutions proposed to resolve these problems are categorised into three groups; as shown in figure 2.2. These are discussed in sections 2.3.1-2.3.3.

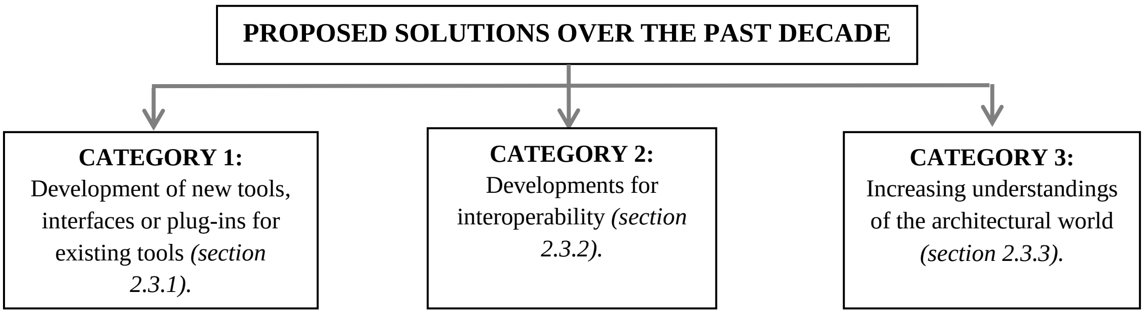


Fig. 2.2. Proposed solutions to improve BPS uptake and use to inform architectural decision-making over the previous decade.

2.3.1 DEVELOPMENT OF NEW TOOLS, INTERFACES OR PLUG-INS FOR EXISTING TOOLS; CATEGORY 1

Over the previous decade; much research activity has been focused on this category of solutions. Development of ‘architect-friendly’ propositions (reviewed in section 2.3.1.1) and proliferation of new third-party interfaces (reviewed in section 2.3.1.2) **are the solution-directions which have received most interest and attention by researchers in the BPS field.**

[3] Discussed between sections 2.2.1-2.2.3.3.

2.3.1.1 Simplified ‘architect-friendly’ tools

Departing from the position that *“simulations should adapt to the design process not vice versa,”* (Morbitzer 2003), and that existent BPS software are not optimised for architectural use, **large efforts have been channelled towards creating new simplified ‘architect-friendly’ tools,** such as those presented in (Zimmerman 2005; Bonvin et al. 2007; Urban 2007; Autodesk 2011; Ochoa and Capeluto 2009; Donn et al. 2009; Bunker et al. 2011; Autodesk 2012a; Autodesk 2012b to cite a few).

These tools have GUI interfaces which communicate effectively with architects. They are hugely simplified, making them well-suited for concept design. Few parameters are needed for input, meaning that architects do not have to go through the tedious and time-consuming task of defining each and every input parameter. Ball-park figures are also generated as outputs; giving rough estimates of performance. Thus, simplified ‘architect-friendly’ tools support fast generation of design alternatives under a design-and-test approach. They also facilitate rapid comparisons of solutions.

2.3.1.2 New third-party user interfaces

These are ‘add-on’ user interfaces which can be used with existing calculation engines. Interfaces are often created to address complexities in data-input[4], by allowing the user to create a geometrical model of the building. New interfaces also address visualisation problems[5]; to improve architectural uptake of BPS. Examples can be seen in (Punjabi and Miranda 2005; Gugliemetti et al. 2011; See et al. 2011 Yezioro et al. 2011; Capeluto 2011; DOE 2011; DOE-2 2012; DesignBuilder Software 2012; NREL 2012a; NREL 2012b). However, while ‘add-on’ interfaces hold great potential to overcome some of the earlier-mentioned obstacles, many are still criticised for failing to address architects’ needs. Urban (2007) reports that many interfaces still require sophisticated input detail to run simulations.

[4] Discussed earlier in section 2.2.3.1.

[5] Reviewed in section 2.2.3.2.

2.3.1.3 Optimisation tools

Optimisation tools allow the designer to search a wide range of possible alternatives within the solution-space; reaching the optimal-performing solution which meet a set of pre-determined design objectives.

The range of solutions available depends on the optimisation method. In Marsh and Haghparast (2004), simple scripts are used to generate a relatively limited number of rough solutions; to be used by designers to develop further. Optimisation techniques using Genetic Algorithms (GA) are used when designers need to search for a wider range of solutions in a larger solution domain. Examples are proposed in Caldas and Norford (2002), who used GA to optimise envelope design, and in Nielsen (2002), where GA were used for a combined optimum solution of geometry and internal building components. Other examples of GA optimisations in performative building design can be found in Wright and Loosemore (2001) and Hauglustaine and Azar (2001). Wider solution-searches are also permitted through a combination of gradient and non-gradient based algorithms which are embedded in the optimisation tool ArDOT (Mourshed et al. 2003b). GenOpt is another generic tool which uses minimisation algorithms to reduce the number of input parameters with multiple iterations (Wetter 2001; Berkeley Lab 2011). At each iteration the input parameters are reduced until the minimum number of solutions is found (Wetter 2001).

2.3.1.4 Data management schemes

These have been proposed to address output-complexities[6]. Stravoravdis and Marsh (2005) deployed a method of scripting to control modelling and simulation processes. Large amounts of data generated were stored in open-source online database systems, facilitating access and retrieval of either all or part of the data. The possibility to perform further calculations on either all the data or selected parts of it also becomes feasible with the use of scripts. Dondeti and Reinhart (2011) similarly propose a data management scheme to filter, organise, store and visually display simulation outputs. Again, this proposal is reliant on scripts and uses open source interfaces. However, the difference in this proposal is that it focuses on visualisation, and can be equally used for daylight analyses alongside energy analyses.

[6] Discussed in section 2.2.3.1.

2.3.1.5 Improvements in collaborative simulation modelling[7]

The tools reviewed here recognise BPS as a collaborative activity drawing knowledge and skills from various design team members. They therefore propose methods to improve collaboration and communication between architects and BPS specialists.

The IPV (Integrated Performance based View) tool (Prazeres and Clarke 2003; Prazeres et al. 2007 and 2009) addresses problems of data management between design team members. This tool initially sought to couple cognition rules and perceptualisation (Prazeres and Clarke 2003). The idea was further developed into an internet-based communication tool; I²PV (Integrated, Intelligent Performance View) (Prazeres et al. 2007), and later into I³PV (Integrated, **Interactive** and Intelligent Performance View) (Prazeres et al., 2009). I³PV is aimed at supporting concurrent and interactive simulation modelling. The tool allows simulations to be conducted while retrieving information from relational databases. It also allows comparison of several design options using multi-media techniques. I³PV also includes a data-connectivity platform; allowing communication between design team members who are geographically dispersed.

CoED; Collaboration Enhancing among Design participants is another proposition which recognises enhancing collaboration (Bleiberg and Shaviv 2007). This proposal also uses Genetic Algorithms for optimisation[8]. Each design team member inputs their ideas into the tool as input data. These data are then arranged into relationship matrices, and GA are then used to trade-off between the design options, returning the optimum solution as the output.

2.3.2 DEVELOPMENTS FOR INTEROPERABILITY; CATEGORY 2

BPS developments such as those described in section 2.3.1 are often described as 'tool-centric' (O'Sullivan and Keane 2005). Modelling conducted in a single tool is usually done for a particularised purpose, by a single professional. If for any reason, an element

[7] This sub-section overlaps with the category described in section 2.3.2, but because the efforts here are essentially BPS efforts and not software interoperability efforts, they have been included under this category.

[8] Genetic algorithms were discussed in section 2.3.1.3.

such as building geometry needs to be remodelled or amended in a different software application; the previously constructed model cannot be re-used.

Instead, advocates of interoperability recommend a 'data-centric' approach, whereby data is only input once into a single interoperable platform, but can then be re-used in other software applications. Repetition of input-definition is avoided saving time and effort. To support interoperable data exchanges, an underlying infrastructure such as Industry Foundation Classes (IFCs) must be available to permit common data-exchange between different applications[9] (O'Sullivan and Keane 2005). Green Building XML (gbXML) is another interoperable format available for the same purpose (Dong et al. 2007; Moon et al. 2011).

Recent interoperability developments are largely tailored towards HVAC improvements, such as the propositions of Baznajac (2003) and O'Sullivan and Keane (2005). **However, interoperability for the purpose of architectural and BPS integration is much more limited.** Exemplar initiatives are proposed by Yi et al. (2007), Augenbroe et al. (2003) and Osello et al. (2011). In Yi et al. (2007), an IFC-based common database is developed for the Designer's Simulation Toolkit (DeST) database[10]. The Design Analysis Interface (DAI) Initiative (Augenbroe et al. 2003) provides a four-tiered process-centric workbench to support interactions between BPS tools and the architectural design process. Osello et al. (2011) also propose to improve interoperability between architectural and BPS software by presenting a method to standardise the contents of data in architectural models.

2.3.3 INCREASING UNDERSTANDINGS OF THE ARCHITECTURAL WORLD; CATEGORY 3

Realising that most BPS tools do not correlate with architects' requirements, BPS researchers have been driven towards an increased appreciation of the architectural world. This trend aids in the understanding of architects' needs and potential

[9] IFCs were developed by the International Alliance for Interoperability (IAI) to improve communication, cost and quality (O'Sullivan and Keane 2005).

[10] DeST is an integrated simulation platform developed by the institute of Building Environment and Building Energy Performance at Tsinghua University, China in the 1990s. DeST combines multiple BPS engines into a single simulation platform.

preferences in BPS software. These attempts tend to be through large-scale surveys or ethnographic studies of architectural studios or practices.

2.3.3.1 <u>Large-scale surveys</u>

Surveys such as these are reported by Pedrini and Szokolay (2005), Attia et al. (2009), Venancio et al. (2011a) and Attia et al. (2012). This list is not exhaustive; the intention is simply to convey the context in which these surveys are used and the types of outcomes which can be collated from this methodology. Attia et al.'s (2009) survey compared ten BPS tools which have been deemed 'architect-friendly,' to construct a set of usability criteria for architects to assess BPS tools in the USA market. In Attia et al. (2012) the afore-mentioned criteria were used by both architects and engineers respectively to rank available tools. It was concluded from this investigation that there is **a wide gap between architects' and engineers' BPS selection criteria.** Architects prefer tools with integrated knowledge bases to facilitate decision-making, and user interfaces. Engineers chose tools based upon accuracy and the tools' ability to simulate complex building components with appropriate levels of detail. **Moreover, the authors of this study alluded to potential barriers which exist outside the scope of tool development;** highlighting architects' and engineers' current uni-disciplinary non-integrative practices.

Alternatively, surveys such as those conducted by Szokolay and Pedrini (2005) and Venancio et al. (2011a) focused on **gaining insight into architects' decision-making bases,** and how BPS tools can therefore inform that. Conclusions drawn from these surveys include that **BPS requires decision-making to be made on logical and rational thinking procedures** which are not congruent with architects' decision-making; as much architectural decision-making is often based on the designer's intuition especially when problems are still ill-defined.

2.3.3.2 <u>Ethnographic studies</u>

Ethnographic studies are exemplified by the contributions of Soebarto (2005), MacDonald et al. (2005) and Charles and Thomas (2009a and 2009b). Soebarto (2005) reports on experiences of teaching BPS tools to architectural students. **She concludes that introducing BPS software was a difficult task due to the incongruences between architectural design and BPS software.** Charles and Thomas (2009a and

2009b) report on inter-disciplinary teaching experience initiatives training architecture and engineering students together. These initiatives **mimic collaboration** between architects and BPS specialists in real-life projects. **The authors conclude that educational collaborative platforms give students an early insightful understanding of project dynamics within multi-disciplinary professional environments.**

Reporting on these teaching experiences is not limited solely to student environments. In a country-specific report, Macdonald et al. (2005) describe experiences of the Scottish Energy Systems Group (SESG) in transferring simulation into the hands of local architectural practices in Scotland. This initiative is described to have incorporated knowledge-transfer mechanisms including seminars, workshops, newsletters, internet-based advice and in-house deployments to support practitioners directly. **The authors conclude that this initiative has prompted a change in the ethos of architectural design practices in Scotland; toward an in-house adoption of BPS.**

2.4 DISCUSSION AND CRITICISM OF SOLUTION-APPROACHES

Each of the preceding solution-approaches can be critiqued from at least one of the forthcoming vantage points; which may be hindering the employment of BPS in architects' design decision-making.

2.4.1 TOOL-BASED RESPONSES TO TOOL-BASED PROBLEMS

All solutions reviewed in sections 2.3.1 and 2.3.2 are computational; either proliferation of new tools for architectural use or propositions to marry between two or more software solutions. These tool-based solutions seem consistent with the computational nature of the tool-based problem. Achieving optimum performance requires detailed representation of heat and mass transfer processes occurring over time. Such complex interactions cannot be calculated by hand; great computational effort is needed to represent these dynamic interactions. **This reasoning provides a palpable explanation as to why proposed solutions to the problem of integrating BPS in architectural decision-making are predominantly approached from a computational perspective.**

Nevertheless, it is repeatedly reported that despite over a decade of tool-proliferation; BPS uptake in the architectural design process is still relatively limited (Morbitzer 2003, Zhu et al. 2007; Attia et al. 2009, Bombardekar and Poerschke 2009; Venancio et al.

2011a; Venancio et al. 2011b; Bleil De Souza 2012). Solution-propositions seem to have fallen into a repetitive cycle. Tool-based propositions to solve the problem assume that previous attempts are inadequate for architectural use; and that the solution essentially lies in the creation of a new piece of software. Each new tool claims to address the same barriers as the previous tools. **Nonetheless, continual attempts to create new 'architect-friendly' tools or interfaces; or to marry between different technologies have not worked as aspired. Repetitively creating new tools does not automatically guarantee that they will be used.**

2.4.2 ASSUMPTIONS OF THE ARCHITECTURAL DESIGN PROCESS

These tool-based solutions are often based on assumptions about architects and a presupposed knowledge of their praxis and 'modus operandi.' However, these *"tools are being developed following a false paradigm about how designers work"* (Donn 2004). Bannister (2005) also states that there is *"a gap between how they* [tool developers] *think simulation tools should be used and how they are being used."* Efforts such as those reviewed in section 2.3.3 do not seem to adequately inform tool-developers' understandings of the architectural world.

This misinformation is evident in Arnold (2011), who supposes design problem-solving to follow the rigour of a 'scientific' paradigm when stripped to its core; that designing is *"in essence a series of experiments, testing a variety of design hypotheses."* Moreover, because "*building simulation is, in essence a scientific experiment* [...] *a hypothesis is tested through modelling..."* the ability to seamlessly integrate one scientific experiment (BPS) with another scientific experiment (design) is considered a reasonable and unproblematic proposition.

In congruence, most BPS researchers and tool-creators seeking to explain the actions of design, generalize the architectural design process into a set of scenario-based compartmental procedures, consisting of well-defined series of sealed time steps, where the start of the activities of one design stage marks the finite end of the previous one. Examples of this type of representation are evident in De Wilde (2002), Morbitzer (2003), Zhu et al. (2007) and Xia et al. (2008) to name a few. Again, because BPS software essentially consist of *"scientific law-like statements of interacting and interwoven computational routines"* (Williamson 2010), **such a rigorous break-down of the architectural design process agrees with the software logic, and BPS**

researchers' need to achieve such a scenario-based break-down becomes self-explanatory.

However, it is likely that these rudimentary, unrevised assumptions of architectural praxis, and efforts that have repetitively been built upon these assumptions could be an underlying reason for poor employment of BPS in architects' decision-making. Most BPS researchers and tool developers are not architects, and will have had little knowledge or experience in architectural design themselves to correct these assumptions.

2.4.3 DISCONNECTION BETWEEN ACADEMIA AND ARCHITECTURAL INDUSTRY

BPS research and tool-proliferation often occurs in academic environments. These are usually affiliated with engineering or building physics departments, with little alignment to the practical, day-to-day experiences and concerns of practitioners working in architectural firms. **Despite zealous efforts conducted in tool/interface developments, many of these do not equally pervade into architectural practice.** Some architectural schools are used as 'test-beds' for investigation of BPS developments (Caldas and Norford 2001), but these investigations cannot be considered holistic depictions of the architectural world. In academic environments; constraints common to practising architects in real-time projects; pressing demands of a financial nature, or cliental requirements, are not experienced. **It is therefore apparent that a disconnection between the BPS research field and the architectural industry exists.**

2.5 IDENTIFYING THE GAP; THE HUMAN PERSPECTIVE

Critical review of the literature reveals that BPS is mostly observed as a completely objective, linear and computational set of procedures with little or no human intervention. However, according to Williamson (2010), application of BPS in projects *"will be heavily influenced by the philosophical judgements of the person making the judgement"* (Williamson 2010). Congruently, *"to understand the meaning of simulation, first there must be recognition that there are different ontological positions or views about the nature of the world and in addition there are different epistemological beliefs"* (Williamson 2010). BPS results are largely affected by decisions made by professionals; such as when to start simulating performance, what inputs to use and output interpretation which are all effectively made by humans and must therefore be influenced by personal judgements.

2.5.1 HOW HUMANS HAVE BEEN ADDRESSED IN PREVIOUS BPS LITERATURE

Mahdavi (2011a) states that ***"the human dimension of building performance simulation has not been thoroughly addressed in the past. A deeper understanding of this dimension may divulge promising opportunities for progress in the building performance simulation domain"*** (Mahdavi 2011a). In his contribution, Mahdavi highlights the fundamentality of the 'people' presence in BPS; calling for a new research direction in the BPS field. He exemplifies this fundamentality by proposing a shift of investigation towards three particular human dimensions;

a) **The dimension of people as tool-users;** and therefore features which BPS tools need to exhibit to improve these tool-users' experiences in using the tools. He also examines how users' competences could be enhanced to improve usability, and how conditions for BPS-uptake could be improved.

b) **The dimension of people as modelled agents[11];** and therefore reaching an adequate empirical and standardised representation of their presence, occupancy, activities and actions in buildings. A conceptual framework is proposed in this contribution to signify 'people-presence' in BPS.

c) **The dimension of people as subjects of BPS;** and therefore reaching a quantifiable basis to evaluate buildings' 'habitability;' for these. Building 'habitability' relates to peoples' phenomenological experiences of their surrounding environment and their perceptions of thermal conditions, acoustics and lighting. It is argued in this publication that this understanding is *"the most essential utility of BPS"* yet it is *"currently rather fragmentary."*

Bleil De Souza (2008 and 2012) also addresses the problem of using BPS to inform architects' decision-making by conducting an in-depth examination of architects' and BPS specialists' worldviews; adopting a similar perspective to Mahdavi's (2011a) first

[11] This dimension of 'people presence' is probably the most common human dimension addressed in the literature. This dimension was also the focus of (Mahdavi 2011b); and has also previously been addressed in (Hoes et al., 2009; Yu et al., 2011; Klein et al., 2012 to cite a few examples).

‘people as tool-users’ dimension. She argues that current research in this field is unilateral and fails to take into account underlying individual knowledge and praxis of these two professional groups. She instead proposes a discussion based on the *“acknowledgement that building physicists and building designers* [...] *subscribe to different worldviews and paradigms when undertaking their everyday activities;”* followed by an ensued side-by-side criticism and theoretical reflection on problem-solving paradigms followed by each group (Bleil De Souza 2008; Bleil De Souza 2012). Bleil De Souza also highlights the need of increased **qualitative and participatory research** in the BPS area; which could advance it ***“towards a more effective set of outcomes”*** (Bleil De Souza 2012).

2.5.2 CONTINUED EXPLORATION OF THE HUMAN DIMENSION IN THIS PHD

The contribution of this PhD thesis departs from convergence of three vantage points:

a) Criticisms presented in section 2.4 of common solution-approaches to remove the barriers highlighted in section 2.3. The literature review revealed that most of these solutions are mainly computational and tool-based; and are often based on unrepresentative assumptions of the design process which need to be corrected.

b) Mahdavi’s (2011a) proposal to thoroughly explore elements of a human dimensionality in BPS research.

c) Bleil De Souza’s (2012) suggestion that the BPS area would largely benefit from qualitative studies to complement the theoretical, comparative groundwork she has already established; to expand the scope of possibilities in this research area.

Convergence of the above three points initiates the following starting points for this PhD contribution:

– **The need for social research on the ‘human’ side of integration:** Inherently, progression and management of building projects occur by professionals. The decision to use BPS in architects’ decision-making is essentially one of many decisions made by these building professionals. It is therefore necessary to acknowledge the ‘human’ pertinence; and to recognise that this integration is ultimately a merger of architects' and BPS specialists' social worlds. **Investigations of a social nature into these two worlds and traditions could offer valuable insights, and expose non-technical barriers impeding use of BPS in architectural projects.**

- **<u>The meaning and role of collaboration:</u>** The present situation is that most of the time, architects collaborate with BPS specialists to conduct BPS predictions (MacDonald et al. 2005; Bleiberg and Shaviv 2007; Bombardekar and Poerschke 2009). Therefore, the role of BPS specialists in collaboration with architects requires urgent attention; and what is intended by the word 'collaboration' needs to be outlined.

  It was previously cited in section 2.2.3.4 that architects often need to collaborate with external consultants for BPS; because of the high degrees of specialisation required. Multiple research efforts have been channelled towards enhancing architect-BPS collaboration (Augenbroe et al. 2003; Prazeres and Clarke 2003; Prazeres and Clarke 2007 and 2009; Yi et al. 2007; Bleiberg and Shaviv 2007; Osello et al. 2011 to cite a few). However, these initiatives mainly propagate an 'out-sourcing' archetype of collaboration (Mahdavi 2011a) by setting up data-exchange mechanisms. This 'out-sourcing' archetype departs from an assumption that collaboration only entails fragmenting the design into a number of 'parts' which are distributed to different professionals; based on their respective specialisms. Each professional works on 'their part' of the design in comfortable isolation from other members of the design team; possibly meeting from time-to-time to adjust the design accordingly. At the end of the process; all professionals come together once again to re-assemble each of their respective parts.

  It is argued in this thesis that this fragmented one-way 'out-sourcing' archetype of collaboration is insufficient as a means of integrating BPS in the design process. Instead of creating data-exchange mechanisms between professionals who are both physically-isolated and ideologically-disparate, collaboration needs to be regarded as creating an integrative and unified platform for both architects and BPS specialists to work together as a single team; from the start of the design and throughout the process. This unified platform pre-supposes a view of the design process as a social process. By recurring to this view; collaboration is regarded as an orchestrated synthesis of different disciplines; within which diverse worldviews, different knowledge-domains and professional ‘languages’ are acknowledged. This social view of the architectural design process, and the implications of combining professionals who represent divergent disciplines in collaboration are discussed in chapter 3.

3. BUILDING PERFORMANCE SIMULATION IN THE CONTEXT OF THE SOCIAL DESIGN PROCESS

"The lone design genius, if not mythical or completely extinct, is surely on the endangered species list" – Domeshek et al. (1994).

3.1 INTRODUCTION

The purpose of this chapter is to locate BPS for design decision-making in a social context; as a starting point to explore the 'human' dimension inherent in collaborations between architects and BPS specialists. The architectural design process is therefore argued in this chapter as a social process; into which both architects and BPS specialists converge. Multi-disciplinary collaboration prompts the discussion of architects' and BPS specialists' worldview differences, and implications these differences may have on collaboration. The overarching research question which this thesis aims to answer and the research hypothesis depart from these discussions. Consequently, a mixed-methods research approach which follows a pragmatic research philosophy is proposed as a means of answering this research question. Departing from this pragmatic approach, the methodology of the empirical work conducted in this thesis is outlined at the end of this chapter.

3.2 ARCHITECTURAL DESIGN AS A SOCIAL PROCESS

It was underlined in chapter 2[1] that the most frequent approach to increase architects' utilisation of BPS in their design decision-making is by putting 'architect-friendly' tools or interfaces into the hands of architects. This approach aligns with the *"lone design genius"* perception of the architect quoted above. According to this perception; the architect is envisaged as the ultimate decision-maker; operating in isolation and only collaborating with other professionals when needed; following the 'out-sourcing' archetype of collaboration identified at the end of the previous chapter.

Nevertheless, it is hereby argued that the first step towards increasing BPS impact on architectural decision-making is to revise this misconception as an altogether incorrect starting point. During the 1990s, an alternate vision to design was recognised; and the

[1] Sections 2.3.1.1 and 2.3.1.2.

study of the design process shifted in focus; from the individual designer **to a wider-encompassing recognition of design as a team-work activity** (Cross and Cross 1995).

Architectural design has since been identified as an intrinsically social process; driven by interactions and negotiations of an entire design team (Kalay 2001; Bucciarelli 2002; Alexiou and Zamenopoulos 2008 and Oak 2011). In 'design as a social process,' the sphere of design activity extends beyond that of the single designer towards an instrumental collaboration of multidisciplinary professionals. This includes engineers, external consultants and contractors alongside the architect as shown in the diagram in figure 3.1. Stakeholders such as the client or end-user also affect how design-decisions are made (Luck et al. 2001 and Luck 2003).

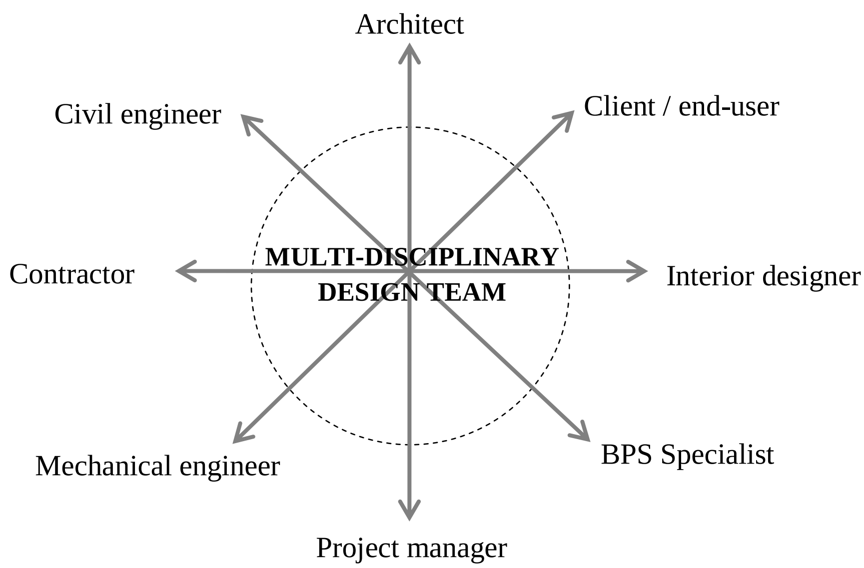


Fig. 3.1. Showing possible members in a multi-disciplinary collaborating design-team.

Each member in this collective is likely to originate from different disciplinary backgrounds (Kalay 2001). They come together into a single social setting to enable design aspirations which would remain unforeseeable if strictly undertaken from a unilateral perspective (Kalay 2001; Chiu 2002). Thus, multi-disciplinary collaboration in the social design process helps to overcome limitations of knowledge, physical capabilities and power.

3.2.1 ARCHITECTS AND BPS SPECIALISTS IN COLLABORATION; NARROWING IT DOWN

Within the 'social design process,' the multi-disciplinary collaboration of interest in this thesis is that between architects and BPS specialists; as illustrated in figure 3.2[2].

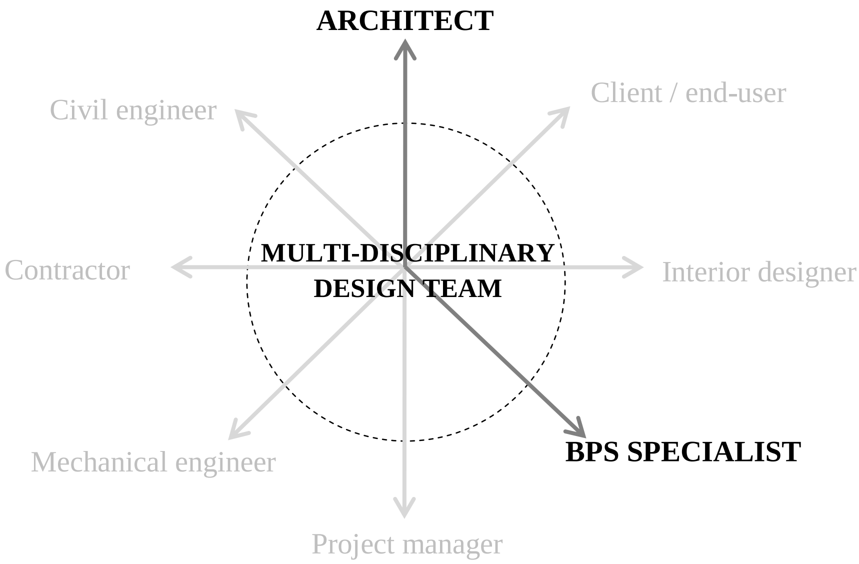


Fig. 3.2. Adapted from fig. 3.1. beforehand; scrutinising collaboration between architects and BPS specialists in this research.

3.3 IMPLICATIONS OF MULTI-DISCIPLINARITY ON COLLABORATION BETWEEN ARCHITECTS AND BPS SPECIALISTS

Subscribing to this view of 'design as a social process' prioritises discussion of worldview differences between architects and BPS specialists. These differences and the implications they may have on collaboration are discussed in the following sub-sections.

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[2] The researcher acknowledges that it is virtually impossible to objectively detach the particular relationship between architects and BPS from its context; and to examine this relationship in full isolation from the rest of the design-team. It will be inevitable that this relationship will have an impact on, and be impacted by, other members of the surrounding design team (e.g. client, contractor, etc.).

3.3.1 DIFFERENCES IN WORLDVIEW

In their book, *The Social Construction of Reality*, Berger and Luckmann (1967) contend that **there is no such thing as a single objective reality shared amongst all individuals.** They instead argue that reality is subjective to each social group; through which it is developed, transmitted and maintained. Importance, value and ideological 'truths' can only be affixed based on worldview.

To tailor this concept to collaborations between architects and BPS specialists; members of these two professional groups recur to divergent worldviews and therefore adopt different praxis in their day-to-day work (Bleil De Souza 2012). BPS specialists' worldviews are similar to those of natural scientists; which can be described as positivist; realist or objective in nature (Bleil De Souza 2012). In contrast; architects recur to a worldview analogous to the worldviews in the arts and humanities fields which tend to be constructionist, interpretivist or relativist (Bleil De Souza 2012).

Architects and BPS specialists recur to different worldviews as a consequence of differences in educational and professional training. **Education and training are central to shaping worldview and social reality** (Kalay 2001). These provide a 'professional upbringing'; and instil a 'correct' way of thinking and seeing the world. Each building professional will therefore enter the collaboration based on their individual foundational knowledge-bases and belief systems; which are unlikely to overlap. Differences in educational background will ultimately alter how each member of the collaborative design-team 'sees' the design process and product (Bucciarelli 2002).

3.3.1.1 Differences in professional aims

Professional aims and motivations depart from worldviews. If the worldviews of architects and BPS specialists are completely different, their aims are unlikely to overlap. For example, **an architect's focus on a project may be concerned with reaching an aesthetically-pleasing internal environment. On the other hand, the BPS specialist may direct all his/her efforts towards optimising the energy-efficiency of the building.** The latter may want to compromise aesthetics to reach aspirations of reduced energy-consumption; which the architect may not agree with. Conflicts may arise as a result.

3.3.1.2 Different languages spoken

Worldview also shapes language and understanding. 'Language' in this context is not simply a mode of expression; it is a socially-constructed system of symbols by which subjective realities are moulded and mediated (Baxter 2010; Oak 2011). **Language is an embodiment of worldview; as reciprocally worldview is an embodiment of language; the two are interwoven.**

In a multi-disciplinary collaboration each professional is likely to speak a language associated with the worldview to which he or she originally subscribes[3]. Thus, information communicated by an architect who subscribes to a constructionist worldview may not be fully understood by a BPS specialist. In order for the sent meaning to be mutually understood by the other party, the professional language employed by both parties must be the same. Poggenpohl et al. (2004) presents an analogy between 'language' and 'money;' *"like money, language is an economy of transaction with certain standards based on the context of use.* ***Words are the medium of exchange from which understanding is derived."*** If sender and recipient employ the same professional language in collaboration and communication; intended meanings will accordingly be shared and understood. On the other hand, collaborations in which each professional speaks a different professional language may lead to misunderstandings and conflict.

3.4 RESEARCH QUESTIONS AND RESEARCH HYPOTHESIS

The overarching research question and hypothesis of this thesis have been reached through convergence of the following three points of discussion arising in both chapters 2 and 3;

- That despite the increasing number of tools proposed to enhance BPS use to inform architectural decision-making; BPS uptake remains considerably low (discussed in chapter 2; section 2.4.1).
- That architects instead often collaborate with BPS specialists as a means of integrating BPS in their design processes. However, this collaboration is often

[3] Different 'languages' here are not intended in their trans-national sense; e.g. English or German. Rather, different professional discourses are used by multi-disciplinary professionals so that certain words or phrases hold ambiguous meanings, which are understood differently by members of different disciplines.

limited to a simplistic 'out-sourcing' of BPS tasks to the specialists; in which design is not acknowledged as an inherently social process (discussed in chapter 2; section 2.5.2).

- That architects and BPS specialists recur to different worldviews; they have different professional aims and will speak different professional languages. These differences may lead to misunderstandings and conflict in collaboration (discussed in this chapter; chapter 3).

Accordingly, the overarching research question of this thesis is;

Do non-technical barriers which arise during collaboration between architects and BPS specialists; reduce the potential for BPS to inform architectural design decision-making?

To facilitate answering this question; this research question can be divided into three 'sub'-questions;

1. **What** are the non-technical barriers which arise in collaboration between architects and BPS specialists?

2. **How** do these non-technical barriers reduce the potential for BPS to inform architectural design decision-making?

3. Can we confirm the **existence and prevalence of these non-technical barriers amongst the wider population** of architects and BPS specialists practising in England and Wales?

Consequently, the hypothesis of this thesis is that **non-technical barriers arising from problems in collaboration between architects and BPS specialists may be reducing the potential of BPS in informing design decision-making.** These serve as additional barriers alongside software-related barriers such as architectural tool-usability; identified in the literature.

3.5 MIXED METHODS TO ANSWER RESEARCH QUESTIONS

Subsumed within previous discussions of the human dimension of BPS, the social design process, multi-disciplinary collaboration and worldview differences is an implication that qualitative approaches are necessary for the forthcoming empirical investigation. Proponents of qualitative research methods in the social sciences profess the superiority of the *"deep, rich observational data"* which emerges as a result of these methods (Sieber 1973). However, suspicions are often raised concerning the generalization of qualitative research results (Bryman 1988). Alternative quantitative approaches which boast the *"virtues of hard, generalizable data"* (Sieber 1973) are equally disregarded by qualitative purists for being too *"static"* and *"superficial"* (Bryman 1988). Thus emerges a long-standing philosophical debate between proponents of the two dominant research approaches in the social sciences; **and the consequent dilemma of deciding whether qualitative or quantitative approaches are best used to answer this thesis' research question.** As a starting point to this key decision, it is first necessary to identify the philosophical differences underpinning each approach; the conflicting status of each philosophy and the implications these differences and conflicts may have on research design.

3.5.1 THE PARADIGM WARS

The relationship between qualitative and quantitative approaches has historically been described as antagonistic (Sieber 1973; Bryman 1988) and in competition for supremacy (Lincoln and Guba 2003). This antagonism is propelled by differences in ontological and epistemological philosophies which govern each of the two approaches.

Qualitative approaches depart from social constructionist, interpretivist or relativist philosophies. These philosophies are underpinned by relativist ontological beliefs; in which reality is referential to the social milieu in which it has been constructed, and in which individuals are instilled (Denzin and Lincoln 2005). A similar relativist epistemological belief is recurred to; that human knowledge is contingent to the surroundings in which it is situated. According to this belief, knowledge which is mutually-shared across all individuals does not exist.

Quantitative research methods recur to positivist and post-positivist philosophies, in which the existence of a single, objective and 'true' reality is ontologically subsumed. The world is believed to exist independently of those who inhabit it. Positivists equally uphold an objective and non-reflexive epistemological belief in the 'oneness' of knowledge; which is mutually shared by all individuals and which is 'out there' to be empirically-discovered.

3.5.1.1 Implications of the paradigm wars on research design

According to Hughes (1990), *"every research tool or procedure is inextricably embedded in commitments to particular versions of the world and to knowing the world."* Therefore, choices of research method and research instruments to be used in a study ultimately demonstrate the researcher's allegiance to either of the two dominant research philosophies. It is further posited that the two philosophies; and their associated methods, are incompatible and cannot be merged for use in the same research study. In Guba's (1985) opinion, attempts to mix qualitative and quantitative methods depart from a shallow supposition that this merger is a simplistic cohesion of methods only. However, this supposition fails to realise that, *"we are dealing with an either-or proposition; in which one must pledge allegiance to one paradigm or the other."*

3.5.1.2 Implications of the chosen philosophy on research design

Adherence to either of these philosophies therefore poses specific implications on the ensuing research design. In qualitative research, theory does not precede experimentation; but emerges inductively from the data (Guba 1990). These methods are therefore used in exploratory studies; to answer research questions of 'how,' 'why' or 'whether.' Answers to these questions are not intended to provide generalizations; but to facilitate acquiring in-depth understandings of the social world.

Quantitative methods in contrast depart from pre-ascertained theories. These methods tend to rely on the construction of hypotheses to be tested and either proven correct or falsified. The process is deductive; in which numbers are inherently used as units of analysis towards the production of generalizable results.

3.5.2 A PRAGMATIC APPROACH TO RECONCILE THE PHILOSOPHIES

Despite the divide between qualitative and quantitative research traditions, Hammersley (1996) contends that the two approaches should not be regarded as alternatives; ***"we need both"*** (Hammersley 1996). It is therefore recommended by Sieber (1973), Howe (1988), Brewer and Hunter (1989), Hammersley (1996), Johnson and Onwuegbuzie (2004), Bryman (2006) and Morgan (2007) to name a few that a non-purist, cross-paradigmatic and mixed position is best adopted to incorporate features of **both** qualitative and quantitative research design into a single study. **This is known as taking a pragmatic approach; and is the chosen methodological approach for the research presented in this thesis.**

3.5.2.1 Pragmatism; philosophically

To address purists' refusals of philosophical and methodological dualisms[4], a few positions are deliberated to situate the pragmatist philosophy in relation to interpretivist and positivist philosophies. Johnson and Onwuegbuzie (2004) describe pragmatism as the ***"middle position*** *philosophically;"* lying between qualitative and quantitative research if the two can be located on opposite sides of a hypothetical continuum. They also describe pragmatism as the ***"third wave"*** or ***"third research movement;"*** in parallel to the two dominant research traditions. Hammersley (1996) describes pragmatism as *"methodological eclecticism;"* contending that this position opposes the paradigm view of qualitative and quantitative purists.

3.5.2.2 Pragmatism; methodologically

The pragmatic approach allows selection of methods and instruments **from both qualitative and quantitative research traditions which best answer the research questions; rather than on the bases of epistemological reasoning.** Thus, research design is observed from a technical and practical standpoint; without following *"the conceptual straitjacket of the disciplines"* (Horlick-Jones and Sime 2004).

Johnson and Onwuegbuzie (2004) argue that mixed-methods research designs return superior results in comparison to mono-methods designs. By using both qualitative and quantitative research instruments, successful features of both research traditions are combined, and their respective weaknesses are cancelled out at the same time (Hammersley 1996). Watson (1990) and Maxcy (2003) additionally maintain that, because mixed methods bridge across different research traditions; their use promises further advancement of knowledge than possible using mono-methods research designs. Further advantages of mixed-methods designs are demonstrated in table 3.1. These advantages are collated based on a comprehensive review of mixed-methods publications by Bryman (2006); in which advantages of mixed-methods research were cited by 232 authors.

[4] As mentioned in section 3.5.1.1.

Table 3.1. Advantages of mixed-methods designs; adapted from Bryman (2006).

ADVANTAGE		EXPLANATION
RESEARCH DESIGN	**Different research questions**	Qualitative research questions, seeking to describe social phenomena and generate theories, and quantitative research questions designed to test hypotheses, can both be answered.
	Confirm and discover	Qualitative methods are used to generate hypotheses, and quantitative methods are then applied to test these hypotheses in the same study.
	Instrument development	Using qualitative methods can facilitate better design of quantitative instruments for use in later research stages (e.g. in the development of better wording for questionnaires).
	Sampling	Qualitative approaches used initially can facilitate sampling for subsequent quantitative research stages.
	Completeness	Using both qualitative and quantitative methods allows a more complete account of the research to be depicted.
	Utility	It is suggested that results from mixed methods approaches are considered more useful than mono-methods' findings.
	Offset	Merging quantitative and qualitative research methods allows the weaknesses of one method to be offset by the strengths of the other.
RESULTS' EXPLANATIONS	**Process**	Quantitative methods explain structures of the social world whereas qualitative methods demonstrate process.
	Context	Results of one method can be used to provide contextual explanation for the results of another.
	Illustration	Qualitative data can illustrate quantitative ones; *"putting 'meat on the bones' of 'dry' quantitative findings"* (Bryman 2006).
	Explanation	Findings of a quantitative research method can explain qualitative phenomena unravelled; or vice versa.
	Unexpected results	Surprising results from quantitative methods can receive enlightenment using qualitative findings; and vice versa.
	Diversity of views	Mixed methods designs can accommodate for more diverse views of researchers and practitioners alike.
RESULTS CONFIRMATION	**Increased validity**	The validity of research results are increased by substantiating qualitative findings against quantitative ones, and vice versa.
	Credibility	Combining both quantitative and qualitative methods increases the credibility of the research findings.

3.5.2.3 Why, how and when to mix methods

Bryman (1988 and 2006) contends that there are very few instructions in the theoretical literature guiding the researcher towards choosing the typology of mixed-methods research best-suited to the needs of the research study. Nevertheless, Moran-Ellis et al. (2006) underline that the purpose of methodological triangulation must be identified from the onset; as this will guide the process by which different methods are combined; and **will also have implications on the epistemological status of resulting knowledge.**

What are the purposes of conducting mixed-methods research?

The rationale for conducting mixed-methods studies most widely cited in social science studies is that of **triangulation** (Denzin 1989; Seale 1999; Stake 2000; Greene et al. 2001; Bryman 2001; Mason 2002; Mason 2006 to cite a few). Triangulation is defined by Moran-Ellis et al. (2006) as; *"an epistemological claim concerning what more can be known about a phenomenon when the findings from data generated by two or more methods are brought together."* However, different epistemological claims as to how the triangulated result should be interpreted have led to the production of divergent typologies of triangulation.

1. Increased validity: In this typology, results yielded from two or more research methods can be compared to determine the results' accuracy. If similar results are produced by all methods; the results are deemed accurate. However, conflicting results are epistemologically seen to indicate a flaw in the research instruments employed (Campbell and Fiske 1959); hence validity of the results cannot be ascertained.

2. Generating complementarity: This typology arose from objections to the epistemological claim subsumed in the previous one. This objection stems from a view that qualitative and quantitative methods depart from different philosophical standpoints[5]. The interpretation of dissimilar results as invalid is therefore denounced. Rather, in this typology divergent results are believed to portray an alternate dimension of the phenomenon in question and to enhance understandings of the social world (Greene et al. 1989).

[5] As reviewed in section 3.5.1; the parent section of this sub-section.

3. Middle-ground position: In this typology the increased validity claim is not accepted. However, it is argued that underpinning philosophies of quantitative and qualitative research methods can still be united in a single study because both interpretivist and positivist phenomena reside in social order.

Triangulation is not the sole impetus of mixing methods identified in the literature. In Greene et al. (1989), three more reasons for mixing methods are proposed;

1. Employing quantitative methods can inform qualitative research designs used at later stages; or vice versa.

2. Mixing methods allows data to be generated at various levels of analytic depth and breadth. For example, qualitative methods result in generation of ‘deep’ data from a small sample; whereas data generated from quantitative methods may be less profound, but will allow exploration of a wider sample.

3. Using more than one method can widen the scope of inquiry and allow investigation of multiple components in a single research project.

How can the methods be mixed?

Moran-Ellis et al. (2006) suggest that methods can be mixed either through ‘integration’ or ‘combination.’ Punch (2005) provides three key points which need to be considered when adopting mixed-methods research; two of which determine whether the methods are integrated or combined;

1. Whether the methods are regarded as equal; and therefore are considered to equally contribute to the body of knowledge or whether one method receives more weight in the research design than the other.

2. Whether the methods are used interactively or whether they are used in separation.

For the mixing of methods to be **integrated, all methods used should be equally-weighted; and should all aim to answer the same research question.** Otherwise; the mixing of methods is considered a combination; not integration (Moran-Ellis et al. 2006).

When should the methods be mixed?

The third key point for consideration proposed by Punch (2005) is whether methods are mixed **simultaneously** or **sequentially.**

Integration is achieved by simultaneously mixing methods at a particular point in the research process. This may be by mixing methods throughout all research stages; from conceptualisation of the research design through to the conclusions. Integration may also be achieved by employing different methods of data-collection and setting up approaches to interconnect the analysis; examining data-sets generated by different philosophical paradigms simultaneously (for example Coxon 2005). Finally, integration may only occur at the conclusive stage of the research. Here, different sets of data are both collected and analysed based on the philosophical traditions which underpin them; but are reconciled in the final conclusive stage.

On the other hand, when research methods are combined, they aim to answer different research questions. This mixing is likely to be undertaken sequentially; at different research stages. One stage will adopt a particular set of methods which recur to their 'own' philosophy. This will be followed by a second stage in which a different set of instruments are employed; recurring to another set of paradigmatic traditions.

3.5.3 APPLYING MIXED-METHODS TO THIS RESEARCH

Answering the overarching research question of this thesis; ***'do non-technical barriers which arise during collaboration between architects and BPS specialists, reduce the potential for BPS to inform architectural decision-making?'*** entailed sub-dividing it into three 'parts' to find;

a) **What** the non-technical barriers are.

b) **How** they threaten to hinder BPS uptake and use in architectural decision-making.

c) The extents to which these barriers are experienced among practitioners in England and Wales.

Answering parts (a) and (b) of the research question necessitated conducting an initial exploration of non-technical barriers as, to date; no previous work has explored the possibility that barriers to BPS uptake and use in architectural decision-making may not solely be software-related. However, answering part (c) of the research question entailed employing quantitative research instruments; to confirm the existence of barriers extracted in parts (a) and (b) in the wider context in England and Wales.

Therefore, **a pragmatic mixed methods research design consisting of two empirical stages was devised.** This allowed the overarching research question of this thesis to be dissected into separate 'parts' or 'sub'-questions so that relevant research instruments were employed to answer each part separately. These parts were then re-assembled conclusively at the end of the thesis. Following on from this introductory section of the thesis (section 1); the empirical stages of this research study are;

- The qualitative stage, in section 2 of this thesis.
- The quantitative stage; in section 3 of this thesis.

At each of these stages, data were both collected and analysed with reference to the philosophical paradigms which underpin them. Data analysis did not occur cross-paradigmatically. Therefore, in the qualitative stage, all instruments of data-collection and analysis recur to a social constructionist philosophical paradigm. Semi-structured interviews were used for data-collection and these data were analysed qualitatively using a thematic content analysis. Interpretations from these analyses informed the subsequent quantitative stage of the research. In this quantitative stage, instruments of data-collection and analysis used recur to a positivist paradigm; as questionnaires were distributed and their results were analysed statistically.

In the case of this research, the purposes of conducting mixed-methods research were three-fold;

- **For triangulating and generating complementarity.** The validity of the findings was not questioned where divergent results were produced by different methods. These differences were instead seen to provide an additional perspective to the multi-faceted and complex social order in examination.
- **To generate data at various levels of analytic depth and breadth**. Data collected during the first qualitative stage were deeper than those collected

during the quantitative stage. However, in the latter stage, data was collected from a larger sample, allowing a wider investigation.

- **To inform the subsequent research-design.** Questionnaire-design in the quantitative stage was informed by the interpretations formed during the earlier qualitative stage. Qualitative interpretations were re-tested statistically. In addition, statements constructed in the questionnaire-design were worded based upon statements voiced during the interviews.

A delicate issue to address here is the **weighting** of qualitative and quantitative approaches in this thesis; as this is one of the factors which determines whether the mixing of methods was the one of integration or combination. The starting point for this research was qualitative; without the conclusive outcomes of section 2, the quantitative follow-up at section 3 would not be needed. If the weighting of each approach was to be determined on this basis alone, it would be inferred that this research was primarily qualitative whereas quantitative methods were used in combination to buttress the qualitative findings. A similar interpretation could be arrived at by examining the sub-questions of the overarching research question. Two of these entailed employing qualitative approaches and only one entailed using quantitative techniques departing from a positivist paradigm.

However, the critical denominator determining whether the mixing of methods was an integration or combination is whether the methods sought to answer the same research question or different ones. **In the case of this research, answers to the three sub-questions arrived at from sections 2 and 3 were reconciled and merged at the final research stage; as depicted in figure 3.3.** Integration occurred at section 4 (chapter 8) to answer the overarching research question of the thesis and to reach a set of research findings. Therefore, both qualitative and quantitative research stages in this thesis equally contributed to the knowledge produced; and were accordingly seen as equally-necessary and equally-weighted.

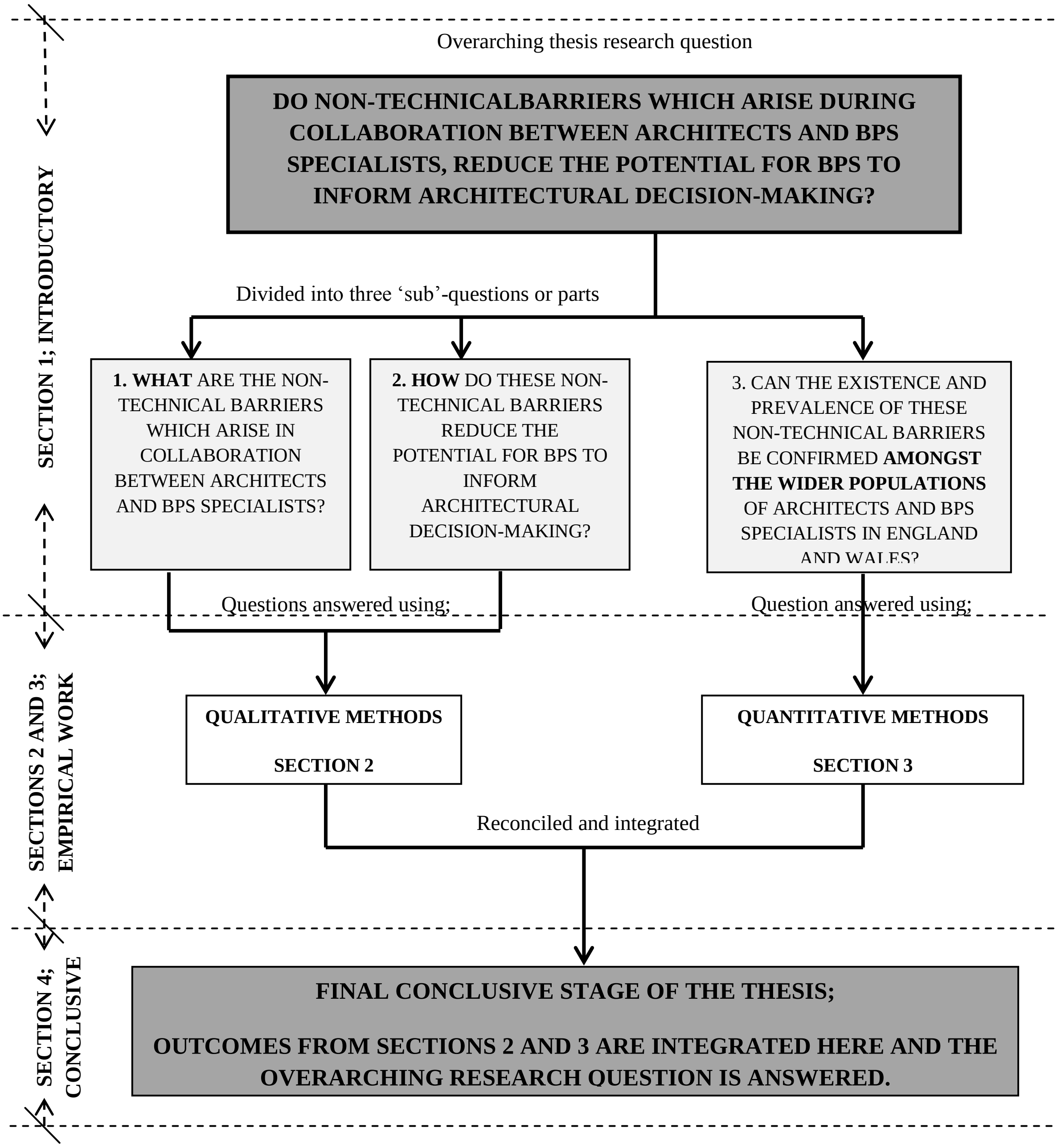


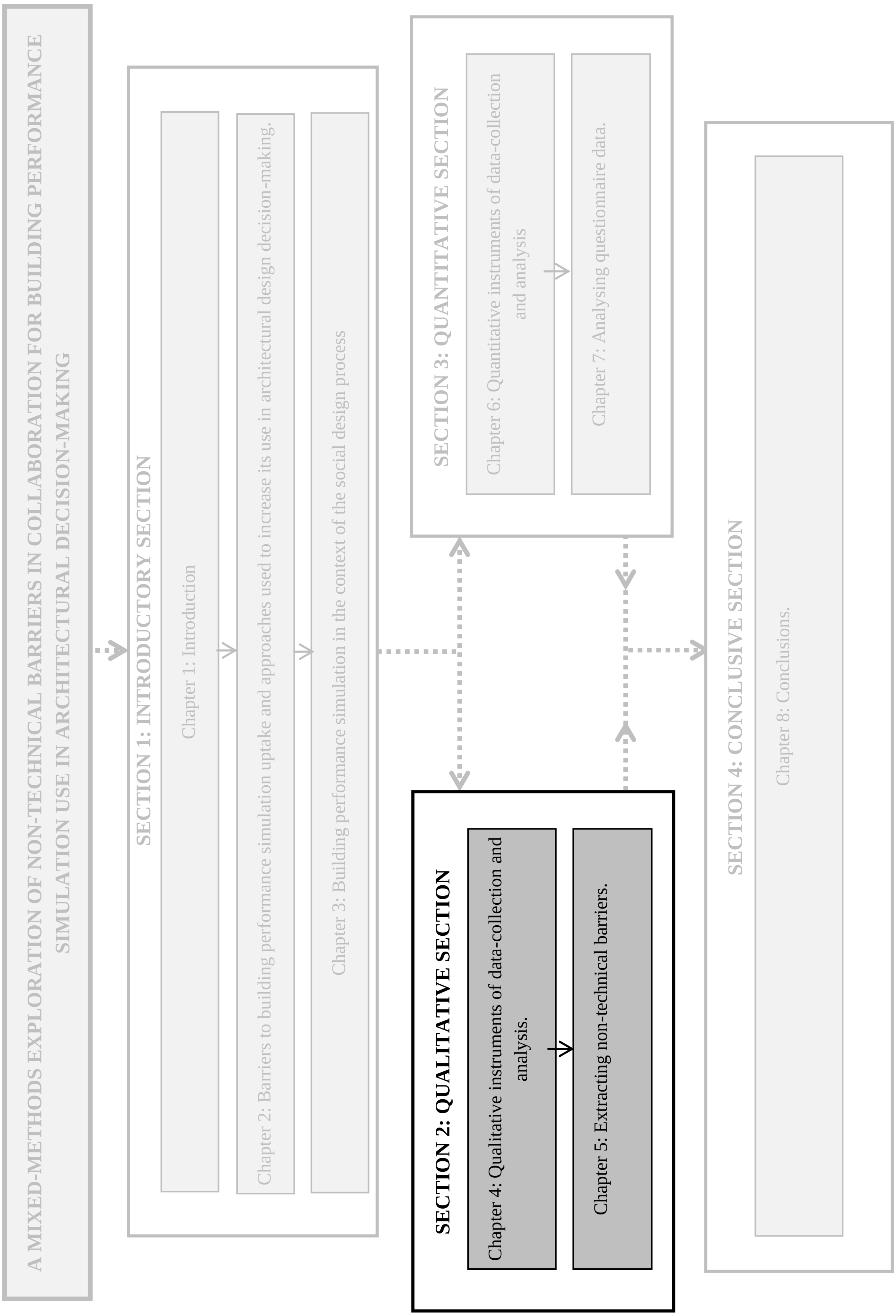
Fig. 3.3. Methodology of this thesis used to answer the research questions following a pragmatic mixed-methods approach.

Consequently in this thesis, section 2 which is concerned with qualitative research methods consists of two chapters; chapters 4 and 5. In chapter 4 qualitative research methods and instruments used for data-collection and analysis are described. In chapter 5; results of the qualitative thematic content analysis are presented.

Section 3 which is concerned with quantitative methods consists of two chapters; chapters 6 and 7. In chapter 6, quantitative instruments of data-collection and analysis are presented. The results from these methods are analysed statistically in chapter 7.

The final section of this thesis consists of only one chapter; chapters 8. In this chapter, outcomes of both the qualitative and quantitative approaches used in this thesis are integrated to form research findings, and the research design used to arrive at these findings and answer the overarching research question are reflected upon.

SECTION 2; QUALITATIVE SECTION



4. QUALITATIVE INSTRUMENTS OF DATA-COLLECTION AND ANALYSIS

"Not everything that can be counted counts, and not everything that counts can be counted" – Sign hanging in Albert Einstein's office at Princeton; quoted in Kaufmann (2003).

4.1 INTRODUCTION

In chapter 4 qualitative methodological instruments of data-collection and analysis used in this empirical stage are described.

It was outlined in chapter 3 that at each empirical stage, data were both collected and analysed in accordance with their underpinning philosophical paradigms. Social constructionism underpinned use of qualitative instruments in this empirical stage; as qualitative methods align with relativist ontological and epistemological beliefs of social constructionism (Dayman and Holloway 2010). By 'borrowing' the methods from the social sciences, qualitative instruments may facilitate a deeper consolidation of complex phenomena inherently reducing the potential for BPS to inform design decision-making in collaborations between architects and BPS specialists; i.e. beyond barriers in the software reviewed in chapter 2. To allow this exploration, one qualitative instrument was employed for data-collection; **semi-structured interviewing.** Data collected from these interviews were analysed using a **qualitative thematic content analysis.**

It is important to note that in qualitative tradition, the researcher becomes a key component and informant in the construction of the social milieu (Alsaadani and Poveda 2011). If different activities of the research process are undertaken by several members of a research team, for example, chances of losing key information between these activities would be greater. Therefore, all procedures and activities described in this chapter, including data-collection, interviewing, transcription and analysis, were conducted by the author of this thesis[1].

[1] 'The researcher' and 'the interviewer' are both used in this chapter to refer to the author of this thesis.

4.2 DATA-COLLECTION THROUGH SEMI-STRUCTURED INTERVIEWING

Semi-structured interviews with architects and BPS specialists were used to extract non-technical barriers in collaboration which may be reducing the potential of BPS in design decision-making. A detailed description of semi-structured interviews is provided in section 4.2.1; followed by a discussion of how interviewing is regarded within the social constructionist philosophy in section 4.2.2. How interviews were applied to this research is discussed between sections 4.2.3-4.2.7.

4.2.1 GENERAL DESCRIPTION OF SEMI-STRUCTURED INTERVIEWS

Semi-structured interviews are reciprocal exchanges whereby an interviewer accesses vital information from an interviewee. Because speech opens a window into the mind of the interviewee, interviews allow access to information which may not be available through other qualitative data-collection techniques; such as ethnography (Patton 1980). This observation encouraged use of interviews as data-collection instruments in the qualitative stage of the research.

Semi-structured interviews are deliberately partially-prepared in advance; relying primarily on a tentative interview guide and on interviewer improvisation (Flick 1998). Few initial open-ended questions are purposively designed to start the conversation and encourage discussion relevant to the overarching research question. Further interview questions are improvised by the interviewer; by reflecting on previous responses and leading on from previous threads of conversation. **In this way, a cyclical construction of the data occurs through interactions between both interviewer and interviewee** (Edley and Litosseliti 2010; Holstein and Gubrium 1995). An assumption that the researcher's knowledge of the research-topic is incomplete is subsumed within this partial preparation. It is equally assumed that the interviewee could offer substantial insights which had neither been mentioned in the existing literature nor previously predicted by the researcher.

The flexibility inherent in this partial preparation enables exploration of characteristically 'in-depth,' multi-layered and profound issues. These issues include interviewees' thoughts, opinions, perceptions and attitudes; all associated with worldview construction and arguably difficult to investigate at a surface level, through a rigid pre-planned list of question, for example.

Moreover, the characteristics of semi-structured interviewing arguably consist of an intermediate fusion of desirable characteristics from both structured and unstructured interviewing (Laustsen 2012). This fusion of characteristics is illustrated in figure 4.1.

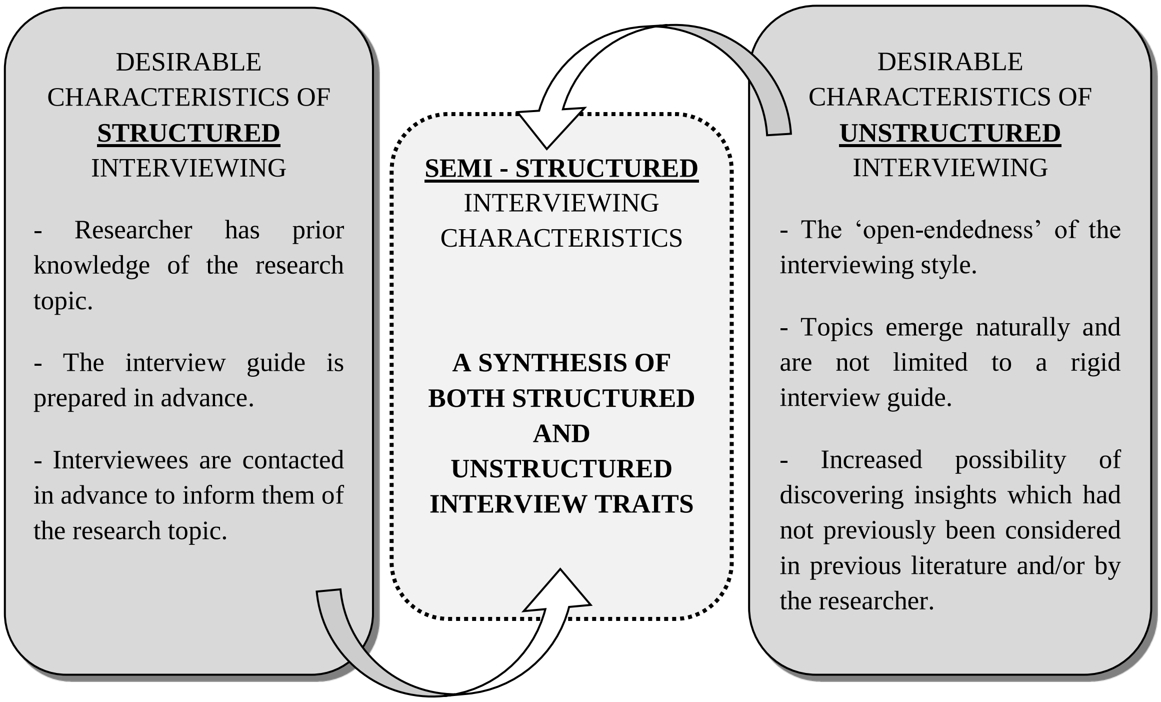


Fig. 4. 1. Depicting how semi-structured interviewing combines desirable characteristics of both structured and unstructured interviewing methods.

In structured interviewing, the scope of the study is narrowed to a set of pre-defined themes and questions; based on existent theories or preceding research studies. Thus, advanced preparation of an interview guide, prior contact with interviewees and provision of details of the research project are all characteristics of structured interviewing. These characteristics are similarly found in semi-structured interviewing; with the exception that advanced preparation is partial, subject to change and allows space for improvisation.

Improvisation is a characteristic incorporated from unstructured interviewing. Here the potential scope of investigation is broadly undefined and therefore much wider than in structured interviewing. In unstructured interviewing the conversation is intended to emerge naturally with no prior reliance on an interview guide. The conversation depends only on the interviewee's contribution and the interviewer's improvisation. Again, these are traits which are shared between unstructured and semi-structured interviewing methods.

4.2.2 INTERVIEWS WITHIN THE SOCIAL CONSTRUCTIONIST PHILOSOPHY

Interviewing is commonly described as a method of 'data-collection'. This description may conjure up connotations of one-sided, objective question-and-answer sessions used to 'harvest' representative specimens of spoken data. However, within the social constructionist philosophy, **interviews are considered as reciprocal interactional events between interviewer and interviewee, for mutual construction of data** (Rapley 2001). This is evident in the forthcoming excerpt from Holstein and Gubrium (1995);

> *"Both parties to the interview are necessarily and unavoidably active. Each is involved in meaning-making work. Meaning is not merely elicited by apt questioning nor simply transported through respondent replies; it is actively and communicatively assembled in the interview encounter. Respondents are not so much repositories of knowledge – treasures of information awaiting excavation – as they are constructors of knowledge in collaboration with interviewers."*

Because both interviewer and interviewee participate in this construction; the view of the interviewer as a potential contaminant to the research findings is rejected within this philosophy (Rapley 2001; Holstein and Gubrium 2004). Rather than attempting to objectify the interviewer's contributions to the interview, for example by avoiding leading questions or by standardising interview questions across all participants, the interviewer's input is considered part of the data-construction. The interviewer's experiences and perspectives are interwoven within the conversational interaction; as without these, resulting accounts would not be constructed in the same way (Rapley 2001; Baker 2002; Sarangi 2004).

4.2.3 HOW INTERVIEWS WERE DESIGNED FOR THIS RESEARCH

4.2.3.1 The interview guide

A tentative one-page interview guide was designed, which consisted of questions revolving around the three themes shown in table 4.1. The guide was used in a purposively flexible manner. Not all questions designed were necessarily posed to all the interviewees; and they were not asked in the same order.

Table 4.1. Showing thematic topics and questions included in the interview guide for architects and BPS specialists.

	ARCHITECTS	BPS SPECIALISTS
THEME 1; BACKGROUND EDUCATION; How background education and experience shape architects' and BPS specialists' experiences in the building industry.	1. Can we start by talking a little bit about your undergraduate architectural education? Can you tell me a little bit about that? Did you carry on with a postgraduate degree?	1. Can we start by talking a little bit about your undergraduate education? Can you tell me a little bit about that? Did you carry on with a postgraduate degree?
	2. What about your school of architecture? Was there a general trend in the architectural education? What was the focus? How were students encouraged to observe architecture in general and how did that reflect on their work?	2. On which area(s) was most emphasis placed during your undergraduate schooling? Was there a specific aspect where most emphasis was placed?
	3. Do you think that this sort of emphasis has shaped your personal understanding of the discipline? How have you carried it forward in your work and your career?	3. Do you think that this sort of emphasis has shaped your personal understanding of the discipline? How have you carried it forward in your work and your career?
THEME 2; WORKING PRACTICES AND PROBLEM-SOLVING; Architects' and BPS specialists' descriptions of their own work, practice and problem-solving techniques.	1. Can you tell me a little bit about your working process? How do you work and what are your main considerations when you work?	1. Can you tell me a little bit about your working process? How do you work and what are your main considerations when you work?
	2. Can you tell me a little bit about how you go about solving a design problem?	2. Can you tell me a little bit about how you go about solving a simulation problem?
	3. How do you work together with the rest of your team? Does the structural organisation of your practice support this?	3. How do you work together with the rest of your team? Does the structural organisation of your practice support this?
	N/A	4. Is there any specific software that you use to carry out simulations? Why this software in particular? Are you aware of any areas where this software could be improved, in your opinion?
THEME 3; EXPERIENCES IN COLLABORATION; Architects' and BPS specialists' experiences in collaboration with each other.	1. Why do you hire a consultant to conduct simulations?	1. Why do you do simulations? What are the main aims of the simulations?
	2. At what stage of the design process do you begin collaborating with specialists for the purpose of simulation to inform your design decision-making?	2. At what stage of the architectural design process do you receive simulation tasks from designers to analyse the performance of their designed buildings? At what stage do you think architects should start considering simulation to inform their design decision-making?
	3. Can you tell me how you think BPS specialists carry out their problem-solving exercises?	3. Can you tell me how you think architects carry out their problem-solving exercises?
	4. At what stage during the design process do you begin to discuss the project with a simulation specialist, for simulation and analysis of performance?	4. At what stage during the design process do architects begin discussing their architectural designs with you, for simulation and analysis of performance?
	5. What methods or means do you usually use when you communicate with BPS specialists? Does communication usually take place through face-to-face meetings? Do you usually use drawings and sketches, for example, rather than numbers and spread-sheets, etc.?	5. What methods or means do you usually use when you communicate with architects? Does communication usually take place through face-to-face meetings? Do you usually use numbers and spread-sheets, graphs, in written form, etc. rather than drawings and sketches, for example?

4.2.3.2 Multiple interviews per participant

The question of how many interviews should be conducted with each participant is disputed amongst qualitative researchers (Knox and Burkard 2009). Single interviews with each participant are most commonly used (DiCicco-Bloom and Crabtree 2006). However, a single meeting with a participant with whom the researcher had had no prior contact was unlikely to bring forth profound biographical accounts of experience, controversial opinions, feelings or attitudes. Without this key information, the objective of interviewing would have been essentially overlooked (Patton 1980).

On the other hand, these ‘in-depth’ elements were exposed by using multiple interviews. Multiple interviews help construct a positive rapport between the two parties. Having met with the researcher more than once, a trustful relationship between the interviewee and interviewer is cultivated; encouraging the interviewee to ‘open up’ more candidly about his or her experiences (Adler and Adler 2002). Deeper participant disclosure is fostered, allowing a more profound construction of the social world than that likely to emerge from single interviews. Multiple interviews also allow the researcher more time to reflect on the data constructed in previous interactions. Early analyses can be conducted between meetings, and the researcher may then re-question elements of the conversation which were not clear, or those worthy of greater elucidation.

Initially, Seidman’s (1991) example of a series of three interviews was followed; attributing an overarching theme[2] to each interview. Hence, the first interview was intended to focus on the participant’s background education and experiences, and the second would address current working procedures and problem-solving techniques. The third interview was intended to address the interviewee’s experiences in collaboration with members of ‘other’ group (i.e. the architect in collaboration with the BPS specialist and the BPS specialist in collaboration with the architect.) A fourth interview was added to allow both the interviewer and interviewee to reflect on the data constructed in the previous three and any impressions which were formulated throughout the process. The decision to conduct four interviews with each participant was revised during the pilot study; which is described in section 4.2.3.3.

[2] These were the themes shown in table 4.1.

4.2.3.3 Pilot interviews

A pilot study was conducted locally to test the interview design; as described in sections 4.2.3.1 and 4.2.3.2. Eight interviews were conducted with two participants; four with each, throughout a two-month period. One of these participants was an architect; the other was a BPS specialist. Both were members of the academic environment in which this research was conducted[3], but both had previous practical experience in the building industry outside the academic field. The interviews were piloted with specific aims of testing the following:

Aim 1: To test the questions designed in the interview guide, and to ensure that they:

- Would elicit the types of responses needed to answer the overarching research question stated in chapter 3; section 3.4.
- Were open-ended enough to steer the conversation, extract detailed accounts of experience and allow the deduction of possible non-technical barriers which may arise in collaboration between architects and BPS specialists.

Aim 2: To test the multiple-interview approach designed; and to ensure that the number of interviews chosen in the initial design was suitable.

Aim 3: To practice and test the researcher's interviewing techniques, as the researcher did not have prior experience in interviewing[4].

The first aim of the pilot study was fully-satisfied. Questions designed in the interview guide were successful in eliciting the types of responses needed to answer the research question; and were open-ended enough to allow novel insights to emerge.

A positive outcome was also retrieved from the multiple-interviews approach (aim 2); particularly in allowing a trustful relationship to grow between both parties of the interview. However, conducting four interviews per participant was too repetitive and time-consuming. While cost did not feature too highly at the pilot stage[5]; it was evident that interviewing each participant four times was going to be cost-intensive. It was therefore decided that the multiple-interviewing approach would be condensed to just

[3] The Welsh School of Architecture (WSA), Cardiff University.

[4] The pilot interview stage was considered a 'practice run' during which the researcher could identify her own strengths and weaknesses in interviewing technique.

[5] Interviews were conducted locally so the researcher did not need to travel to meet participants.

two interviews. Interview 1 would address themes 1 and 2; **participants' background education and experiences,** and **current working procedures and problem-solving techniques.** Interview 2 would address the third theme; **the interviewee's relationship with members of the 'other' group.** An opportunity would also be provided at the end of interview 2 to reflect on impressions gained throughout the interviewing process, or to re-question aspects which remained elusive.

The pilot stage was a useful opportunity to train the researcher in interviewing techniques. One of the particular weaknesses noted was that she had a tendency to interrupt the interviewees in the middle of their speech; therefore disturbing their chain of thought and jeopardizing both the content and quality of data-constructed. A conscious effort was made to control this weakness in consequent interviews.

In summary, the pilot study interviews yielded a positive outcome. Data constructed at this stage was information-rich. Although weaknesses were encountered, they had minimal effect on the content of produced data. Because of this positive outcome, the data generated from the pilot interviews were included in the qualitative thematic content analysis (chapter 5).

4.2.4 SAMPLING AND RECRUITMENT

A combination of purposive and snowball sampling was used to recruit participants from England and Wales into the study; but these were conducted under the rationale of theoretical sampling and theoretical saturation. Theoretical sampling entails the recruitment of more participants into the study until the data-set becomes 'saturated' with information on all topics of discussion; and new participants are no longer able to offer novel insights (Strauss and Corbin 1990 and 1998; Lincoln and Guba 1985). In theoretical sampling therefore; the aim is to generate theoretically-saturated thematic categories from a small sample-size; rather than seeking a large sample size representative of the population (Bowen 2008). Appropriateness of the sample is based upon participants' abilities to contribute to the research topic (Bowen 2008). To diversify the insights constructed during the interviews to the largest possible extent, architects and BPS specialists who were recruited originated from different world regions and had varying years of experience in the building industry; as documented in table 4.2.

4.2.4.1 Early purposive sampling to recruit architects

Architects were purposively sampled from the RIBA Directory of UK Chartered Practices (RIBA 2011a). The search was limited to architects employed in practices in England and Wales **which explicitly mentioned using BPS on their practice websites[6].** This criterion was intended to limit recruitment to architects working in practices where BPS was used, to ensure that recruited architects did have some experience using BPS, or that they had presumably had experience in collaborating with BPS specialists.

Surprisingly, explicit mention of BPS featured sparsely on practice websites. Many architectural practices attached a ‘sustainability’ label to their name and included commitment to ‘sustainability’ within their practice-ethos. However, only twenty-three practices were explicit in their mentioned use of BPS on their practice websites. Emails were sent to them all; describing the research project and asking whether any of the in-house architects would be interested in being interviewed for this purpose. In summary, sixteen interviews were conducted with eight purposively-sampled architects who had experience collaborating with BPS specialists in practical projects.

4.2.4.2 Snowball sampling to recruit BPS specialists

To gain an unbiased and well-rounded understanding of non-technical barriers in collaboration, it was equally important to consider opinions and experiences of BPS specialists who collaborate with architects. Eight BPS specialists were recruited into this interviewing stage of the research using snowball sampling; their contact details were provided by architects who had been interviewed earlier. The same number of architects and BPS specialists were interviewed; to ensure that the data-sets were not biased in favour of either architects’ or BPS specialists’ opinions. Each BPS specialist was interviewed twice; therefore sixteen interviews were conducted with BPS specialists. While the same interview guide used for the architects was also used here (see table 4.1), **key insights gathered from the architects’ interviews were also posed directly at BPS specialists to allow the researcher to gain the ‘alternate’ perspective; wherever applicable.** Therefore, thirty-two interviews were conducted with sixteen participants in total (table 4.2).

[6] Although practice websites were used to recruit participants into the study, opinions mentioned by these participants were not taken to represent the views of the practice at which they were employed. Rather, they were recognised to represent the view of the participant him/herself.

Table 4.2. Documenting details of architects and BPS specialists interviewed during this qualitative research stage.

NAME[7]	PROFESSION	GENDER[8]	BASED IN	WORLD REGION OF ORIGIN	APPROX. YEARS OF EXPERIENCE
A1-pilot	Architect	Male	Wales	UK	30+
A2	Architect	Male	England	UK	15-20
A3	Architect	Male	England	UK	25-30
A4	Architect	Male	England	Continental Europe	15-20
A5	Architect	Male	Wales	Australasia	10-15
A6	Architect	Male	England	UK	15-20
A7	Architect	Male	England	UK	5-10
A8	Architect	Male	England	Continental Europe	5-10
S1-pilot	BPS specialist	Male	Wales	Continental Europe	5-10
S2	BPS specialist	Male	England	Indian Sub-Continent	5-10
S3	BPS specialist	Male	Wales	UK	10-15
S4	BPS specialist	Male	England	West Africa	10-15
S5	BPS specialist	Male	England	UK	10-15
S6	BPS specialist	Male	Wales	UK	15-20
S7	BPS specialist	Male	England	Continental Europe	10-15
S8	BPS specialist	Male	England	UK	5-10

[7] Pseudonyms are used instead of the interviewees' real names to safeguard data confidentiality and anonymity, as ensured in the consent forms signed by each of the interviewees. Ethical research practices followed in this qualitative research stage are discussed in section 4.2.5.

[8] Male dominance in the sample of architects and BPS specialists was not intended. However, only male participants responded to the emails requesting participation, and were willing to be recruited into this qualitative stage of the study.

4.2.5 ETHICAL CONSIDERATIONS

Measures were taken to ensure that the interviews were conducted ethically. Interviewees were provided with an information sheet inviting them to participate in the research. This gave full details of the project including aims, dimensions of their participation, interview-duration, data-storage, access to the data and results' dissemination. Names and full contact details of the research team[9] were also provided.

Interviewees' fully-informed consent was sought through a consent form. Here they were informed that their participation was entirely voluntary and that they could withdraw at any time without giving reason. It was also explained that data would become both confidential and anonymous upon collection, so that the information constructed was no longer traceable back to their individual person. These measures were approved by the Research Ethics Committee of the Welsh School of Architecture in September 2010; under the reference of EC1009.045[10].

4.2.6 EXECUTION OF THE INTERVIEWS

The interview guide described in section 4.2.3.1 was used as a starting point for the interviews, using open-ended questions **to provide initial prompts for further, unplanned topics of discussion.** Participants were invited to discuss all topics which they saw fit to the overarching theme of discussion; and to produce elaborate accounts of their own experiences of collaborating with architects or BPS specialists; for BPS to better inform design decisions. **Giving room for lengthy discussions and narrative accounts meant that the responses represented the uninterrupted, unbounded thoughts and perceptions of the individual; using phrases, vocabularies which they saw fit to convey the chosen message.**

To encourage conversation and dissuade short, abrupt answers, all interviewees were ensured from the beginning that there was no 'correct' answer. It was explicitly stated at the start of each interview that the interviewer was primarily interested in interviewees' own personal experiences in the building industry. Interviewees were also ensured that their opinions would not be interpreted as representative of the practice at which they were employed; potentially allowing greater freedom of expression. Each interview was

[9] The researcher and supervisory team.

[10] Samples of the information sheet and consent form are shown in Appendix A. Approval of the Welsh School of Architecture Research Ethics Committee is also shown in Appendix A.

conducted on a one-to-one basis and in private; therefore opinions were untarnished by group pressures or colleagues' contradictory viewpoints.

4.2.6.1 Interview duration, recording and transcription

Each interview lasted between fifty and ninety minutes, and was fully audio-recorded and transcribed verbatim by the researcher. Approximately 40 hours of audio-recorded interview material were produced in total during this empirical stage. Field notes were also written up in full after completion of each interview.

Transcription is essentially an additional process of data-construction by the transcriptionist; rather than an objective recording of what was said during the interviews (Hammersley 2010). Because the researcher conducted the interviews, transcribed and analysed them, less information was fragmented in the transitions between these activities. Nevertheless, it is necessary to highlight key decisions pertaining to transcription techniques used; as these are not homogeneous across all research traditions[11].

In this research, all data constructed was treated as equally important and thus all interviews were transcribed in full. Therefore the data were fully-preserved to the largest possible extent and were available throughout the duration of the entire research project for repeated analysis. Verbatim transcriptions of all spoken words were made via standard orthography. Descriptions were used to signify non-verbal vocal expressions such as laughter, and physical gestures, rather than transcription systems traditionally employed by linguists which indicate phonetics temporal sequences of utterances, intonations, etc. (e.g. Jefferson 2004 or Silverman 2006). This is because the former tend to be less complex and therefore easier to follow in later analytical stages. These procedures of verbatim transcriptions yielded 953 pages of text[12] and a corpus of over 350,000 words.

4.2.6.2 Influence of interview context on data constructed

Interviewees were invited to decide on a suitable location for interviews to be conducted. Most preferred to use meeting rooms of practices at which they were

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[11] Transcription techniques used in sociolinguistics and conversation analysis, for example, tend use both standard orthography and phonetic symbols; making these transcripts much more detailed than those produced by other qualitative researchers.

[12] Samples of the interview transcripts are provided in Appendices B and C.

employed. Dayman and Holloway (2010) contend that interviews conducted in participants' 'own' contexts are beneficial as participants may feel more relaxed, which is likely to impact on the quality and depth of data constructed. Only four interviews took place at coffee shops; at the participants' preference.

In few instances, the physical setting of the interview influenced the course of conversation. For example, one architect chose to be interviewed at the Royal Institute of British Architects (RIBA) headquarters in London. Throughout the interview, he repeatedly resorted to examples from the surroundings to inform his speech. Thus when prompted to talk about stereotypical images of architects and BPS specialists, he pointed to a lady saying,

"You only have to look at the stereotypical architect...you just have to go into the [book-] *shop over there and... she came out looking pretty cool. Do you know what I mean? If you went into the CIBSE, for example, you'd get a different type of people.*[13] *"*

4.2.7 EXPERIENCED ADVANTAGES AND LIMITATIONS

The following advantages of semi-structured interviewing were noted throughout the interviews:

- **A first-hand insight into human thought, decision-making and behaviour was provided:** Human thought and opinion; arguably driving factors behind collaboration and decision-making in the architectural design process; could be plausibly captured by simply ***talking*** to participants.

- **Participant enjoyment and empowerment:** Participants reported that they enjoyed reflecting on their career trajectories. Most participants informed the researcher that they do not often have time to reflect on their own experiences in their day-to-day life. Off-tape, all participants interviewed were curious as to what other interviewees had to say about common themes explored. This curiosity was considered an indicator of both interest and enjoyment.

  Participation in these interviews was also an empowering opportunity for the interviewees; allowing them to actively contribute to the research agenda. Interviewee empowerment is reported in Vahasantanen and Saarinen (2012) to

[13] Deeper discussion of architects' and BPS specialists' stereotypes is analysed in chapter 5 and chapter 7.

impact on the nature and quality of data constructed; as empowered interviewees steer the interview in the direction of their choosing. In this research; it became evident that as power dynamics were shifted towards the interviewee; more elaborate accounts of experiences were produced; and interviewees voiced their opinions with less restraint.

- **Multi-vocality:** Interviewing multiple participants about the same topic allowed different perspectives to be obtained. Multi-vocality allowed the researcher to determine whether opinions, experiences and understandings were shared amongst multiple participants or whether there are notable divergences between them.

A number of limitations were also experienced:

- **The Hawthorne Effect:** This is when interviewees alter their speech, in reaction to being closely observed and recorded (Wickström and Bendix 2000). This was experienced repeatedly throughout the interviews. Upon switching the audio-recording off at the end of the interview; the setting was entirely transformed from a formal one; where participants felt obliged to provide what they perceived to be ‘correct’ answers; to a less constrained and more casual discussion where participants could speak freely. Often, more interesting information and deeper reflections were constructed off-tape; in the few minutes following the interview than during the audio-recorded interview. In these situations, notes were promptly written in absence of the interviewee; to accurately reformulate details of the discussion in those few minutes. However, these data could not be as accurately transcribed as the audio-recorded interview.

- **Resource-intensive:** Interviewing placed heavy stresses on available resources. Travelling to meet participants was both expensive and time-consuming. Verbatim transcription was also a time-consuming exercise. Thus; interviewing and transcription spanned a total duration of eighteen months[14].

[14] During this period, other research activities were simultaneously undertaken, including analysis, questionnaire design and quantitative data-collection which are all discussed in the forthcoming chapters.

- **Reliance on the interviewer's skills:** Despite having been previously informed how the interviews were going to be undertaken[15]; most participants entered the interview setting with a *'what do you want to know?'* attitude; expecting a rigid and rapid question-and-answer session. It was up to the interviewer to manoeuvre the conversational track from an expected closed-ended question-and-answer session to an open-ended conversational interaction. This was mainly by constantly conveying interest in the participants' speech; using both verbal cues (e.g. repeating *'yes,' 'mm'* or *'uh-huh'*) and non-verbal cues (nodding, maintaining eye contact and smiling) throughout. However, when the researcher's attention was seemingly diverted, for example to take notes, the interviewees would become self-conscious and often discontinue their speech.

4.3 DATA ANALYSIS

Interviewing is known to result in the rapid generation of large, cumbersome amounts of data; albeit very rich in nature (Bryman 2001). However, approaches to qualitative analysis are seldom prescriptive in nature (Flick 1998; Bryman 2001). Bryman and Burgess (1994) instead argue that a procedural step-by-step set of rules guiding the analysis is undesirable in qualitative tradition.

It was therefore up to the researcher to decide upon the analytical path which would allow filtration of the large amounts of interview data. Qualitative thematic content analysis was chosen to explore what the interviewees had to say; with respect to their own professions and collaboration for BPS; i.e. the content of the interviews (section 4.3.1).

4.3.1 EXTRACTION OF THEMES; QUALITATIVE THEMATIC CONTENT ANALYSIS

Qualitative thematic content analysis is defined as a *"qualitative data-reduction and sense-making effort that takes a volume of qualitative material and attempts to identify core consistencies and meanings"* (Patton 2002). Bryman (2001) states that *"the processes through which the themes are extracted* [in qualitative content analysis] *are often (if not invariably) left implicit."* Granheim and Lundman (2004) outline that different procedures are often used by different researchers for qualitative thematic

[15] This information was provided in the information sheet and consent form described in section 4.2.5; shown in Appendix A.

content analysis; guided by the specific aims and questions of the research problem. The procedure employed in this research was guided by the overarching aim of **extrapolating underlying themes which could be interpreted as non-technical barriers in collaboration between architects and BPS specialists.** This procedure is depicted in figure 4.2, and is described in the subsequent paragraphs.

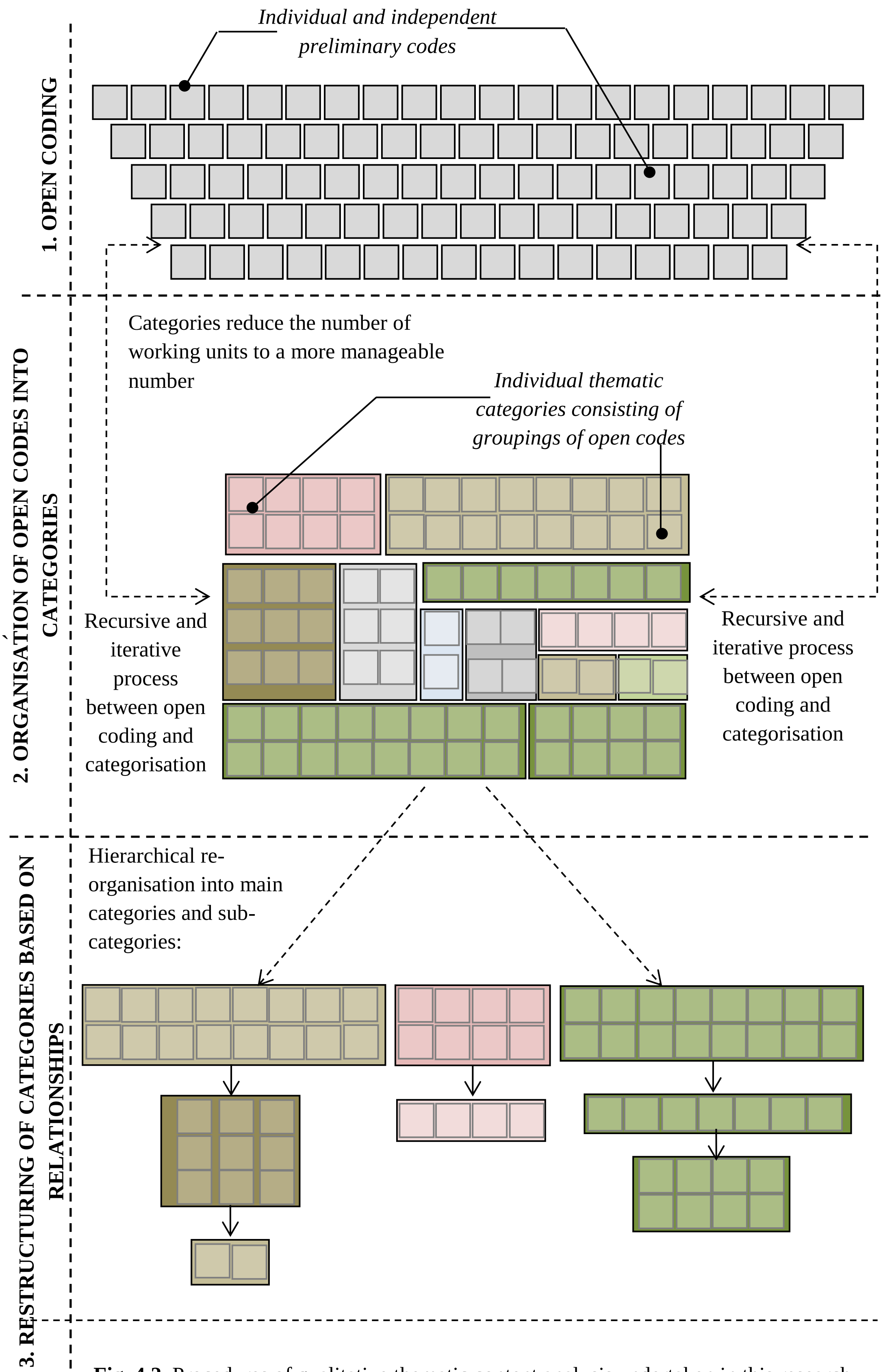

Fig. 4.2. Procedures of qualitative thematic content analysis undertaken in this research.

To gain familiarity with the interview transcripts, the first step of the analysis was to review each transcript from beginning to end. The first four transcripts were open-coded by highlighting sentences, phrases and individual words which captured a possible non-technical barrier; reducing the potential for BPS to inform architects' decisions. Simplistic notes in the margins of interview transcripts were used to document analytical impressions. Abstract labels were also assigned to each of these preliminary codes; which were also noted in transcription margins. These open codes were subsequently sorted into categories depending on correspondences and inter-relationships.

Four transcripts were coded at a time using the same procedure. Upon completion of open-coding of every four transcripts, these were sorted into their relevant categories. At this point, categories coded from the previous four transcripts were revised and re-organised in alignment with newly emergent codes and categories. **Thus the process of open-coding and categorising was a recursive and iterative one; occurring at varying levels of analytical depth.** This iterative process gave the researcher an opportunity to reflect on previously defined and labelled codes. New categories were added when emergent codes did not fit pre-ascertained categories. Alternatively, some categories were altogether removed and others were re-labelled.

Once all open-coding and initial categorisation had been completed, the data within each category were re-examined. A re-working and re-structuring of the categories was necessitated based on internal relationships between them. Therefore, some categories were further grouped into larger thematic clusters around which other categories could be arranged. Alternatively, some categories were split into sub-categories and ascribed as subordinate to larger clusters. At the end of this analytical procedure, a total of three main thematic categories were extracted from the interview data followed by up to four levels of sub-categories. These are tabulated in table 4.3; and all discussed at depth throughout chapter 5.

Table 4.3. Main thematic categories and sub-categories extracted from the interview data.

MAIN THEMATIC CATEGORY	SUB-CATEGORIES LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	INFERENCES
HISTORICAL CONTEXT (section 5.2).	Systemic thinking and the explosion of creativity (section 5.2.1).	The Modern movement (section 5.2.1.1).			
		The Post-Modern movement (section 5.2.1.2).			
	Resource constraints and the rise of sustainability; and introduction of BPS into the architectural discipline (section 5.2.2).	Changing composition of design teams; the need for BPS specialists (section 5.2.2.1).			Inferences about changing compositions of design teams (section 5.2.2.4).
		Elder architects' resistance to change (section 5.2.2.2).			
		Overlaps, disputes and rivalry (section 5.2.2.3).			
ARCHITECTURAL EDUCATION AND IDEOLOGY (section 5.3).	Handling contradictions (section 5.3.1).	Art versus science in architectural design (section 5.3.1.1).	(i)Misinterpretation of architecture as art.		Inferences about art and science in architectural design (section 5.3.1.2).
			(ii) Meaning of art to architects.		
			(iii) Science and design; the legacy of modernism.		
		Creativity versus constraints (section 5.3.1.3).	(i) Handling constraints.		Inferences about creativity versus constraints (section 5.3.1.4).
			(ii) Challenging constraints and shaping the architects' identity.		
			(iii) BPS specialists and constraints.		
	Personality traits (section 5.3.2).	Architects' ignorance and lack of interest in BPS (section 5.3.2.1).	(i) Ignorance or lack of interest?		Inferences about impacts of architects' ignorance and lack of interest on collaboration (section 5.3.2.2).
			(ii) Ignorance or lack of accuracy?		
			(iii) Knowledge, interest and age.		
			(iv) Architects' knowledge jeopardises the role of the BPS specialist.		
		Architects' arrogance (section 5.3.2.3).	(i) Arrogance as a consequence of historical tradition.		Inferences about the direct impacts of architects' arrogance on collaboration (section 5.3.2.4).
			(ii) Arrogance reinforced through education and professional enculturation.		
			(iii) Creative professionals need to be arrogant.		
			(iv) Arrogance at the service of power.		
			(v) Arrogance as compensation for the erosion of status.		
NON-TECHNICAL BARRIERS IN COLLABORATION (section 5.4).	Negative attitudes toward BPS and stereotyping (section 5.4.1).	Negative attitudes toward BPS (section 5.4.1.1).			Inferences about the impacts of negative attitudes and stereotypes (section 5.4.1.3).
		Stereotyping (section 5.4.1.2).			
	Industry-related barriers (section 5.4.2).	The building project as a commercial exercise (section 5.4.2.1).	(i) Clients discouraging early collaboration		Inferences about the building project as a commercial exercise (section 5.4.2.2).
			(ii) Different goals of collaborating team members and opportunism.		
		Perceptions of the purpose of BPS (section 5.4.2.3).	(i) Architects' negative attitudes toward Part L and compliance.	The divide between 'compliance' tools and 'design' tools.	Inferences about architects' perceptions of the purpose of BPS (section 5.4.2.4).
				Impact of this divide on BPS professionals.	
	Trust dynamics and communication (section 5.4.3).	Trust dynamics (section 5.4.3.1).	(i) BPS specialists' trust in architects.		Inferences about trust and communication (section 5.4.3.3).
			(ii) Architects' trust in BPS specialists.		
		Communication (section 5.4.3.2).	(i) Different worldviews, languages and ambiguities.		

4.4 SUMMARY OF QUALITATIVE INSTRUMENTS

The overarching aim of this thesis is to extract and explore non-technical barriers arising in collaboration between architects and BPS specialists. The possibility that non-technical barriers could be reducing the potential for BPS to inform architects' decision-making in the design process was hypothesised in chapter 3; as an addition to the pervading assumption that barriers hindering BPS integration lie solely in limitations in existing BPS software; as reviewed in chapter 2.

Adopting a social constructionist stance allowed this possibility to be tested. By employing qualitative instruments described in this chapter, potential non-technical barriers could be extracted, explored and discussed in depth. Instruments used in this qualitative section of the research were semi-structured interviews for data-collection; and qualitative thematic content analysis for data-interpretation.

Although data-collection and analysis were described sequentially and in separate sections[16] of the chapter, this divide has been created for organisational purposes only. However, in carrying out the methods, such a definitive, clear-cut divide between these two types of activities did not exist. Processes of data-collection, interpretation and analysis were strongly interwoven. They occurred almost simultaneously and in-tandem from the moment the researcher became immersed in the field. The earliest arrivals of data were immediately subjected to a cyclical loop of questioning, critical thinking, interpretation and re-interpretation. Subsequent episodes of data-collection fed into this cyclical loop; also informed by critical thinking and causing revision of previous interpretations. Inferences formed based on this qualitative interpretation and analyses are presented in chapter 5.

[16] Data-collection through semi-structured interviews was discussed in section 4.2 and procedures of analyses were presented in section 4.3.

5. EXTRACTING NON-TECHNICAL BARRIERS

"Three reasons problems are inevitable; first, we live in a world of growing complexity and diversity; second, we interact with people; and third, we cannot control all the situation[s] *we face."* – John C. Maxwell; American Leadership expert.

5.1 INTRODUCTION

In this chapter, thematic categories extracted using the qualitative thematic content analysis[1] are presented and discussed. Three main thematic categories were extracted;

Thematic category 1: Historical context (section 5.2)

Thematic category 2: Architectural education and ideology (section 5.3)

Thematic category 3: Non-technical barriers in collaboration (section 5.4).

Each of these consisted of a series of sub-categories; which are deliberated in the relevant subordinate sub-sections. It is important to note that the categories and sub-categories extracted from architects' and BPS specialists' interviews are **not** presented in isolation; as two opposing 'sides.' Instead, they are gathered from members of **both** professions, as experiences and opinions voiced by both 'sides' often overlapped. Occasionally, architects and BPS specialists would provide two different sides of a story to form a cohesive whole. Thus, the reader will find that the discussion is supplemented with quotes from **both** sets of professionals (all of them in italics); in support of most sub-categories.

After the discussion of each sub-category, inferences predicting its' potential impacts on the collaborative relationship and the use of BPS to inform architectural design decision-making are made. It is important to note that, while a large number of sub-categories are discussed in this chapter, these represent the researcher's **own subjective interpretations of social phenomena.** None are intended as generalizations; rather they provide an insightful in-depth understanding of non-technical barriers which arise during collaboration. However, to conclude this qualitative stage of the research, inferences made qualitatively and quotations from the interviewees were used to design a set of statements; as shown in section 5.5. These statements are then used in the

[1] This analytical instrument was described in chapter 4, section 4.3.1.

forthcoming quantitative research stage to confirm the existence of non-technical barriers extracted qualitatively in England and Wales.

Frequent references to the literature are made throughout this chapter; to satisfy either one or both the following objectives;

- To support a sub-category, or to highlight contrasts between a sub-category and opposing results or insights in the literature.
- Theories from fields such as sociology and cognitive sciences are used as references to substantiate several sub-categories and to explain how these could hinder BPS integration.

A number of thematic sub-categories and qualitative inferences discussed in the body of this chapter have not previously been explored in BPS research. If they are confirmed quantitatively in the subsequent empirical section; these may constitute what may be, to the best of the researcher's knowledge at the time of writing, **novel contributions to the body of knowledge.** These potential additions to knowledge are highlighted in the body of this chapter as and when they appear.

5.2 HISTORICAL CONTEXT

Under this main thematic category, two levels of sub-categories are discussed, as shown in table 5.1. To fully understand the significance of non-technical barriers reducing the potential for BPS to inform decision-making elicited in this chapter; it is prerequisite to highlight the background context from which these barriers depart.

Table 5.1. Highlighting sub-categories of the main thematic category entitled ‘Historical context;’ discussed in this section of the chapter.

MAIN THEMATIC CATEGORY	SUB-CATEGORIES				INFERENCES
	LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	
HISTORICAL CONTEXT (section 5.2).	Systemic thinking and the explosion of creativity (section 5.2.1).	The Modern movement (section 5.2.1.1).			
		The Post-Modern movement (section 5.2.1.2).			
	Resource constraints and the rise of sustainability; and introduction of BPS into the architectural discipline (section 5.2.2).	Changing composition of design teams; the need for BPS specialists (section 5.2.2.1).			Inferences about changing compositions of design teams (section 5.2.2.4).
		Elder architects’ resistance to change (section 5.2.2.2).			
		Overlaps, disputes and rivalry (section 5.2.2.3).			
ARCHITECTURAL EDUCATION AND IDEOLOGY (section 5.3).	Handling contradictions (section 5.3.1).	Art versus science in architectural design (section 5.3.1.1).	(i)Misinterpretation of architecture as art.		Inferences about art and science in architectural design (section 5.3.1.2).
			(ii) Meaning of art to architects.		
			(iii) Science and design; the legacy of modernism.		
		Creativity versus constraints (section 5.3.1.3).	(i) Handling constraints.		Inferences about creativity versus constraints (section 5.3.1.4).
			(ii) Challenging constraints and shaping the architects’ identity.		
			(iii) BPS specialists and constraints.		
	Personality traits (section 5.3.2).	Architects’ ignorance and lack of interest in BPS (section 5.3.2.1).	(i) Ignorance or lack of interest?		Inferences about impacts of architects’ ignorance and lack of interest on collaboration (section 5.3.2.2).
			(ii) Ignorance or lack of accuracy?		
			(iii) Knowledge, interest and age.		
			(iv) Architects’ knowledge jeopardises the role of the BPS specialist.		
		Architects’ arrogance (section 5.3.2.3).	(i) Arrogance as a consequence of historical tradition.		Inferences about the direct impacts of architects’ arrogance on collaboration (section 5.3.2.4).
			(ii) Arrogance reinforced through education and professional enculturation.		
			(iii) Creative professionals need to be arrogant.		
			(iv) Arrogance at the service of power.		
			(v) Arrogance as compensation for the erosion of status.		
NON-TECHNICAL BARRIERS IN COLLABORATION (section 5.4).	Negative attitudes toward BPS and stereotyping (section 5.4.1).	Negative attitudes toward BPS (section 5.4.1.1).			Inferences about the impacts of negative attitudes and stereotypes (section 5.4.1.3).
		Stereotyping (section 5.4.1.2).			
	Industry-related barriers (section 5.4.2).	The building project as a commercial exercise (section 5.4.2.1).	(i) Clients imposing restraints to BPS integration.		Inferences about the building project as a commercial exercise (section 5.4.2.2).
			(ii) Different goals of collaborating team members and opportunism.		
		Perceptions of the purpose of BPS (section 5.4.2.3).	(i) Architects’ negative attitudes toward Part L and compliance.	The divide between ‘compliance’ tools and ‘design’ tools.	Inferences about architects’ perceptions of the purpose of BPS (section 5.4.2.4).
				Impact of this divide on BPS professionals.	
	Trust dynamics and communication (section 5.4.3).	Trust dynamics (section 5.4.3.1).	(i) BPS specialists’ trust in architects.		Inferences about trust and communication (section 5.4.3.3).
			(ii) Architects’ trust in BPS specialists.		
		Communication (section 5.4.3.2).	(i) Different worldviews, languages and ambiguities.		

This background and context are composed of consecutive architectural movements; from introduction of systemic thinking in architecture during the Modern movement, the counter-active Post-Modern movement and the rise of sustainability; at which the need for BPS technologies arises. These architectural movements and world events are illustrated in the timeline in figure 5.1. The Second World War and the Oil Crisis are also indicated as notable world events which introduced unprecedented changes in design-thinking.

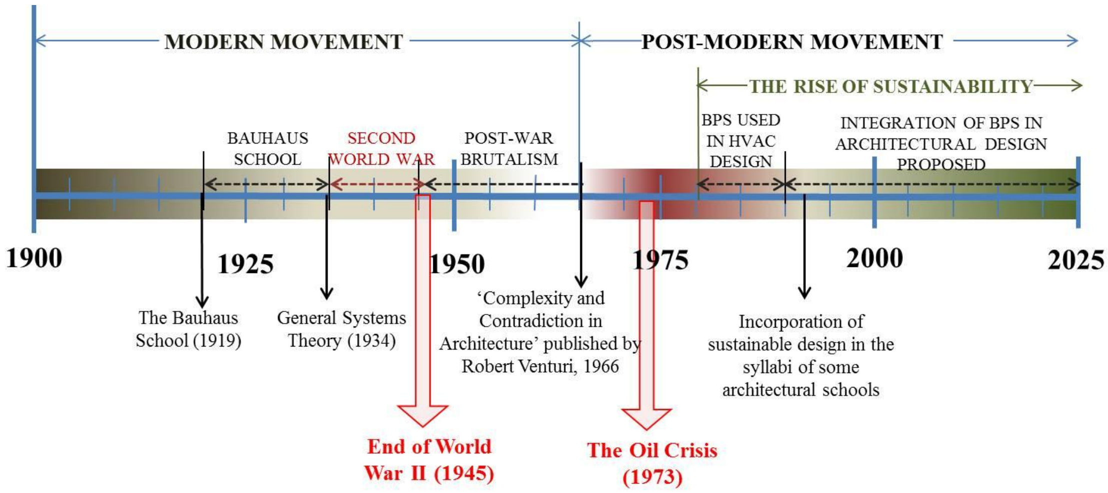

Fig. 5.1. Timeline of architectural movements.

5.2.1 SYSTEMIC THINKING AND THE EXPLOSION OF CREATIVITY

Conceptualisation of General Systems Theory in the 1930s (Von Bertalanffy 1968) and adoption of systemic-friendly ideas in the architectural discipline which followed was a catalyst for an evolutionary shift in design-thinking over the next century.

5.2.1.1 The Modern movement

Buckminster Fuller regarded systemic thinking as *"one of the modern tools of high intellectual advantage;"* because by *"employing it, we begin to think of the largest and most comprehensive systems and try to do so scientifically"* (Fuller 1968). By employing this 'intellectual tool,' engineers recognised buildings as sophisticated networks of systems and inter-related information flows. Systemic-thinking consequently facilitated the transformation of buildings from heavy monolithic constructions to an assemblage of pre-engineered and pre-configured constituent 'parts;' put together to form a synergetic whole. Mass production of these pre-fabricated components through modern industrial technologies lead to an ensuing series of dynamically-constructed, wide-spanning and lightweight structures to be realised throughout the Modern architectural movement.

Systemic-thinking friendly ideas were particularly embraced by the Bauhaus school during the Modern Movement; as they provided practical affirmation of the Bauhaus foundational concept that *"function* [is] *the foundation of design, and industrial standardisation* [is] *the basis of construction"* (Bachman 2003). Thus, technically-oriented systemic solutions stripped buildings of ornamentation; and creativity became associated with industrial processes and was expressed by visible constructional vocabularies.

This purely-functional and industrial character was further exploited following the Second World War. Widespread devastation necessitated the adoption of systemic-friendly ideas to recover some of the damage; including rapid construction, mass production and use of prefabricated materials. Brutalism not only legitimatised the systems-friendly ideas of the Bauhaus; it ennobled the ensuing industrial character of buildings constructed during the 1940s and 50s (Bachman 2003).

5.2.1.2 <u>The Post-Modern movement</u>

In the Post-Modern movement, however, this industrial and highly-functional character of buildings was rejected; *"architects can no longer be intimidated by the* ***puritanically moral language*** *of orthodox modern architecture"* (Venturi 1977). Systemic thinking was subjugated to the establishment of systems and networks required for the building to 'work;' and technology and functionality were no longer seen as starting points for design-conception.

The Post-Modernists proposed to counter-act the *"puritanically moral language of orthodox modern architecture"* (Venturi 1977); by adopting a philosophical discourse which served as the basis for conceptual thinking. This discourse implied that **designs were motivated by an enlightened ethos of novelty and creativity rather than a functional one impoverished of originality.** Venturi (1977) argued for *"an architecture of complexity and contradiction;"* advocating creativity and aesthetic superiority over functionality and technicality. He metaphorically encouraged architects to employ the philosophical discourse which echoed the 'complexity and contradiction' of their design aspirations;

“There are better reasons than that of rhetorical vainglory that have induced poet after poet to choose ambiguity and paradox rather than plain discursive simplicity. It is not enough for the poet to analyse his experience as the scientist does, breaking it up into parts, distinguishing part from part, classifying the various parts […] ***if the poet must perforce dramatize the oneness of experience*** […] ***then his use of paradox and ambiguity is necessary.”***

Inspired by this desire to *“dramatize the oneness of experience”* moulded by the designs they created a profound, philosophical and emotive discourse was adopted by architects of the Post-Modern era. An unparalleled *“explosion of creativity;”* as described by participant A7, ensued and a belief that the architect *“could do anything;”* was mirrored in the discourse. Architects interviewed for the research highlight that; *“everyone* [was] *trying to build an iconic structure”* and *“a lot of effort”* was driven into *“trying to make something stand out.”*

The Post-Modernist discourse was further propagated by paradigms of architectural education. This is evidenced in participant A2’s metaphoric description of his own architectural training, in which he delineates philosophical conceptualism as *“the holy grail that was dangled out there as something to aspire to.”*

5.2.2 RESOURCE CONSTRAINTS; THE RISE OF SUSTAINABILITY AND INTRODUCTION OF BPS INTO THE ARCHITECTURAL DISCIPLINE

In alignment with complex internal space relationships designed during this Post-Modernist *“explosion of creativity”* a need to resolve complex mechanical and technical requirements to service these spaces arose. These requirements pertained to HVAC (heating, ventilation and air-conditioning), electrical design, wiring and plumbing; all systemic networks within the building design. Until the 1970s integration of mechanical systems in building design had seemed relatively unproblematic. Mechanical space cooling had already been widespread since the 1950s (Bachman 2003). Thus by the 1970s, heavy HVAC installations were commonplace, and so long as energy was considered inexpensive and the environmental impacts of energy-consumption unclear; this type of solution was seen as both feasible and obvious.

However, the oil crisis of the 1970s placed a sudden limit on previously unwarranted freedoms; as buildings alone were deemed responsible for over 50% of the world’s greenhouse gas emissions. Suddenly, energy became a commodity. By the 1990s and the early part of the 21st Century, international directives encouraging energy-conscious design had been introduced; such as the Energy Performance of Buildings Directive in Europe (EPBD 2003). In developed nations, these directives gave way to the enforcement of stringent building regulations focusing particularly on energy consumption; in an attempt to reduce buildings' dependence on finite natural resources.

In parallel to these developments; and following initial successes in lighting design, airflow and HVAC systems design in the 1980s, the benefits of simulation software were proposed to assist in architectural decision-making. BPS software has since paved the way towards stringent numerical indicators to quantify building energy performance before construction. Although use of BPS is today encouraged in architectural design; it is not as widely implemented as aspired; as reviewed in chapter 2.

5.2.2.1 Changing composition of design teams; the need for BPS specialists

The increasing requirement of BPS uptake in architectural design has since had a profound effect on the composition of architectural design teams. Until recently, design decisions would have been made by architects trained under the traditional guild system. Multi-disciplinarity did not transcend boundaries of architectural decision-making. So, for example, although architects routinely collaborated with structural engineers; through years of formalised knowledge and training; structural problem-solving had already become a design feat. This allowed for structural engineers to be appointed only once most architectural decisions were resolved.

However, collaboration with BPS specialists could not be simply postponed until later in the decision-making process due to the intricate nature of thermodynamic problems. Unlike structural problem-solving, which is a static response to a constant gravitational pull, energy calculations respond to various dynamic forces. These fluctuate at varying degrees throughout different times of the season, month, day and even on an hourly basis. Dynamic fluctuations are intimately associated with architectural decisions such as building form, orientation, envelope and internal spatial layout. Moreover, varying yet inter-related and concurrent demands of different performance fields such as solar, lighting and thermal (heating and/or cooling) increase the complexity of environmental control (Bachman 2003).

Finally, in structural design, solutions are almost always sized to withstand maximum peak structural loads; and over-sizing the structural systems will bear near-negligible impacts on the natural environment. However, over-sizing mechanical systems to ensure satisfactory comfort conditions will invariably have severe environmental impacts. Alternatively, under-sizing or completely excluding mechanical servicing components from the building will undoubtedly lead to unbearable comfort conditions in many climates. The complexity of this situation and the need to optimise between thermodynamic forces incurs an **early reliance on collaborations with technical specialists who have an understanding of building physics.**

5.2.2.2 Elder architects' resistance to change

Today's generation of architects, who were trained to embrace the Post-Modernist discourse of philosophy and creativity, often experience difficulties accepting core values of energy-efficient architectural design. The technological aspect entrenched in the culture of energy-efficiencies, and the inherent objectivity associated does not align with motivations of novelty and creativity in the philosophical Post-Modernist architectural discourse. As participant A7 highlights; *"that's not what architecture is about to* [elder architects]. *That's not why they started doing it. The Fosters and Rogers of the world...they were in it for something else...wasn't for a particularly green agenda."*

In these elders' Post-Modern paradigms of education, the role of technologies was arguably reduced to a secondary position; a necessity needed to make their design idea 'work;' rather than a starting point for design conception. Use of BPS technologies to inform the design concept is therefore *"so different from what they've been used to,"* and the necessity of BPS calculations is often met with reactions of, *"well, that's not architecture, is it?"*

Architectural interviewee A3; who is a practising architect currently close to retirement serves as an example of these elder architects. Throughout the interviews he repeatedly expressed his lack of familiarity with concepts of energy-efficient design because he *"didn't do that much at university in respect of sustainability."* Correspondingly, he described his modest knowledge of BPS as *"a black art...it's like being in the front row of a scrum; in rugby...you know stuff's going on but you don't know what's happening."* He uses his age as justification for his unfamiliarity; *"it's just too late for that to affect* *my architecture ... whereas if I was younger... the whole 'energy thing' would be affecting my architecture."*

Accordingly, it is comprehensible that these elder architects do not easily agree to amend their working procedures, having practised architecture based on the philosophical Post-Modernist discourse for decades; to accommodate for a culture change they do not comprehend. This is observed by participant S5, who says, "*old people ... don't want to change themselves, and the way they are building."* Therefore, encouragements to use BPS as an informant to design decision-making are often met with sceptical and resistive questioning; *"'why do we need to learn these things?'"*

5.2.2.3 <u>Overlaps, disputes and rivalry</u>

The changing landscape of design-teams discussed in section 5.2.2.1 earlier means that the boundaries of architects' and BPS specialists' roles and responsibilities sometimes overlap. It is implied from the interviews that BPS specialists' expertise in thermodynamics and their abilities to use BPS software gives them the opportunity - and sometimes authority - to interfere with what used to be exclusively architectural decisions. Decisions of building orientation, form, spatial layout and fabric composition traditionally rely on architectural judgement. However, today these decisions must be assessed quantifiably according to performance; particularly to comply with stringent building regulations.

Old models of architectural practice; where architects' primary value lies in their intuition, are quickly being overtaken by BPS technologies. Perceived responsibilities of BPS specialists therefore occasionally overlap with architects. This overlap is implied by S2 who states; *"I use DSM* [dynamic simulation modelling] *software, so I sometimes recommend the reflectance of surfaces, right? So* [...] *the thermal modeller is basically suggesting the architect what type of colour you have to choose!* ***Previously the architect was deciding!"***

Correspondingly, the architect of today no longer resides in an undisputable leadership position in the design team. Knowledge and technological prowess are progressively shifting positions of power as the BPS specialist can become bestowed with greater authority than the architect. This gives rise to a rivalry situation between the two; which can further be inferred in the following instances:

– **Value of architectural work is undermined by BPS specialists:** Participant S3 describes a scenario where the value of architectural work was explicitly interrogated and devalued amongst an audience of BPS specialists, by a speaker who belongs to the same profession; *"The architects like to think that they're the ones that create the buildings, but **they're only there to sort of cover over our services...** we design our services and the architects are just there to put a rainproof cover over it* [...] ***that's all you're good for; these architects."*** To confirm that this opinion of architects is not personal to the speaker, he adds; *"I knew it got some resonance from people there;"* indicating that members of the audience agreed with the speaker's opinion.

– **BPS specialists' contributions are undervalued by architects:** Participant S1 feels that architects do not usually value his contributions in design; *"sometimes, the modeller is **just a slave** doing a stupid work* […] *I feel my work is just **required, but not necessary** for them* [architects]*."*

  Equally, architects interviewed attempted to discursively reinstate their statures as project leaders. A3 establishes his role as the 'employer,' in a leadership position; simultaneously placing the BPS specialist in a subservient position; ***"I will employ … or we will employ,** as a practice, a good service engineer to do that* [create a comfortable environment] *for us."* Participant A8 refers to BPS specialists he works with as *"a few* [whom] *we regularly **use."***

This insight aligns with the finding reported in Hamza and Greenwood (2009); that architects' previous leadership positions are being *"slightly eroded."*

5.2.2.4 <u>Inferences about changing compositions of design teams and rivalry</u>

This research finds that one of the reasons BPS is still considered a poor informant to architectural decision-making nowadays is **elder architects' adamant refusal to succumb to evolutionary culture-changes within the building industry.** The rivalry situation which has arisen may reduce the potential of BPS in architectural decision-making due to:

- **Power disputes:** The focus of collaboration is shifted away from the goals of reaching an optimised energy-efficient building design. It is instead diverted towards an assertion of hierarchical positions, leading to tensions and dispute.

- **<u>Dysfunctional relationships:</u>** Power disputes give rise to dysfunctional relationships between members of the two groups; leading to an adamant refusal to abide by the others' recommendations, or change design elements. This is demonstrated by A4; who bluntly states, *"I don't think they* [BPS specialists] *have a very flexible way of working with architects.* ***And I think they probably need to change because we are not going to!"***

This situation poses the following debatable and currently unresolved enquiries:

- Whose position is more powerful in multi-disciplinary collaboration? Is it the architect, whose profession is instilled in age-old traditions? Or is it the BPS specialist, whose professional role has recently evolved as a consequence of technical progression?

- Who should have the final word in decision-making? Is it the architect, who has traditionally been responsible for building design; yet whose judgement is often idealistically based on abstract concepts, intuition and rules of thumb? Or is it the BPS specialist, who is empowered with an ability to objectively quantify the impact of each decision?

5.3 ARCHITECTURAL EDUCATION AND IDEOLOGY

The second theme of this chapter; highlighted in table 5.2, is concerned with ideological features of the architectural profession **cultivated through education.** Architectural education is responsible for transferring architectural traditions and features into modern-day practice. While education is valued for cultivating architectural trainees into learned professionals, **it is also crucial in helping students acquire the professional architect's way of thinking.** Students are instilled with a set of interwoven values, practices, behaviours and rituals which describe the professional culture and its legacy.

Table 5.2. Highlighting sub-categories of the second main thematic category entitled ‘Architectural education and ideology;’ discussed in this section of the chapter.

MAIN THEMATIC CATEGORY	SUB-CATEGORIES				INFERENCES
	LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	
HISTORICAL CONTEXT (section 5.2).	Systemic thinking and the explosion of creativity (section 5.2.1).	The Modern movement (section 5.2.1.1).			
		The Post-Modern movement (section 5.2.1.2).			
	Resource constraints and the rise of sustainability; and introduction of BPS into the architectural discipline (section 5.2.2).	Changing composition of design teams; the need for BPS specialists (section 5.2.2.1).			Inferences about changing compositions of design teams (section 5.2.2.4).
		Elder architects’ resistance to change (section 5.2.2.2).			
		Overlaps, disputes and rivalry (section 5.2.2.3).			
ARCHITECTURAL EDUCATION AND IDEOLOGY (section 5.3).	Handling contradictions (section 5.3.1).	Art versus science in architectural design (section 5.3.1.1).	(i)Misinterpretation of architecture as art.		Inferences about art and science in architectural design (section 5.3.1.2).
			(ii) Meaning of art to architects.		
			(iii) Science and design; the legacy of modernism.		
		Creativity versus constraints (section 5.3.1.3).	(i) Handling constraints.		Inferences about creativity versus constraints (section 5.3.1.4).
			(ii) Challenging constraints and shaping the architects’ identity.		
			(iii) BPS specialists and constraints.		
	Personality traits (section 5.3.2).	Architects’ ignorance and lack of interest in BPS (section 5.3.2.1).	(i) Ignorance or lack of interest?		Inferences about impacts of architects’ ignorance and lack of interest on collaboration (section 5.3.2.2).
			(ii) Ignorance or lack of accuracy?		
			(iii) Knowledge, interest and age.		
			(iv) Architects’ knowledge jeopardises the role of the BPS specialist.		
		Architects’ arrogance (section 5.3.2.3).	(i) Arrogance as a consequence of historical tradition.		Inferences about the direct impacts of architects’ arrogance on collaboration (section 5.3.2.4).
			(ii) Arrogance reinforced through education and professional enculturation.		
			(iii) Creative professionals need to be arrogant.		
			(iv) Arrogance at the service of power.		
			(v) Arrogance as compensation for the erosion of status.		
NON-TECHNICAL BARRIERS IN COLLABORATION (section 5.4).	Negative attitudes toward BPS and stereotyping (section 5.4.1).	Negative attitudes toward BPS (section 5.4.1.1).			Inferences about the impacts of negative attitudes and stereotypes (section 5.4.1.3).
		Stereotyping (section 5.4.1.2).			
	Industry-related barriers (section 5.4.2).	The building project as a commercial exercise (section 5.4.2.1).	(i) Clients imposing restraints to BPS integration.		Inferences about the building project as a commercial exercise (section 5.4.2.2).
			(ii) Different goals of collaborating team members and opportunism.		
		Perceptions of the purpose of BPS (section 5.4.2.3).	(i) Architects’ negative attitudes toward Part L and compliance.	The divide between ‘compliance’ tools and ‘design’ tools.	Inferences about architects’ perceptions of the purpose of BPS (section 5.4.2.4).
				Impact of this divide on BPS professionals.	
	Trust dynamics and communication (section 5.4.3).	Trust dynamics (section 5.4.3.1).	(i) BPS specialists’ trust in architects.		Inferences about trust and communication (section 5.4.3.3).
			(ii) Architects’ trust in BPS specialists.		
		Communication (section 5.4.3.2).	(i) Different worldviews, languages and ambiguities.		

A deeper look into architectural education in the UK and **some of the traditions nurtured through Post-Modernist educational styles** may help to understand why BPS use to inform architectural decision-making is currently curtailed. While this theme is not intended as a review of architectural education as a whole; the following are extracted from the interview data and discussed:

a) Features of architectural ideology which may seem contradictory in the Post-Modern discourse

b) Personality traits commonly associated with architects.

Inferences about the impacts these features and personality traits may have on architectural praxis and collaboration with BPS specialists are made.

5.3.1 HANDLING CONTRADICTIONS

Two features of architectural ideology; each consisting of arguably contradictory elements are explored; the ‘art versus science’ dilemma in section 5.3.1.1; leading to the corresponding ‘creativity versus constraints’ paradox in section 5.3.1.3.

5.3.1.1 Art versus science in architectural design

Architectural design is a bricolage of multi-dimensional knowledge, drawing theories across diverse fields and bridging between specialisations (Friedman 2003). **The omnipresence of art and science in architectural design is explored in this section; based on descriptions provided by the interviewees.**

Manifestation of both art and science in architecture is an ancient principle. In *De Architectura* Vitruvius established an architectural ethos based upon a dynamic balance between *‘Utilitas, Firmitas, Venutas’* (Markus and Cameron 2002) as shown in figure 5.2;

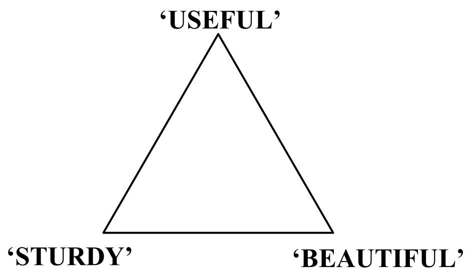

Fig. 5.2. Vitruvius’ triangle

Interviewed architects articulated architectural design as a cross-disciplinary amalgamation of the art and science universes;

- *"...architecture is* [...] *a combination of those two things;* ***a mix of the art and the science coming together*** [...] *and at different times, one side has more of an emphasis than the other..."*
- *"I think architecture's viewed as* **an art** *with* **a technical bias***."*
- *"...we're more of a creative profession,* **art-base** *... than a* **science-base.***"*
- *"I think a lot of people study architecture because it does incorporate* ***both art and science..."***

i. <u>Misinterpretation of architecture as art</u>

A common interpretation amongst BPS specialist interviewees is that architecture is exclusively a form of art. This is implied by Participant S1; ***"engineers don't care about the artistic side*** **[of architecture]."** To dispel this perception; differences between the work of artists and architects are distinguished in table 5.3.

Table 5.3 Differences between the 'artist' and 'architect.' Adapted from Lawson (1990) and by the author.

	ARTIST	ARCHITECT
1.Intellectual ownership.	Likely to be his own master, even if commissioned to work or create for the public.	Almost always commissioned by a client.
2. Working context	Tends to work autonomously.	Usually functions as a member of a design team. Judgements and decisions are not the designer's 'own.'
3. Interest in the problem.	May choose to deal with issues and solve problems of his own interest.	Cannot choose to exclusively deal with problems which are of personal interest.
4. Task generation.	The artist can generate his own task.	The task is brought to the architect by the client; although the architect may contribute to the problem.
5. Expression.	A mode of self-expression.	Conforms to an industry-wide lexicon of signs and symbols in the expression of ideas and production of drawings.
7. Thought directionality.	The artist is free to follow his natural direction of thought; or to change his thinking if he sees fit.	Must consciously channel his thoughts and ideas towards a single end-product.
8. End-solution	May never be able to reach and fully articulate a solution.	A final solution must be reached.
9. Solution evaluation	May be evaluated by art critics; but this may not necessarily be a rational evaluation. It is likely to be highly personal and subjective.	Product will always need evaluation to some degree of rationality; as the architect's work solves a real-world problem.

The crucial difference between the work of the artist and the architect is that the former is primarily encircled around the artist's self. This individualism cannot be applied to the architect. Both the architectural process and product respond to nuances of the client and user. Decisions equally respond to the requirements of other non-architectural design team members. Now that the misinterpretation of the architectural designer as an 'artist' has been clarified, meanings of art for architects are examined; based on the interview data.

ii. What does art mean for architects? Emphasis in the Post-Modern architectural discourse

It the architects' interviews art in design; denoting processes which are intellectually 'soft,' intuitive and intangible, was emphasised as a key element within the Post-Modern discourse. Artistic connotations in the architects' interviews emerged with respect to:

a) **'Conceptualism'** in descriptions such as:

- *"...for some people* [...] *they will have a view that architecture has nothing to do with technology at all* [...] *and you just come up with **amazing concepts of design** and then...leave them to someone else to work out how they actually get built..."*
- *"...there are extremes of architecture* [...] ***the conceptual 'arty' ends of things..."***
- *"I mean the idea at the very beginning, to a certain degree you've got an art* [...] *you're sketching and **you're being conceptual."***

Conceptualism; the initial step in design problem solving, is considered the essence of architectural design in the Post-Modernist paradigm; and a driver for form generation. The previous quotations highlight an explicit union between art and concept generation. Conceptualism is also an emotive process of a subjective nature; not governed by rule-based procedures. Concepts emerge from a plethora of influences, thus requiring emancipation of thought.

b) **'Creativity;'** in descriptions such as:

- ***"... if you haven't got any design ability or artistic ability then you haven't got the creativity*** [...] *and you'll end up probably just* [...] *reverting to technical solutions to design problems as opposed to **creative...artistic...and you know wider issues on design."***
- *"...clients* [...] ***want your creativity**, your* [...] *ability to...**think outside the box** and come up with **creative ideas.** That's going to give them something* [...] *that has value."*

Creativity also lies at the centre of the Post-Modern discourse; as it is regarded as an essential ingredient for design success, without which the value of the solution recedes into something unoriginal and repetitive. Inherent to one's creativity is also an 'artistic' ability; it is the designer's recourses to art which allows one to be 'creative.' Alternatively, the interviewees dismiss 'technicality' as incongruent with 'creativity.'

c) **Visual appreciation of aesthetic quality:**

- *"Certainly when you're an architect* [you can tell] *how it's gone together very well it's* ***about alignment and positioning of elements against each other, which is I guess, is balance, composition, art thing..."***

A mature aesthetic appreciation is a fundamental skill for architects; to achieve aesthetic superiority desired in the Post-Modern paradigm. In the above quote, the participant bases the hallmark of good aesthetics on artistic principles of *"balance"* and *"composition"* for spatial organisation. Aesthetic appreciation is based upon the *Ecole des Beaux Arts* model of learning; which is underpinned by architectural principles documented and followed since the Greek and Roman times (Akin 2002).

iii. Science and design; the legacy of Modernism

The relationship between science and design is described in the literature as elusive (Cross 2006). A three-fold interpretation of the relationship between 'design' and 'science;' is offered in Cross (2006) as shown in figure 5.3.

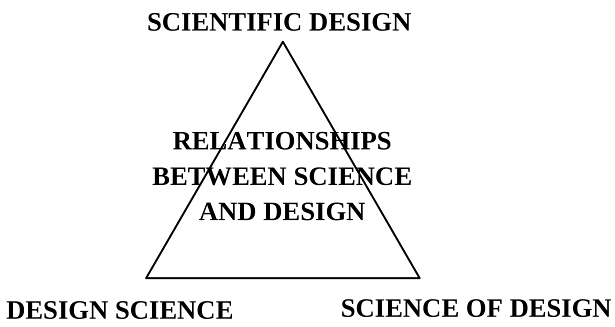

Fig.5.3. Cross' (2006) three-fold interpretation of the 'design'-'science' relationship.

a) **Science of design;** the academic study of design; aimed at increasing our understanding of its principles, practices and procedures.

b) **Scientific design;** reliance of design on 'scientific' knowledge and use of modern technologies. Scientific design is mentioned in the following quotes by architects;

- *"You could create art on paper* ***but you have to deliver a building which is a technical aspect.*** *While you're creating it, it has a tangible technical element."*

- *"I think it should be the two aspects coming together* [...] *and* ***having technology inform creativity****, and vice-versa* [...] *otherwise creativity and concept design is meaningless if it has no* [...] ***structure or no technological reason."***

An additional implication in these quotes is that the 'Scientific Design' paradigm is preceded by the 'artistic;' conceptual stage. As the concept progresses towards a fixated solution, structural or performative validations are sought. **Scientific design gradually overtakes; and the focus is shifted towards constructional details; and ensuring technical diligence within.** This succession is mentioned by Participant A6; *"...after a while in terms of getting a building built, the art will just disappear."*

c) **Design science;** where a single, rationalised and systematic formulation of scientific design activity is undertaken. The designer works within constraint boundaries; which inform design-progression[2]. This approach arguably continues the legacy of the Modern movement in architecture; and is more analogous with engineers' and BPS specialists' design approaches than Post-Modern architects';

- *"You can* ***see a building straight away that's been designed by an engineer,*** *and you can see a building straight away that's been designed by a conceptualist..."*

This would explain BPS specialists' tendencies to compartmentalise the design process into a series of 'cause-and-effect' procedures abstractly illustrated in figure 5.4, and critiqued earlier in chapter 2; section 2.4.2.

[2] Approaches to handling constraints in design problem-solving are explored at depth in section 5.3.1.3.

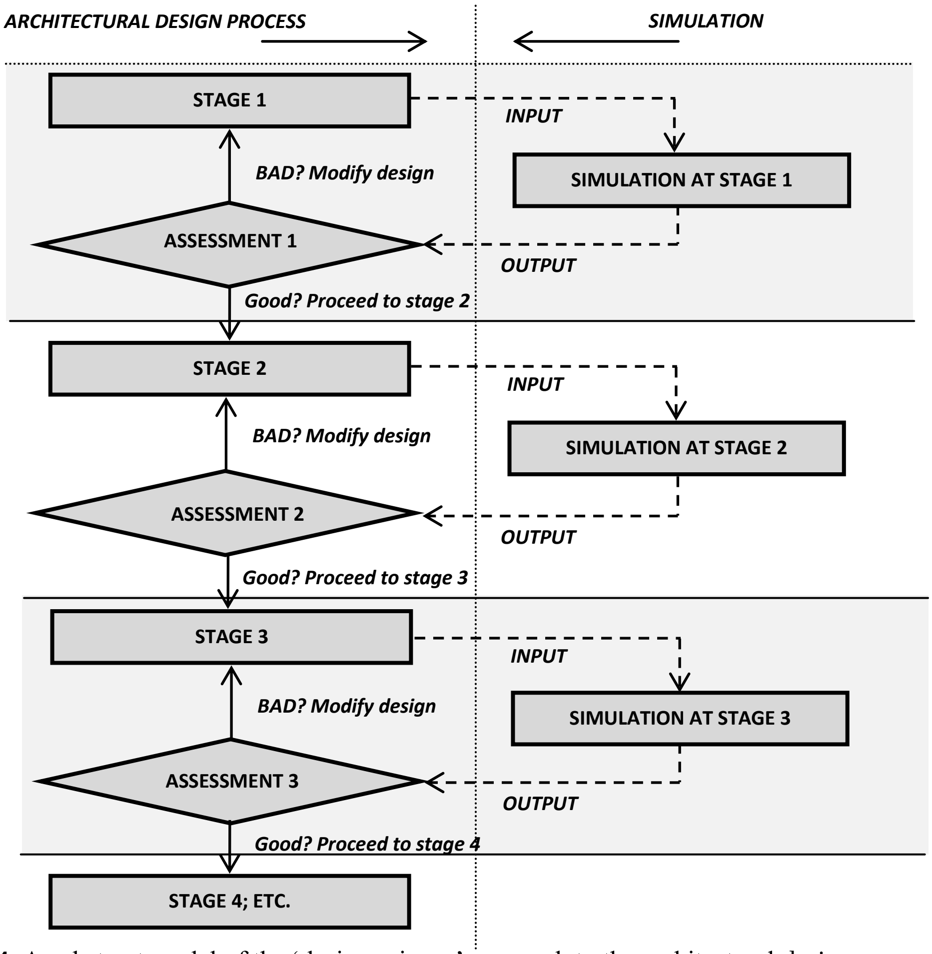

Fig. 5.4. An abstract model of the 'design science' approach to the architectural design process.

Interviewed architects on the other hand seemed to regard the 'Design Science' approach negatively for the lack of novelty in the resultant design-product. The interviewees also conceived that this type of flow-chart model is unrepresentative of the design-process; *"I don't know that I'd be able to draw you a flow-diagram or something for the design process. It has to be more fluid that that."*

Recourse to a 'Design Science' paradigm excludes art from design; particularly the creativity and conceptualism associated with the earliest stages; and therefore conflicts with the Post-Modern philosophy. Architects interviewed for this research therefore argued that following a 'Design Science' paradigm would result in the creation of 'buildings;' not 'architecture.'

5.3.1.2 Inferences about art and science in architectural design

It can be inferred from the preceding discussion that one of the prime barriers to using BPS to inform architectural decision-making is ideological rather than physical. It lies in Post-Modernists' insistence to view design within an enlightened ethos of novelty and creativity; liberated from puritanical functionalism in a Design Science approach which continues the Modernist legacy. The competition for supremacy between 'art' and 'science' commonly witnessed in architectural practices is symbolic of opposing foundational principles of two architectural movements. The struggle between 'art' and 'science' **is therefore a matter of belief. Architects' decisions, including whether to use BPS in design decision-making, arguably depart from this sub-conscious belief.** Arrival at this inference has not been preceded in the literature about BPS integration and use for architectural decision-making. **Hence; the inference that architects' uptake of BPS in the architectural design process may be a matter of belief restricted by Post-Modernist paradigms of architectural education constitutes an addition to the body of knowledge.**

The researcher proposes that; for BPS to become holistically and seamlessly integrated in the design process; and to form a foundation onto which architects can base their design-decisions, a conscious pragmatic approach similar to the one adopted in this thesis, is needed. Conscious pragmatism; freeing architects from former ideological allegiances would allow virtues of both Modernist and Post-Modernist architectural traditions to be acknowledged and mutually exploited to the full. Conscious pragmatism would lead to a much-needed symbiosis of 'art' and 'science;' permitting architects to employ BPS in design decision-making without the fear that heightened creative design aspirations may be compromised.

Meanwhile; another contradiction emerges from this unresolved struggle between Modernism and Post-Modernism; or 'art' and 'science;' that of creativity versus constraints.

5.3.1.3 Creativity versus Constraints

Conflict between design creativity and design constraints was also insinuated in the architects' interviews. They argued that increased constraints on a project pervade over the designer's creativity; curtailing the likelihood of creative design solutions transpiring, which is undesirable especially in the Post-Modern philosophy. This dichotomous relationship between creativity and constraints appears in the following exemplar quotes:

- *"Industry standards dictate what you can and can't do* [...] *and what the size of the site is. And you know even the financial side comes in. I suppose these early stages are really loose because* ***you don't want to be constrained by all those aspects otherwise you just design by numbers..."***

- ***"I think*** **[technical observations]** ***would probably hinder*** **[creativity]** ***a bit****... you probably wouldn't want to stretch the boundaries of imagination and make something bigger."*

- *"You always get the odd individual who hasn't ever been on site very much* [...] ***they're not constrained by getting bogged down on all the technical thoughts."***

- *"...if you ever try to take a conceptually-minded architect and say,* 'you need to learn a simulation tool,'... ***I think it would kill some creativity..."***

This dichotomous relationship has been a concern of design cognition analysts for decades. Thomas and Carroll (1979) found that designers expend little time and energy in problem definition at early stages. Designers allow themselves a certain amount of freedom to change goals and constraints in the early stages; giving space to explore the discourse and creative solutions within. Thomas and Carroll (1979) found that constraints are incrementally refined and become more stringent as the design becomes well-defined. Correspondingly Cross (2001) concluded that rigorous placement of constraints and extensive early problem-formulation does not lead to creative solutions.

Affirmation of this perceived conflict appears predominantly in studies of architectural education and design studio settings, for example (Morrow et al. 2004 and Elnokaly et al. 2008). However, a paradox can be inferred between the aims posited in the afore-named research publications; to dispel the perceived conflict, and the implication given by the interviewees that **such a conflict is actually nurtured through education.** Especially in the Post-Modernist educational paradigm, constraints such as *"the financial component doesn't feature at all at an academic level"* because *"you don't* *want students to be worrying about the financial matters right at the beginning;"* reducing their creativity.

i. Handling constraints

The architects interviewed suggest two alternatives by which constraints are approached in design:

Approach A; Challenging constraints:

- *"Architects* ***are trained to challenge constraints because that's what allows them to be creative.*** *They will challenge ten constraints on a project, nine of them will remain and need to be exactly how they need to be, but there may be one that actually isn't that important after all,* ***and suddenly it opens up a whole new opportunity and that's what your design hangs on."***
- *"We as architects...I think we bring more to that so we say,* **"why does it have to be vertical; it could be more inclined, couldn't it?"**

Approach B; Working within the boundaries of constraints:

- *"To a certain degree having some constraints helps, because* ***they can give you something to work to; a starting point,*** *which can be helpful."*
- *"Often you start with nothing but a number of constraints. If you've got a brief and a number of constraints,* ***you've got a number of different ways of approaching that."***

Interviewed architects outlined differences between the two design approaches; with respect to **problem-solving**, **problem-definition**, **process**, **product** and **the professional group each approach tends to be common to.** These are quoted from the interviews and contrasted side-by-side in table 5.4.

Table 5.4 Differences between the two approaches of handling constraints in design; as inferred from the architects' interviews.

	Approach A: Challenging constraints	**Approach B: Working within constraint-boundaries**
Described as	*"Creative."*	*"Pragmatic."*
Constraints are perceived as	*"Inhibitors to creative design outputs which need to be questioned, broken down and* 'challenged.'"	Opportunities used to *"craft the design solution."*
Problem-definition	*"Ill-defined;"* problem increases in definition gradually.	Well-defined early in the design process.
Directionality	*"Non-linear," "multi-directional and fractured."*	*"Linear; a single avenue of thought."*
Acceptance of constraints	Constraints are to be questioned and *"challenged."*	Constraints are to be accepted.
Process described as	*"Exciting," "creative"* and *"artistic."*	*"Methodical," "legitimate," "sequential"* and *"clinical."*
Associated with	*"Conceptual," "creative-minded"* individuals.	*"Engineers"* and *"procedural 'problem-solvers.'"*
Product	Novel and creative design solutions, with *"a unique identity."* *"Risky; may not deliver anything."*	Will at least lead to a *"safe"* product where *"all criteria are satisfactorily met."* *"You design what you know."*
Professional group	Exclusive to 'creative,' artistic and *"design professionals."*	Similar to *"engineers,' builders,' modellers and technologists'"* procedures.

ii. Challenging constraints and shaping the architect's identity

Challenging constraints is perceived to allow the architect's personal identity to surface through the design, according to the interviewed architects. Recognition and attribution of architectural works to oneself is imperative especially in the Post-Modernist architectural discourse; which emphasises creating a signature 'style' for the architect. This explains *"why architects do similar things time and time again."* This signature 'style' is exemplified by the works of internationally-renowned architects; *"why does*

Richard Meier do all white buildings? Why does Frank Gehry use titanium and fish shapes? Everyone has their own little quirk."

Interviewed architects demonstrated self-satisfaction at the recognition of their work. A3 is proud that; *"people generally say they know which are* **my** *drawings;"* implying ***'my style.'*** Likewise, when A2 sees buildings he has designed; *"there's a sense of pride in that because as a designer* ***you invest so much of your own thought-process."***

Emergence of the architect's personal identity is necessary for architects to build a reputation of innovation. Moreover, innovative and unique designs encourage clients to appoint them. As verified by A4; *"...clients only come to you if you've done a good piece of architecture. The best clients will come to you because you've done the best bit of architecture."* Clients are likely to choose an architect because, *"they want your creativity; the ability to think outside the box and come up with creative ideas; that's going to give them something that has value."* A client will not settle for a building that simply operates; that is *"technically workable;"* which is perceived to be the product of a design problem-solving approach analogous to Approach B (table 5.4).

However, it is noteworthy that challenging constraints is sometimes perceived as a form of arrogance. In a classroom observational study of design, the term **'design arrogance'** was assigned to students who designed to satisfy their own creative aspirations rather than to fulfil the brief (Newstetter and McCracken 2001). A comparable link between architects' personal aspirations and a perceived arrogance can be deduced from the following interview quote; *"that's why people think that architects are arrogant...because they're constantly challenging and asking questions."* The notion of architects' arrogance is explored in greater detail in section 5.3.2.3. Impacts of architects' arrogant dispositions on collaboration; and the consequent potential for BPS to inform architectural decision-making are also inferred in that section.

iii. <u>BPS specialists and constraints</u>

On the other hand, it became evident that the way BPS specialists handle constraints is complementary to Approach B; working within constraint boundaries. This may either be by working within pre-existing boundaries or by setting up new boundaries. The latter is conceivable in the following quote; whereby Participant S7 acknowledges his responsibility is to "[be] *there on the outset to* ***constrain the parameters of design."***

Having had little or no training in architecture; BPS specialists are unlikely to understand the philosophical Post-Modernist discourse adopted by many architects of the current. As there is no need for BPS specialist S5 to conform to the creative discourse; he explicitly states a preference that more constraints should be enforced in building regulations, to restrict design-freedom;

- *"The building regulation does not specify how the building should be oriented...how the form should be...* ***so building orientation and shape should be determined by building regulations as well.*** *Once there is a guideline, it directs everybody. But if there are no guidelines, then I have the freedom to do whatever I want to do.* ***If there's a guideline, it makes sure I don't deviate from that guideline. They have the freedom, but the guidelines would not make them deviate so much."***

It can therefore be inferred that the BPS specialist's perceived task in the design team essentially **opposes architects' need for free space to explore multiple design options.**

5.3.1.4 Inferences about Creativity versus Constraints

One of the reasons inhibiting architects' uptake of BPS could be their perception that tools provide additional constraints; which in turn reduces their ability to freely explore the creative, philosophical discourse. This is particularly pertinent during early stages, where BPS calculations have most impact on building performance. Incongruously these are also the stages at which the most philosophical ethos can be voiced and the most creative solutions are conceived.

Adding to the complexity of the situation and further inhibiting early BPS integration is a common perception amongst architectural designers; **that BPS tools are only to be used for compliance with Approved Document Part L (Conservation of Fuel and Power) of the building regulations in England and Wales[3].** While BPS tools are

[3] This confusion results from architects' lack of awareness of an existent divide between 'design' tools and 'compliance' tools. This divide arises from the way BPS tools are embedded within the regulatory framework, and tools which are accredited to grant compliance. As this current section is not intended to be a discussion of the purposes of BPS and BPS tools; but rather a discussion of design constraints and design creativity, an entire section has been dedicated to this issue of compliance, the divide between 'design' tools and 'compliance' tools and the confusion it has caused in section 5.4.2.3.

ultimately design tools which are best exploited when they are used to inform design decisions; by becoming equated with compliance tools used to check the design against minimum standards; BPS tools are unjustly perceived as a constraint.

5.3.2 PERSONALITY TRAITS

In the following sub-sections, personality traits arguably common to architects, nurtured through architectural education and potentially reducing the impacts of BPS on design decision-making are discussed. In sections 5.3.2.1 and 5.3.2.2; architects' ignorance and lack of interest in BPS is examined. In sections 5.3.2.3 and 5.3.2.4, the possibility that architects are arrogant is questioned. Impediments to collaboration as well as BPS uptake and employment caused by each of these two traits are proposed at the end of these two sections.

5.3.2.1 Architects' ignorance and lack of interest in BPS

BPS specialists interviewed conveyed an impression that architects are generally ignorant of the work conducted in the BPS field. Phrases such as 'don't know' and 'don't understand' surfaced repeatedly in descriptions of members of the architectural profession, for example;

- *"There are often people who* ***don't understand*** *what it is that we are trying to do."*
- *"Some of the architects...they* ***don't know anything about thermal modelling*** *still. Some of them* ***don't know about Part L...*** [so] *you need to tell them."*
- *"I'm generalizing very much now...but the* ***lack of understanding*** *maybe even to* ***a slight ignorance*** *in the importance of the building simulation, and what role the simulation can play in helping their designs."*

The architectural interviewees did not contradict this; and instead blamed this ignorance on architectural education. A5 states that, because of architectural schools' fixation on Post-Modernity; architects *"are not trained as building scientists. So architects, if they were to do simulations themselves, they would almost need to retrain."*

Conversely, S3 suggests that this ignorance may not entirely be a fault of formal architectural education. Having witnessed architects being taught BPS-specific knowledge in a master's programme in which he was previously enrolled, he recalls that *"all the aspects that influence building design, plus lighting, energy modelling and use were discussed in detail,"* and *"the architecture students… were quick, accurate and understood"* BPS calculations. Nevertheless, *"it doesn't seem to carry through into every day practice,"* and architects are *"the people who are* ***most resistant*** *to it"* in practice.

i. <u>Ignorance or lack of interest?</u>

Research in educational psychology reports a positive correlation between interest and knowledge of a particular domain (Hidi 1990, Alexander et al. 1994 and Tobias 1994). Personal interest arouses emotional associative networks in people; fuelling their motivations for knowledge-acquisition and naturally directing their engagement in learning activities (Lawless and Kulikowich 2006). These functions are not present when domains are less interesting to a person (Hidi 1990).

Architects' poor BPS uptake **may largely be a matter of personal interest; or lack of it thereof.** To draw from the interview data, BPS specialists' realise that some architects are simply *"not bothered"* about all matters related to energy-efficiency. BPS specialist S8 hypothesises that, if an architect is *"intellectually interested,"* in BPS they *"will go and find the knowledge;"* whereas *"if you're not interested in it you will not go and find the knowledge."*

ii. <u>Ignorance or lack of accuracy?</u>

BPS specialists interviewed frequently reported a difficulty in receiving correct and accurate input data from architects. Participant S3 finds that *"many architects* [fail to realise] *the importance of getting accurate information, or why you even need to provide it at all."*

Similarly, Participant S2 pronounces that, *"the most difficult thing to get from the architect* ***is the u-value calculation."*** He recognises that *"maybe* [u-values have] *nothing to do with building simulation,* ***but it doesn't help if you're not given the right information to start with,*** *or the information you're given isn't correct."* Incorrect or inaccurate input data *"puts another complication in what we're trying to create."*

Failure to provide accurate input data is augmented with an impression that BPS specialists' need for accurate information is not respected by architects. Participant S3 describes a project in which he collaborated with a team of architects and M&E designers to improve the performance. *"The building was halfway through construction phase and there were hours and hours of work between ourselves and the M&E designers"* to try to improve the building performance; yet no improvements could be made beyond what had already been achieved. Later, the design team discovered that there had been a *"misunderstanding between the architect and the contractor,* [because] *there wasn't that firm a specification"* provided by the architects. Upon discovery of this misunderstanding, "*the walls' u-values went from 0.35 to 0.18;"* which improved the performance drastically. However, S3 conveys disappointment at the architects' dismissive, flippant and unapologetic response to the situation. Rather than apologising or showing any regret at the time lost, there was ***"no apology;"*** from the architects; ***"no* 'did it cause any grief?' *or* 'was there a problem with that?'"**

iii. <u>Knowledge, interest and age</u>

The interviewed BPS specialists suggest that architects' age correlates with their knowledge and/or interest in BPS. They argued that younger architects tend to have a greater encompassment of the *"modern science"* behind building design. They also contend that, *"older architects are harder to deal with professionally"* because the information elder architects provide *"is never really that accurate."*

iv. <u>Architects' knowledge jeopardises the role of the BPS specialist</u>

BPS specialists interviewed expressed anxiety at the deliberation that architects could enter 'their' domain and conduct BPS calculations. It is in architects' ignorance of BPS domain that their position currently thrives; *"if* [architects] *had the knowledge then we wouldn't have the need for a job. So I'm not saying if they do need the knowledge or they don't need the knowledge, I suspect that could mean we have a biased viewpoint;* ***we are working because the rest of the team don't have the knowledge."*** This jeopardy was also acknowledged by one of the architects interviewed; A6 stated that if architects were able to conduct BPS themselves; *"it would take away the work of services engineers."*

5.3.2.2 Inferences about the impacts of architects' ignorance and lack of interest on collaboration

All BPS specialists interviewed reported experiencing difficulties in collaborating with architects; and unsatisfactory professional relationships with architects which arose as a result. Participant S7 highlights this potentially impeding effect; *"perhaps engineers feel they shouldn't engage with architects. If you* [architects] *are not interested in my problem, why are you treating me like someone who can just make it go away? **I can help you but I need to be engaged intellectually.'"***

It is plausible that these reported difficulties arise as a result of differences in worldview between the two groups. Participant S5 declares that *"it's different worlds ... it's a different way of seeing things."* While architects and BPS specialists are often faced with the same problem; they may see the same problem differently and use different approaches to solve it. According to Participant S5 *"sometimes solving the problem is treating the symptom, not treating the cause."* He further illustrates using the following example:

- *"An extremely high glazed building...that space is going to overheat...and the creative engineering solution that the architect is expecting is to make the problem go away, and they perhaps imagine that there is some miracle cooling system that might go in, which means you get all the wonderful aesthetics...the glass and the great views...and heating and cooling is no longer a problem...and fundamentally the easiest way to solve that problem is not to put that much glass in the first place...* [to] *remove the problem in the first place."*

All the interviewed BPS specialists conveyed that the architects they work with tend to be unwilling to modify elements of their building design based upon the results of the simulations. Participant S3 states that the information is fully and effectively communicated to architects[4]; yet ***"it doesn't seem to have the impact or the required result"*** on the design. The following quotes are also indicative of this;

- *"Sometimes* [architects] ***don't want to change the outlook of their building.*** *And you are struggling… because they want the building to look very fancy; very good from the outside."*

[4] Communication is discussed in detail in section 5.4.3.2 of this chapter.

– *"I know that sometimes* ***architects give us trouble****...they are like,* 'no, you just change your things.'"

Architects' negative attitudes which are visible in their unwillingness to co-operate[5] have an inherent impact on BPS specialists' behaviour in collaboration. This unwillingness to co-operate may be interpreted as an example of architects' arrogance; a personality trait which is discussed in section 5.3.2.3.

5.3.2.3 Architects' arrogance

A self-image of arrogance was reiterated frequently throughout the interviews conducted with architects. This self-image was neither directly questioned nor indirectly probed by the interviewer. Instead words such as *'arrogant,' 'arrogance,' 'pride,' 'egos'* and *'intellectually-superior'* were iterated as products of the conversational interaction. Aside from explicit self-descriptions, implicit manifestations of arrogance are also visible in the data. For example, A2 conveys an air of elitism in the remark *"architects I suppose are different to everybody else."* Moreover, all architects interviewed appeared highly defensive of this reputed arrogance; rationalising it for the following contextual reasons:

i. Arrogance as a consequence of historical tradition

Historically, architecture was a practice primarily associated with the elite; kings, queens and priests would prescribe their formal architectural requirements to reflect societal aspirations (Barrow 2004). An elitist profession was born out of this. A4 highlights that; *"historically architecture has always been about the architect making all the decisions."* It is not surprising that a corresponding arrogance would follow suit, becoming a recognisable feature of the architect's evolutionary heritage. This arrogance has been reinforced further by the Post-Modernist discourse; with architects' aspirations for novel creative designs and personal signature 'styles.'

[5] Attitudes and behaviours are discussed in detail in section 5.4.1.1 of this chapter.

ii. Arrogance reinforced through education and professional enculturation

A6 blames architectural schools for constructing a legacy of arrogant demeanours; *"arrogance has something to do with the way architects are trained. They're trained to think that they're great creative people at architecture school; seven or five years of it. It's all about design and philosophical thinking and* [...] *there tends to be a lot of arrogant tutors at schools of architecture."* Consequently, the internalised image of the architect as omnipotent artistic genius; reinforced by beliefs of architectural superiority, prevents them from recognising technical issues which do not fall under the 'artistic' umbrella of architecture.

Furthermore, A6 critiques the UK system of architectural education with respect to three particular facets, which he perceives to contribute towards architects' arrogant dispositions:

a) The content of taught material: is criticised for having a Post-Modernist philosophical focus rather than a technical one; *"I think there's a lot of schools of architecture* [that] *think they can get away more and more and more with lack of teaching…technical stuff. And they do it in a way of making it seem like it's not a trendy thing to do…* 'somehow we're architecturally superior if they just teach students how to talk the philosophical talk.'"

b) The ethos of well-known UK schools: Participant A6 questions whether Post-Modernist traditions teaching the philosophical discourse are embedded within the ethos of famous UK architectural schools; *"you get a big school…which are probably quite good at doing this kind of thing* [teaching students the philosophical talk] *and then all the other London schools copy them; they want to be trendy. And then you get other schools of architecture in other parts of the country which copy them as well. So you go to the end of year show and see some fantastic presentations but you won't see a building. It's almost like you're not allowed to!"*

c) Tutors' lack of practical experience: A6 questions the competence of some tutors in these schools. He predicts that *"a lot of them haven't worked in practice. They've gone straight from education into teaching and they're* *competing to 'out-trendy' each other."* Tutors *"convince themselves as if they've got some deep intellectual thought behind what they're talking about,"* a disposition which is then transferred to students. If anyone, *"*[tries] *to challenge it…* [they] *get accused of being somehow narrow-minded."* **This is subsequently transferred to students.**

iii. <u>Do creative professionals need to be arrogant?</u>

A dichotomy between arrogance and creativity is suggested in the data. A5 proposes that the need to be arrogant is often confused by architects with a need to be creative; *"there's the perception that architects need to be arrogant to push through an idea, and sometimes they need to be creative and not so much arrogant."* Yet arrogance may also be a characteristic inherent in all design professions. According to A6 arrogance, "*goes well with the* [territory]. *Architecture is not just about practical construction…it's about **design** as well."* Moreover, *"in the world of design, if you go into fashion design or anything, it* [arrogance] *will be there and it will lead towards there as well."*

iv. <u>Arrogance at the service of power</u>

Interviewed architects debated that a certain degree of arrogance is often **required** for successful project management of architectural work;

- *"I think to a certain degree it's true; architects are arrogant. That's not necessarily a bad thing. In the world of design; there needs to be a certain level of arrogance anyway to push through a great idea. There's also a certain point that* [architects] *need to be **strong** in keeping a hold of their ideas, because there's a whole load of opportunities; all sorts of barriers for things to be watered down; right through the cost of things and practicalities and services and all of that."*

In a collaboration, these 'barriers' may be imposed by non-architectural design team members who may prioritise tasks differently to the architect. Arrogance may help the architect exercise greater control and **maintain power.** Cuff (1991) highlights that a hierarchical power structure is found to exist in architectural design teams; and this power **endows the architect with an ability to push decisions in the direction that he/she sees fit.** Within the hierarchy, therefore *"the higher the* [architect's position], *or the more famous the practice* [is], *the more ... arrogant*" architects are likely to be.

However, in light of current technological advancements, power is increasingly becoming associated with technology (Barrow 2004). BPS specialists are empowered with state-of-the-art technologies. **They are at an advantageous position to architects in being equipped with foundational knowledge of physics to operate these technologies, and interpret their outputs[6].** Ironically, it is the Post-Modernist elder architects in particular who have more experiential knowledge in the industry; as discussed earlier in section 5.2.2.1 of this chapter, who are least likely to comprehend the aforementioned technologies.

BPS technologies have therefore instigated a change in the power-hierarchy. Power is no longer restricted to the traditional elders of the architectural culture. It is now in the hands of non-architectural professionals, who are enabled to drive decision-making by validating them against numerical indicators. Arrogant temperaments may be adopted by architects to therefore recover some of that power.

v. Arrogance as compensation for the erosion of status

The final explanation for architects' arrogance suggested in the data is that **adopting an arrogant disposition may be a way of coping with a downgrade in financial status of the profession.** Nowadays, *"architects don't get paid very well. So they make up for it by thinking that it's lucky that they live in this great design world. After a while, they become bitter about not getting paid very well. And that makes them compensate by being arrogant."*

5.3.2.4 Inferences about the direct impacts of architects' arrogance on collaboration

Participant A2 highlights that architects are generally aware that arrogant dispositions affect professional relationships; *"people think that architects are arrogant because*

[6] This imminent power-struggle contributes further to the rivalry situation described in section 5.2.2.3 earlier.

they're constantly challenging and asking questions…which is why clients hate architects." Equally; in collaboration with BPS specialists, a visibly arrogant disposition is likely to have a negative impact on the working relationship.

In addition, it is predictable that as a result of Post-Modernist professional enculturation and lack of training in BPS, **practising architects may believe that BPS lies beneath the realm of their elitist design practices. They may become averse to validating their design decisions by way of BPS and refuse to abide by BPS results and recommendations as a matter of belief and principle.**

5.4 NON-TECHNICAL BARRIERS IN COLLABORATION

This third and final theme is concerned with non-technical barriers which emerge when architects and BPS specialists collaborate and physically interact. These non-technical barriers discussed in this section of the chapter (section 5.4) are highlighted in table 5.5.

Table 5.5. Highlighting sub-categories of the third main thematic category entitled ‘Non-technical barriers in collaboration;’ discussed in this section of the chapter.

MAIN THEMATIC CATEGORY	SUB-CATEGORIES				INFERENCES
	LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	
HISTORICAL CONTEXT (section 5.2).	Systemic thinking and the explosion of creativity (section 5.2.1).	The Modern movement (section 5.2.1.1).			
		The Post-Modern movement (section 5.2.1.2).			
	Resource constraints and the rise of sustainability; and introduction of BPS into the architectural discipline (section 5.2.2).	Changing composition of design teams; the need for BPS specialists (section 5.2.2.1).			Inferences about changing compositions of design teams (section 5.2.2.4).
		Elder architects’ resistance to change (section 5.2.2.2).			
		Overlaps, disputes and rivalry (section 5.2.2.3).			
ARCHITECTURAL EDUCATION AND IDEOLOGY (section 5.3).	Handling contradictions (section 5.3.1).	Art versus science in architectural design (section 5.3.1.1).	(i)Misinterpretation of architecture as art.		Inferences about art and science in architectural design (section 5.3.1.2).
			(ii) Meaning of art to architects.		
			(iii) Science and design; the legacy of modernism.		
		Creativity versus constraints (section 5.3.1.3).	(i) Handling constraints.		Inferences about creativity versus constraints (section 5.3.1.4).
			(ii) Challenging constraints and shaping the architects’ identity.		
			(iii) BPS specialists and constraints.		
	Personality traits (section 5.3.2).	Architects’ ignorance and lack of interest in BPS (section 5.3.2.1).	(i) Ignorance or lack of interest?		Inferences about impacts of architects’ ignorance and lack of interest on collaboration (section 5.3.2.2).
			(ii) Ignorance or lack of accuracy?		
			(iii) Knowledge, interest and age.		
			(iv) Architects’ knowledge jeopardises the role of the BPS specialist.		
		Architects’ arrogance (section 5.3.2.3).	(i) Arrogance as a consequence of historical tradition.		Inferences about the direct impacts of architects’ arrogance on collaboration (section 5.3.2.4).
			(ii) Arrogance reinforced through education and professional enculturation.		
			(iii) Creative professionals need to be arrogant.		
			(iv) Arrogance at the service of power.		
			(v) Arrogance as compensation for the erosion of status.		
NON-TECHNICAL BARRIERS IN COLLABORATION (section 5.4).	Negative attitudes toward BPS and stereotyping (section 5.4.1).	Negative attitudes toward BPS (section 5.4.1.1).			Inferences about the impacts of negative attitudes and stereotypes (section 5.4.1.3).
		Stereotyping (section 5.4.1.2).			
	Industry-related barriers (section 5.4.2).	The building project as a commercial exercise (section 5.4.2.1).	(i) Clients imposing restraints to BPS integration.		Inferences about the building project as a commercial exercise (section 5.4.2.2).
			(ii) Different goals of collaborating team members and opportunism.		
		Perceptions of the purpose of BPS (section 5.4.2.3).	(i) Architects’ negative attitudes toward Part L and compliance.	The divide between ‘compliance’ tools and ‘design’ tools.	Inferences about architects’ perceptions of the purpose of BPS (section 5.4.2.4).
				Impact of this divide on BPS professionals.	
	Trust dynamics and communication (section 5.4.3).	Trust dynamics (section 5.4.3.1).	(i) BPS specialists’ trust in architects.		Inferences about trust and communication (section 5.4.3.3).
			(ii) Architects’ trust in BPS specialists.		
		Communication (section 5.4.3.2).	(i) Different worldviews, languages and ambiguities.		

5.4.1 NEGATIVE ATTITUDES TOWARD BPS AND STEREOTYPING

5.4.1.1 Negative attitudes toward BPS

Post-Modernist paradigms of architectural education poorly-adapted to correspond with momentous changes in the architectural industry; and arrogant dispositions encouraged by this educational paradigm; have resulted in **negative attitudes towards BPS being borne as a consequence.** Unappreciative attitudes voiced by architects were implicit in descriptions of BPS as a *"paperwork exercise"* which *"sometimes...detract from what real architecture is all about."* However, to understand how negative attitudes may threaten BPS integration, it is first necessary to define the term 'attitude'.

What attitudes are and what they allow us to do:

An attitude is basically a person's position towards a particular attitude-object (Malhotra 2005). By imposing an evaluative structure on an attitude-object; this allows us to either favourably include this object within our realms of acceptance; or to decide not to accept it. In an institutional context; this cognitive assignment of a basic 'like' or 'dislike' stature towards pressing demands imminent in a professional environment is, when stripped to its core, a facilitating coping mechanism.

Attitude formation:

Attitudes are believed to be constructed based upon **one's subjective values and internal beliefs of an object's attributes**. Attitude theorists argue that direct experiences with particular attitude-objects lead to stronger and more consistent attitude formations than less direct exposures (Sherman 1982; Cetola 1988).

It is possible that, alongside the educational foundation which many of today's architects received, and the corresponding ignorance and lack of interest in BPS described earlier in section 5.3.2.1; each of the barriers listed below would potentially contribute towards the formation of negative attitudes towards BPS;

a) An overarching view of building projects as commercial exercises. This is discussed in section 5.4.2.1 to follow.
b) Stringent compliance requirements coupled with architects' perception of BPS as rigid compliance tools. This is discussed in section 5.4.2.3 to follow.
c) Poor interpersonal trust dynamics between architects and BPS specialists. This is discussed in section 5.4.3.1 to follow.

Attitudes and behaviours

Attitude theorists recognise the existence of a relationship between one's attitude and behaviour towards an attitude-object. Individuals who uphold positive attitudes towards an attitude-object will generally demonstrate positive behaviours to that object, and vice versa (Haddock and Maio 2012). Therefore, some of the behavioural difficulties reported by BPS specialists when working with architects may be reflections of architects' negative attitudes towards BPS. These may include:

a) Architects' failure to provide BPS specialists with accurate and correct input data; as discussed in section 5.3.2.1.
b) Architects' unwillingness to act upon BPS output results and recommendations; as discussed in section 5.3.2.4

5.4.1.2 Stereotyping

Only one explicit description of a pervasive architectural stereotype was pronounced throughout the entire interview data-set. The following excerpt has been taken from an interview conducted with A6;

> *"You only have to look at the stereotypical architect...**and I've got a black shirt on myself** but I mean...I'm very conservative. But you just have to go in the shop over there* [RIBA BOOKSHOP] *and... **she came out looking pretty cool.** Do you know what I mean? **If you went into the CIBSE, for example, you'd get a different type of people."***

Further mention of this stereotyping phenomenon; either by architects or BPS specialists interviewed, was not made. In addition, no alternative reference to a stereotypical image of or BPS specialists was mentioned by any of the participants.

However, this single quote highlights the possibility that **architects and BPS specialists in a multi-disciplinary collaboration may uphold stereotypical impressions; both about themselves and each other.**

<u>Defining stereotypes and the reasons for stereotyping</u>

A stereotype is a standardised and simplistic view by which all members of the same social group are perceived to have the same characteristics. By forming stereotypical views, people rely on subjective thoughts and conceptual connections to make assumptions about the stereotyped other. In a professional setting; one's stereotypical views may become swathed by one's own preceding attitudes toward the product handled or service offered by the stereotyped other. An architect who has negative, unappreciative attitudes towards BPS; as suggested earlier in section 5.4.1.1, may also form stereotypical impressions about BPS specialists on the basis of these attitudes; which is why stereotyping is examined in this thesis.

Hurst (2007) explains that, *"one reason for stereotypes is the lack of personal, concrete familiarity that individuals have with persons…lack of familiarity encourages the* ***lumping together*** *of unknown individuals"* (Hurst 2007). It is a powerful cognitive tool used to reduce and simplify large blocks of complex information; stereotyping is a by-product of ignorance[7] about the stereotyped other.

In addition, people sometimes stereotype to satisfy a need to feel good about their own selves. When an individual designates his or her own social group as 'standard' or 'normal,' the other group is consequently undermined. By labelling the stereotyped other as 'inferior' or 'abnormal,' one's self-esteem is enhanced. Thus, this notion of stereotyping could be situated alongside that of architects' arrogance discussed in section 5.3.2.3; architects' formation of stereotypical impressions towards BPS specialists may be a consequence of their arrogant dispositions; nurtured through paradigms of architectural education.

[7] Ignorance and lack of interest were discussed earlier in section 5.3.2.1.

5.4.1.3 Inferences about the impacts of negative attitudes and stereotypes; and the need for a quantitative follow-up

It is plausible that architects' negative attitudes towards BPS, coupled with arrogant dispositions and stereotypical impressions; would all result in ineffective collaborative relationships between architects and BPS specialists in collaboration. Indications of these ineffective collaborative relationships are implied in the following interview quotes;

– *"When the clients are there, the last thing you want to be doing is **arguing** between the consultants about whose fault it is."*

– *"He doesn't want to hear us* **bickering."**

– "*I think there's a certain amount of **mickey-taking** between architects and engineers."*

– *"They will kind of almost* **ridicule** *you for saying that it needs to work or look good."*

While negative attitudes and stereotyping invariably pose a serious threat to BPS integration in the design process by causing ineffective collaborative relationships between the two parties; it is important to highlight that **negative attitudes towards BPS were only implicit in this interview data.** Similarly, the notion of prevalent stereotypical impressions of architects and BPS specialists **was expressed only once.** However, the interview data **does not** permit any of the following affirmations:

- That practising architects in England and Wales do have negative attitudes towards BPS.
- That architects and/or BPS specialists work together based on stereotypical impressions.
- That the relationship between architects and BPS specialists collaborating in England and Wales are indeed ineffective.

The qualitative nature of this research allows disclosure of profound barriers in a human-human interaction dimensionality; yet as highlighted in chapter 3, it is important to recognise limitations of qualitative research. To overcome these limitations; and in line with the pragmatic approach of this thesis; this category of **qualitative insights was therefore triangulated in the following quantitative stage of this thesis using a follow-up quantitative survey[8].** The survey permitted a more widespread investigation of attitudes, stereotypes and relationships amongst the wider population of architects and BPS specialists practising in England and Wales.

5.4.2 INDUSTRY-RELATED BARRIERS

Two industry-related barriers impeding BPS uptake and use in architectural decision-making are suggested in the interview data. These are discussed between sections 5.4.2.1 and 5.4.2.3.

5.4.2.1 The building project as a commercial exercise

In this section, **the view of the building project as a business perspective; designed to reap financial benefits is discussed.** From this perspective, it is not surprising that collaborating actors on a project place these financial objectives above virtuous energy-efficiency goals.

i. Clients discouraging early collaboration between architects and BPS specialists

As cited in chapter 2, BPS is most advantageous at early design stages in informing architectural design decisions. However, according to the architectural interviewees clients are the prime inhibitors to BPS use through early collaboration with BPS specialists. Being the financial driver behind a project, the client is regarded at the top of the social hierarchy as testified by participant A4; *"we're all appointed by clients. You could probably view those as your employer rather than your client."* Therefore, *"you're very reliant on the client, unfortunately, in a lot of ways." "The client drives so much of"* how the project is procured and delivered; depending on his/her objectives and priorities. Participant A2 highlights that *"the client see*(s) *the building purely as a commercial exercise,"* and *"few clients will have a higher sustainability agenda."*

[8] Results of the quantitative survey are presented in chapter 7.

Participant A2 remarks that, *"it is rare that we get that opportunity to work with a simulationist...before we make a planning application;"* i.e. Stage D of the RIBA Work Stages (RIBA 2008). However, he sees *"no reasons why it* [early BPS integration through collaboration] *can't be done other than the client's reluctance to have a cast of thousands around the table,* ***when they don't even know for themselves, whether they've got a viable project under their hands."*** A6 states that; to collaborate with BPS specialists early in the design process means that *"the client has to pay suddenly for two consultants right at the beginning rather than one that's managing it."* A4 supports this; *"the client doesn't want to employ half a dozen consultants to work"* on the project rather than only one. The idea that clients may form barriers to BPS uptake and use early in the design process has not been widely explored in previous research. However, in their survey Pilgrim et al. (2003) identified lack of cliental interest and demand as a pertinent barrier to integrating BPS in the architectural design process.

Clients' reluctance to employ BPS specialists at the early design stages may have negative implications on the project. If BPS specialists are only appointed at later stages, (e.g. RIBA Work Stages D onwards), their calculations will no longer inform architectural decision-making; as major decisions will have been fixated. Consequently, energy-efficiency calculations conducted later in the design process become reduced to compliance checks[9].

Participant A5 additionally notes that late appointment of BPS specialists in collaboration has **ironically resulted in financial losses for the client;** in previous situations. *"Because the client didn't want to spend the money they* [only] *did the thermal modelling* [of] *what was considered the two worst facades which were the south and west facade."* Post-construction, the building *"overheated on the north."* To reduce overheating, the architects *"had to put in extra fretting and all sorts of things...lower G-value glass...maximised the shading...to make it all work, which brought* [temperatures] *down to acceptable levels."* However, this still *"cost the client more money."*

[9] The issue of BPS being conducted for compliance purposes only; and the perception upheld amongst many architects that BPS is essentially a compliance-checking exercise, is discussed at depth in section 5.4.2.3.

ii. <u>Different goals of collaborating team-members and opportunism</u>

Multi-disciplinary collaborations tend to be temporary alliances. Design team members may share project goals, but it is unlikely that their personal and professional goals will overlap. Disagreeing professional goals may include increased financial benefit or a growing market reputation. This situation is aggravated if these professionals represent competing organisations.

Collaborating team-members often set out to achieve their **own long-term organisational and professional goals;** rather than the short-term goals of the project. Opportunistic behaviours[10] often feature highly in such alliances as a consequence. Exemplar recurrence of such opportunism is manifested **in intentionally-poor communication;** by transmitting a message which is intentionally unclear; or by choosing to withhold particular pieces of information. According to Participant S2, this is common within the building projects; *"I have seen in the industry, some of the architects...some of the consultants, **they don't want to share*** **[information]** ***with you...they want to keep*** **[it]** ***to themselves...because they think*** **[if]** ***they have got the knowledge, they are superior to you."***

Participant S4 admits to favouring his own financial goals over the overarching goals of the collaboration; *"I don't think an architect realises you don't even model a building in SBEM* [11] *...so I never tell them because **the process would reduce our fee slightly."*** He also admits to withholding information in the output report produced by his consultancy; *"...we give* [architects] *a report based on the outputs themselves, **and to justify our fee,** our report is padded out just as it is with a nice introduction, executive summary and everything else. **But I don't think we communicate the results and the impact of the results."***

Misalignment of project, professional and organisational goals is potentially liable for fostering ineffective collaborative relationships, such as those discussed earlier in section 5.4.1.3. Opportunism is likely to induce reciprocated attitudes of close monitoring and control. A vicious cycle is pre-disposed; breeding poor trust dynamics

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[10] Opportunistic behaviour is that which involves consciously taking advantage of circumstances for self-interest; with little or no regard for principles (Kadefors 2004).

[11] Simplified Building Energy Model (SBEM) is introduced and discussed in detail in section 5.4.2.3.

in the collaborative relationship; and further contributing to ineffective collaborative relationships[12].

5.4.2.2 Inferences about the building project as a commercial exercise

The quotations in the previous section primarily refer to clients' and BPS specialists' financial motivations; whereas architects' economic goals were hardly discussed throughout the interviews. In the few instances that architects did discuss financial interests; these were deferred as almost menial and lowly; *"architecture...it's not about the money."* However, during the interviews, it appeared to the researcher that the architects were deliberately attempting to portray their discipline in a virtuous light; unconcerned with humble money-making activities.

However, it would be unfair to elevate architects' motivations above the others'. Architectural practices, companies, consultancies and firms ***are*** ultimately business endeavours; regardless of the end-product or service they provide. Financial benefit ***will*** inherently lie at the heart of ***any*** professional endeavour; even if it is just to make enough money to keep the business afloat.

Despite the fact that financial impetuses were not explicitly voiced by any of the architectural interviewees; this motivation could still be inferred from the situations architects chose to describe. For example, while cliental business requirements may indeed form substantial barriers to using BPS to inform decision-making; the fact that the interviewed architects succumbed to these cliental requirements is an indication of their own financial drivers. Had the architects alternatively ***insisted*** on appointing BPS specialists in an early collaboration, for example, they would risk losing their clients and therefore; the financial profits they bring.

Based on this deduction, it would be safe to say that ***all*** project actors; clients, external consultants and architects alike, ultimately envisage a building as a commercial activity. Their decision-making in the design process ***will*** be affected by this central goal. A power-struggle ultimately arises here; as actors each employ different tactics to maximise their own profits; such as the instances of intentionally-poor communication enlisted in the previous section. **The power-struggle also resides in the fact that one**

[12] Trust dynamics between architects and BPS specialists are discussed at depth in section 5.4.3.1. The impacts poor communication may have on trust dynamics are predicted in section 5.4.3.2.

actor's financial gains may simultaneously reduce another professional's profitability. This amplifies the rivalry situation described in sections 5.2.2.3 and 5.2.2.4.

5.4.2.3 Perceptions about the purpose and potential of BPS

In this section, architects' perception of the purpose of BPS as predominantly a compliance exercise is discussed. This perception arises from a divide between categories of tools used to grant compliance; and tools which can be used to inform design decisions. This perception is coupled with negative attitudes towards Part L of the building regulations in England and Wales; which are discussed in the following paragraphs.

i. Architects' negative attitudes towards Part L of the building regulations and compliance

Interviewed architects explicitly demonstrated negative attitudes toward Approved Document Part L of the building regulations (Conservation of Fuel and Power). This is evident in expressions such as; *"I'm 80% negative about Part L, but I'm sure every architect has the same opinion"* and *"I'm not sure building regulations are as good as they are written."*

Architects' attitudes towards building regulations in general have been widely explored by Imrie (2004 and 2007), Imrie and Street (2009) and Hamza and Greenwood (2009). This list is not exhaustive; it is intended to illustrate the breadth of previous exploration[13]. It is recognised in these publications that architects consider building regulations as bureaucratic restrictions; which are seldom regarded in a positive light. The following reasons explaining architects' negative attitudes towards Part L were insinuated in the interview data:

a) Increased knowledge requirement: Along with many tasks architects are routinely required to undertake, their knowledge must encompass detailed

[13] With the exception of Hamza and Greenwood (2009), the regulatory context investigated in these references was not confined to an energy-efficiency related scope.

building regulations; adding to the list of responsibilities to keep up with. A4 says, *"we have to have a broad knowledge of a lot of things…loads of information, loads of knowledge on the other statuary requirements, from planning to building regs* [regulations] *to highway,"* etc. Participant A5 alludes to the complexities of this branch of building regulations; in the description *"it's a minefield actually!"*

b) <u>An additional constraint to be challenged:</u> Part L is perceived by these architects as an **additional constraint** to their design sphere[14]. This is evident in the following quotes;

– *"I'm not sure building regulations are as good as they are written. They could be* ***quite constraining."***

– Part L is ***"constraining our flair and freedom.*** *I get tired of it!"*

– *"I think* **you get bogged down** *with the regulations and standards, definitely."*

– ***"The beautiful bits of architecture that you see in magazines aren't always compliant."***

This finding is supported by previous literature. Imrie and Street (2009) highlight that architects feel building design is bounded by highly prescriptive standards which *"strangle"* the creative process. Carmona et al. (2006) fear that *"formulaic building designs"* will ensue due to the *"prescriptive"* nature of building regulations.

c) <u>Difficult to keep up with changes:</u> A5 explains that, *"Part L keeps changing. For example, what we're building now is on the old Part L. But if we're going to do the same building again, the first thing I ought to do is to get the whole building remodelled energy-wise to check it is compliant."* The interviewees

[14] Constraints in architectural design were previously investigated in section 5.3.1.3, and a dichotomous relationship between creativity and constraints was underlined.

also feel that Part L is becoming increasingly constraining and challenging to satisfy; as mentioned in the following quotes:

– "*Part L has* ***become pretty tough. The new version*** **[is]** ***out****...it's a real challenge for us to make things work."*

– *"Bearing in mind that* ***Part L is going to keep changing and getting more onerous.*** *There's not much hope for it."*

– **Part L** ***"is very difficult.*** *I mean it would be interesting to see how it turns out in the future,* ***but it's only getting more and more difficult."***

d) Cheating software results: Negative attitudes towards Part L are transferred by association towards the software used to grant compliance. Participant A5 cynically conveys an impression that compliance software can sometimes be 'cheated;' *"if you want 40% improvements over Part L, if you run the software and start to fiddle the figures as it were, you can get that to work."*

Many architects do not recognise that software used to grant compliance with Part L (compliance software) does not fall within the same category as BPS software; used for design decision-making. There is a divide between the two; the origins of which lie within the framework regulating minimum standards for building performance, the way performance simulations are embedded within this framework and the BPS tools which are accredited to grant compliance. Contextual origins and reasons for this divide are expanded upon in the forthcoming paragraphs.

The divide between 'compliance' tools and 'design' tools

In concurrence with the Directive on Energy Performance of Buildings driver[15], a number of predictive tools were introduced in the UK to apply the National Calculation

[15] The Directive on Energy Performance of Buildings (EPBD 2003) introduced in January 2003 requires member states to apply a National Calculation Methodology (NCM) within their framework of building regulations; to demonstrate compliance with energy performance criteria.

Methodology (NCM) and verify non-domestic building compliance with criteria specified in Approved Document Part L (Conservation of Fuel and Power).

The tool originally developed for NCM execution is the Simple Building Energy Model (SBEM)[16]; which is a quasi-steady state default calculation tool. A non-graphical user interface is incorporated for data-input. However, in steady-state calculators, building parameters are fixed and variables are averaged out over long periods of time (Raslan and Davies 2009). Complex interactions and heat transfer phenomena occurring over short-time steps are not accounted for. **Thus emerges an argument that tools relying on steady-state models are not BPS or 'simulation' tools,** for their failure to simulate intricate transient energy transfers (Clarke 2001; Raslan and Davies 2009). Instead they are restricted to a category of **'compliance' tools**. BPS specialists interviewed concur that results of steady-state compliance are not *"accurate;"* and that *"Part L models rarely behave as real life ...it's a standardised thing which rarely happens in the same way as possible buildings."*

To address this inaccuracy, a limited number of third-party Dynamic Simulation Modelling (DSM) tools later became accredited for compliance purposes (Raslan and Davies 2009). Predictions of much greater complexity than those conducted in steady-state calculators can be undertaken in DSM. Simulation algorithms embedded within the latter allow detailed, iterative and transient calculations to simulate hour-by-hour heat exchanges and physical behaviours. DSM tools ***are considered BPS tools by the broader BPS community,*** for their ability to 'simulate' hourly thermal exchanges. T**hese tools are also envisaged as 'design' tools** for their potential to assist design decision-making.

<u>Impact of this divide on BPS professionals</u>

However, not ***all*** available 'design' tools are accredited for compliance in the UK. Additionally, professionals must be fully-licensed to use them to guarantee compliance. S3 describes this issue of professional licensing as a *"hassle factor;"* which encourages most professionals to use a single piece of software, in which they have *"already been measured and deemed competent once."* The alternative; to use both a 'compliance'

[16] SBEM is for non-domestic building projects. The alternative default calculation tool used for domestic projects is SAP. However, discussion of SAP has not been included because it did not feature in any of the interviews.

tool and a 'design' tool for compliance measurements would mean that *"you* [would] *have to go through peer review and things like that"* again to become licensed. For example, Participant S3 is fully-able to use Integrated Environmental Solutions (IES) software for 'design' purposes. However, for 'compliance' modelling work, he only uses SBEM. Although IES is a DSM software package accredited for compliance modelling in the UK, this interviewee is not licensed to use it for compliance modelling.

Understandings of this methodological and practical divide were clearly evident amongst members of the BPS community interviewed for this research. For example, participant S1 was clearly able to distinguish between the two; *"the software that I'm using are divided in two big categories; design tools and compliance tools."*

However, the majority of architects interviewed did not have an apparent understanding of this divide. This could partially be attributed to architects ignorance and/or lack of interest in the BPS field on the whole; explored previously in section 5.3.2.1. Amongst the majority of architects interviewed, initial introduction of the concept of BPS would invariably spark a thread of conversation about compliance-modelling and fulfilment of Part L criteria. By association therefore, it can be inferred that the overarching understanding amongst interviewed architects is that **BPS is limited to compliance requirements; a mythical understanding in need of correction.**

Architects' restricted apprehension of the purposes of available software was confirmed by BPS specialists interviewed. Participant S2 states that, *"...still it's very difficult to explain to the architect what is the difference between SBEM"* and modelling for design purposes. In S3's experience; "*I don't think an architect realises that you don't even model a building in SBEM."* These quotations substantiate the notion that **many architects may be unaware that building performance simulations exist outside a regulatory framework.** The idea that building simulations may assist in design decision-making may be an **alien concept to many architects.**

Architects' poor understanding of the divide and stringent regulatory constraints often coupled with an overarching view of a building project as a business endeavour described in section 5.4.2.1 means that, calculations of energy performance **are often only conducted to demonstrate compliance.** This has been previously noted in the literature by (De Wilde et al. 1999, De Wilde et al. 2002 and Bleil De Souza and Knight 2007 to cite a few).

Participant S3 provides an example of a scenario; in which he *"suggested we model the building* [using DSM] *to find out if one* [strategy] *is more appropriate than the other, or to find out which is better in terms of payback; in terms of CO2 reduction...in terms of supply...in terms of demand."* This comparison was not possible using SBEM. However, the client's response to this suggestion was, *"no we just want to get the cheapest way possible please; just modelling for legislative reasons. And just leave it at that, nothing else."* In these cases, compliance modelling is considered *"a tick in the box"* which does not *"influence the design in any way. It just provides benchmark requirements."*

Also suggested within BPS specialists' interviews is that reliance on compliance software only; with little recourse to design tools; **may be reducing design-quality; rather than enhancing it; as should be the ultimate objective.** This perception is evident within the following interview extract;

> *"We had an extension to a large warehouse...one zone...one large room; no heating demand, no domestic hot water demand. It was being used by a pharmaceutical company as a buffer zone...* [for] *flu vaccinations to be stored in bulk for times when it was needed. So there was no minimum or maximum temperatures that medicines could be stored at. I think the building itself, unheated, was in the comfort zone itself...and the occupancy was going to be very very low.* ***However, with the modelling software*** **[SBEM]** ***you can't pick and choose these types of things.*** *So automatically there's a demand for hot water allocated when there wasn't going to be. And there had to be a demand for heating. But the suggested energy consumption of this new building was ten...twenty...thirty times what its' actual consumption was going to be...****which swathes the client's decision-making possibly to become compliant.*** *Now I'd suggest that, because the building was going to remain unheated, the fabric was maybe not as important than maybe...looking at something that would happen when the building was used because lighting would go on. However, because the way the compliance was working, the software was improving the fabric first, and a lot of budget was being spent improving the fabric, by which point when it came to the point of spending money on a good lighting strategy, it wasn't there. So they went for a fairly standard approach for that,* ***and I thought it was kind of working counter-productively."***

Furthermore; the interviewee who provided this account states; *"that's what happens regularly with the compliance software,"* because with *"the other type of modelling* [design tools] *we have more of a license to look at different things and change parameters. Whereas with compliance software, we don't."*

In addition, unless the BPS specialist is licensed to use 'design'-tools for compliance modelling; BPS calculations sometimes have to be undertaken twice; once in a design tool and once in a compliance tool such as SBEM. Participant S4 says; *"on occasions we've used compliance software to demonstrate compliance; and then* [we] *remodel the building with IES to show the client some of their specific needs."* **Thus the task of the BPS specialist is doubled; at greater effort and no added cost;** *"we just had to 'bite the bullet' and not make that much money on it. And hence we had to model it twice."*

Of this repetition; Participant S1 remarks; *"it's completely stupid to analyse something several times;* [spending] *millions of hours modelling something to make sure it works perfectly. And then you have to comply it. 'Yes but I just did it before! Same steps! Same things! Why am I doing it again in a really easier way?' It's a paradox! You do it first really complicated but it doesn't show directly the compliance. And then you have to do it again easily using a software that is not as accurate as you used before, but it tells you* 'yes, you are complying with the regulation.' *It's completely stupid; yeah."*

5.4.2.4 Inferences about architects' perceptions of the purpose of BPS

It can be concluded that the way building performance simulations are embedded within the regulatory framework, and the divide between compliance tools and design tools caused as such, has had a negative impact overall on the status of BPS in informing architectural decision-making.

For the architects, this divide causes problems which they may be largely unaware of. Their perception of the purpose of BPS as solely a compliance objective means that prevalent negative attitudes towards Part L are unjustly equated with BPS design tools as well. BPS is therefore only seen as an additional constraint slowing down the design process. Meanwhile, the potential held within powerful BPS tools assistive in design decision-making and to potentially reinforce the architectural discourse remains unrecognised and under-utilised.

For BPS specialists, the divide is the cause of problems of a different nature. BPS specialists ***are*** aware of the divide between 'compliance' tools and 'design' tools. While use of the former in collaboration with architects is unavoidable; to maximise the potential of BPS in design decision-making they would need to exert a greater effort towards proving to architects that BPS is useful for more than just compliance checks and approvals. **As compliance checks must inevitably be conducted; this becomes an additional constraint for the BPS specialist to overcome in improving energy consumption and calculating truly representative values of building performance.**

In summary, compliance-checking has become a common constraint for both architects and BPS specialists. Instead of maximising the potential of energy savings, and of producing practical inputs for the realisation of creative architectural discourses; this step of compliance-checking has ultimately become an obstacle slowing down the fluidity of BPS integration into the design process.

Although it has previously been noted in the literature that BPS is often conducted for the sole purpose of compliance; the divide between design and compliance tools within the context of England and Wales has received little attention in BPS research. Furthermore, the possibility that the potential of BPS informing architectural decision making in projects in England and Wales is inherently affected by this divide has not been questioned. If this inference is quantitatively confirmed section 3 of the thesis; **this insight would therefore constitute a worthy addition to the body of knowledge.**

5.4.3 TRUST DYNAMICS AND COMMUNICATION

The final non-technical barriers explored in this chapter are those of poor trust dynamics and ineffective communication. These two concepts are linked in this section for their inextricable and concurrent inter-relationship. Trust is prerequisite to open communication; yet open communication forms the foundation of trust. In section 5.4.3.1 trust dynamics are defined, interpersonal trust models are introduced and references to trust and/or distrust in the interviews are made. Subsequently, open communication is discussed in section 5.4.3.2 as a means of enhancing trust dynamics.

5.4.3.1 Trust dynamics

Interpersonal trust dynamics were mentioned by both architects and BPS specialists. Before proceeding to discuss how trust dynamics may affect BPS uptake for design decision-making, it is first necessary to define interpersonal trust, and outline its necessity in project relationships.

What is trust and why is it important in collaborative project relationships?

Interpersonal trust is a *"psychological state comprising the intention to accept vulnerability, based upon positive expectations of the intention or the behaviour of the other"* (Rousseau et al. 1998). Having trustworthy intentions in collaboration entails assuming that other project team-members are trustworthy, and withholding from the expectation that they may engage in opportunistic actions (Nooteboom 2006). Cheung et al. (2011) describe trust as *"the lubricant of social interaction"* for the positive impacts it promises project design and delivery.

Trust is described as a two-sided virtue (Laan et al. 2011). Formation of a trustworthy relationship **depends on the behaviours of both parties in that relationship.** An assumption of trustworthiness tends to **induce reciprocated patterns of benevolence** (Rousseau et al. 1998). Opportunistic behaviours are alternatively likely to stimulate pre-emptive distrust; and attitudes of close monitoring and control. Based on these theories therefore; it can be inferred that the notion of trust is closely linked to that of attitudes and behaviours; discussed earlier in section 5.4.1.1. Furthermore; it is also predictable that ineffective collaborative relationships such as those outlined earlier are likely to breed poor trust.

Cheung et al. (2011) outline that multi-disciplinary building project collaborations and alliances are seldom characterised by trustful dispositions. Instead, adversarial relationships between practitioners are the norm in building project environments. Laan et al. (2011) suggest a number of possible reasons for this; pertaining to features of the building industry introduced earlier in section 5.4.2.1;

- Building projects are typified by **frequent change;** commonly leading to dispute. They are also characterised by high-complexity, uncertainty and risk.

- Virtuous trust dynamics between multi-disciplinary team members do not develop automatically. Stakeholders in one-off projects are usually **representatives of independent organisations,** as discussed earlier in section 5.4.2.1, and may be relative strangers to each other on an interpersonal level.

- Building design delivery demands high commitment in terms of time and effort. Consequently, professionals are unlikely to have enough time to devote towards engaging in lengthy interaction processes, which may help build trustworthy relationships.

Interpersonal trust-relationships in collaborative building project environments conducted in previous research have primarily been studied in an owner-contractor relationship context; appearing in Wong et al. (2008), Kadefors (2004), Wong and Cheung (2004), Pinto et al. (2009) and Cheung et al. (2011) to cite a few. On the other hand, comparable research studies concerned with trustworthy interpersonal architect-BPS specialist relationships could not be found[17]. Thus, the inference that interpersonal trust relationships between architects and BPS specialists in collaboration may play a decisive role in reducing the potential for BPS to inform architectural design decision-making is **a noteworthy addition to the body of knowledge contributed through this PhD;** if the same result is arrived at through quantitative analysis conducted in section 3.

<u>Interpersonal trust models</u>

Several models of trust have been proposed; three notable ones include those by Hartman (1999), Rousseau et al. (1998) and Lewicki and Bunker (1996). Hartman's (1999) *'integrity – competence –intuitive'* trust model is particularly relevant to the research conducted in this thesis **because it was developed with an interest in building project environments. Underlying this model is an assumption that**

[17] Williamson 2010 investigated trust in the BPS context but his investigation was more concerned with trustworthiness of the models.

collaborators will have had little or no experience working together[18]. Hartman's (1999) model has therefore been selected to examine references to trust emergent from the interviews. Each dimension of Hartman's trust model is defined in table 5.6.

Table 5.6 Definitions of each dimension of trust according to Hartman's (1999) model.

Integrity trust	The trustor's belief in the morality of the other party (the trustee); and that the trustee will inherently look after the trustor's interests.
Competence trust	The trustor's belief that the trustee is capable to carry out allocated tasks.
Intuitive trust	An instinctive 'gut feeling' that the trustee's intentions and actions are trustworthy.

Both architects and BPS specialists interviewed signalled poor trust in collaborative relationships. Each focused on different dimensions of trust and different reasons distrustful dispositions.

i. <u>BPS specialists' trust in architects</u>

<u>**Competence trust:**</u> BPS specialists expressed poor trust in architects' competence to conduct BPS tasks[19]. This is evident in the following quotes;

- ***"I don't think an engineer would trust results from an architect!*** *Because unless I believe in the* **technical competence** *of the person who's modelling, why would they? The person has to carry the same* **credentials and experience** *so,* 'are you as good as our modeller?' *Or* 'are you as good as me?'"

- *"If* [an architect] *comes to me to say,* 'we've oriented the building better because of some modelling we'd done...' *I'd find that very interesting and I'd be thinking,* 'wow, this is good! Someone wanted to engage about this!' *But my next question would be,* 'what package did you use?' *And if they say,* 'Ecotect'

[18] This assumption is not included neither in Rousseau et al.'s (1998) model nor Lewicki and Bunker's (1996) one.

[19] This comes as a subversive response to some of the concurrent research efforts reviewed in chapter 2; towards proliferation of 'architect-friendly' tools encouraging architects' self-uptake of BPS and gradually rendering it as part of their traditional skill-set.

there'll be bells going off the back of my head going 'oh my God! I've got to now explain why this isn't the best result,' *because I suspect we'll come out with a different answer."*

Integrity trust: Interviewed BPS specialists also openly questioned trust in architects' integrity in conducting BPS tasks themselves; based on their motivations. Poor integrity trust is arguably a consequence of the way energy performance checks and BPS are embedded within the UK regulatory framework described in section 5.4.2.3. The widespread regard of building projects as business endeavours explored earlier in section 5.4.2.1 also contributes to this poor integrity trust; as is visible in the following dialogical exchange;

Interviewer: *"If an architect was to use modelling software in collaboration with you, would you trust the work that they do?"*

S3: *"Possibly not... **a very sceptical side of me** would be saying,* 'someone else will have done this calculation to demonstrate compliance, **and gone for the easiest option and maybe manipulated some software to demonstrate compliance.'** *So I'd be very sceptical of someone else's work in that respect.*"

Intuitive trust: The two aforementioned forms of trust are confounded with an element of poor intuitive trust. Participant S5 states that his distrust in architects' competence is confounded with an additional layer of **poor intuitive trust; that architects, *"perhaps got another level to prove* [simply because] *the work is coming from an architect."***

Similarly, it is also implied that Participant S3's poor trust in architects' integrity is associated with **an intuitive belief** that architects' impetus to perform BPS tasks is to achieve compliance. *"If we were viewing someone else's work...**who's maybe trying to evaluate a building before...for some other reason;"*** beyond compliance, *"then I think I'd be more reassured that it's being done correctly, because there'd be **no ulterior motive behind them."***

ii. Architects' trust in BPS specialists

Architects interviewed were less overt in their discussion of trust. Only references to one form of trust **-poor trust in BPS specialists' integrity-** were inferred in the architects' interviews. These are conveyed in the following two quotes;

- ***“If** the services engineer does his job.”*

- *“I expect* [the services engineer] *to work with me.* ***But there’s got to be a trust there. I’ve got to have an expectation that he will do his best.”***

References towards competence and intuitive trust could not be deduced from this interview data.

The need to enhance architects’ integrity trust in BPS specialists through efficient communication was distinguished by several of the BPS specialists interviewed. Participant S2 recognises that, *“if the architect...is not going to know about the job of this stuff altogether and the work it involves...they will never know what we are doing.”* In attempts to construct trustworthy relationships; the participant stated that his firm normally *“organise CPDs... we invite them here or we go into their office”* to help provide an understanding of what architects’ work entails; *“so that is building the relationship.”* Similarly, Participant S5 states that; *“one of the things that our firm does is to send you out to an architectural practice for a couple of weeks to work with architects and make you more sympathetic”* to their worldview.

5.4.3.2 Open communication to improve trust relationships

Ruppel and Harrington (2000) highlight the link **between trust and effective interpersonal communication in professional relationships.** Frequent and open communication; allowing mutual understanding of the other’s ideology, worldview, opinions and approaches to problem-solving may lead to a gradual construction of trust.

However, while communication plays an intrinsic role in nurturing trustworthy professional relationships, **effective communications are also a precondition of congruent information transfer and successful collaboration** (Ryghaug and Sorensen 2009). BPS specialists interviewed demonstrated a concern that *“the understanding and interpretation* [of information] *is difficult...it doesn’t seem to have the impact or the required result at the end of”* on the designed end-product. Methods and channels of communication were ruled out as potential obstacles preventing message conveyance; *“the channels of communication tend to be fairly open.”* However, within the architect – BPS specialist relationship; one of the prime governances of meaning-interpretation repetitively mentioned **was that architects and BPS specialists ultimately recur to different worldviews.** It is therefore plausible that each is likely to understand information from disparate points of reference. This assertion was recognised by S5, who explained; *"It is different worlds."* Participant S4 acknowledges difficulty in; *"trying to communicate the message to two different people who have got two different expectations of what the building is doing."* These differences are likely to complicate the communicative exchange.

i. <u>Different worldviews, languages and ambiguities</u>

Recourse to different worldviews often means that different languages are spoken. Linguistic diversities between building industry professionals further **complicates the construction of mutually-understood meanings** (Ryghaug and Sorensen 2009). This is relevant to architects and BPS specialists; as *"people who are engineers are very numbers and results driven;"* while *"architects...lack technical ability to engage with engineers;"* for their employment of a different architectural discourse. Certain terminologies may be interpreted ambiguously by members of each profession.

Two such ambiguous terms are exemplified by Participant S2; the words *'detail'* and *'zone:'*

a) <u>**'Detail;'**</u> the interviewee states that the accuracy and suitability of the architectural model for energy-modelling uses, *"is all about the detail."* However, he expresses frustration upon receiving a model from an architect which has *"got far too many details. It's got mullions as well! Every single detail which I don't need!"*

   The word 'detail' ultimately holds a different set of connotations to the architect. *"Mullions"* and *"junctions"* are construction details which are invariably incorporated in architectural models.

   It is equally implied that the architect in question seems to have **little understanding of the requirements of BPS.** He fails to understand that, from an energy point of view; the impact of these details on energy performance will only slow down the speed of the calculation. Consequently, before running the analysis, Participant S2 had to *"spend a lot of time taking that out."*

b) **<u>‘Zone;’</u>** Participant S2 gives an opinion that, *“if* [architects] *are putting the internal partition in, that’s their duty to basically put in another partition as well and make it a* ***zone.*** *Then that model will be accurate for* [the energy] *model.”*

To clarify the ambiguity here, it is necessary to interpret the word ‘zoning’ from both BPS and architectural viewpoints. ‘Zoning’ in the BPS field is primarily **a thermal concept** rather than a geometrical one (DOE 2011). Bleil De Souza and Alsaadani (2012) define a ‘zone’ as a fully-bounded volume of air bounded by heat transfer surfaces. Thus the concept is often employed in BPS literature in relation to **building usage and operation;** for example in CIBSE (1998) and Platt et al. (2010).

For an architect unfamiliar with BPS, thermal zoning is probably an alien concept. ‘Zoning’ in the architectural world ***is*** a geometrical concept connoting internal spatial and functional layout. Consequently, the architect’s failure to *“put in another partition ...and make it a zone”* is predictably a breakdown in communication; rather than a matter of presumptuousness as was implicit from the participant’s tone in the interview.

5.4.3.3 <u>Inferences about trust and communication and conclusions drawn</u>

Non-technical barriers discussed throughout section 5.4 have all contributed towards the discussion of trust dynamics and communication in this final section. Ideological features discussed as part of theme two (section 5.3); particularly those of architects’ knowledge and/or interest in BPS also contribute to trustworthiness in architect-BPS specialist relationships. **This observation calls highlights that trust is not a ‘stand-alone’ concept.** Trust dynamics are affixed within the context in which they are bred and nurtured; either growing or deteriorating based on these contextual surroundings.

Furthermore, trusting another member in the collaborative team is; in a way, admitting one’s own vulnerabilities; be those knowledge limitations, lesser capabilities or fewer resources, amongst various others. However, in light of the **power struggle** and **rivalry situation** which were reiterated several times throughout this chapter (sections 5.2.2.3, 5.2.2.4 and 5.4.2.2), it seems unlikely that either party would candidly admit this vulnerability and therefore be able to openly trust the other. Pure common sense advises that; so long as negative trust dynamics are in place, they will continue to have a potentially destructive impact on the collaborative effort. **In this case, no matter how advanced the BPS technologies are, poor interpersonal trust dynamics threaten to impede the delivery of energy-efficient buildings.** Although the concept of trust may ***appear*** distantly related to BPS; trustworthy relationships are crucial to a harmonious and fluid collaboration between architects and BPS specialists.

Finally, an inherent link between trust and open communication was established in this section. BPS specialists acknowledged that a break-down in communication exists; possibly as a result of different 'languages' being spoken in the industry. Two ambiguous terminologies were highlighted in this section; highlighting that more linguistic differences and terminologies may exist between members of the two professions.

5.5 FROM INTERVIEWS TO QUESTIONNAIRES

While a number of pertinent inferences have been made in this chapter; these are not considered conclusive as they pertain to qualitative data collected from a limited number of interviewees. Although the interview data allowed formation of in-depth understandings about each non-technical barrier extracted, generalizations could not be formed about any of these barriers based on the interview data alone.

Therefore, self-completion questionnaires were used in the following quantitative stage of the research to confirm the existence of the non-technical barriers extracted in the wider context of England and Wales. Positivist philosophies traditionally underpin such quantitative methods of data-collection; which follow the logic of the physical and natural sciences and rely largely on hypothesis-testing and falsification. Data is produced in predominantly numerical and alpha-numerical format. Statistical tests are then applied to these data to deduce results, and to express the extents to which the results may be coincidental or whether they are indicative of generalizable patterns within the social order. Therefore, by employing methods which recur to a different research philosophy in the following research stage, **this further served the purpose of methodological triangulation and generating complementarity, as outlined in chapter 3.**

Specifically, barriers extracted, discussed and inferences made under the thematic category entitled *'non-technical barriers in collaboration'* (section 5.4) were retested in the questionnaires; as highlighted in table 5.7, as these all arise during the interaction between architects and BPS specialists in practice. On the other hand, it was considered irrelevant to quantitatively re-test and triangulate sub-categories extracted under *'historical context'* (section 5.2) and *'architectural education and ideology'* (section 5.3) as these are considered background to the non-technical barriers extracted in section 5.4; and have been thoroughly addressed in the past.

Table 5.7. Showing non-technical barriers re-tested in the quantitative stage.

MAIN THEMATIC CATEGORY	SUB-CATEGORIES				INFERENCES
	LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	
NON-TECHNICAL BARRIERS IN COLLABORATION (section 5.4).	Negative attitudes toward BPS and stereotyping (section 5.4.1).	Negative attitudes toward BPS (section 5.4.1.1).			Inferences about the impacts of negative attitudes and stereotypes (section 5.4.1.3).
		Stereotyping (section 5.4.1.2).			
	Industry-related barriers (section 5.4.2).	The building project as a commercial exercise (section 5.4.2.1).	(i) Clients discouraging early collaborations		Inferences about the building project as a commercial exercise (section 5.4.2.2).
			(ii) Different goals of collaborating team members and opportunism.		
		Perceptions of the purpose of BPS (section 5.4.2.3).	(i) Architects' negative attitudes toward Part L and compliance.	The divide between 'compliance' tools and 'design' tools.	Inferences about architects' perceptions of the purpose of BPS (section 5.4.2.4).
				Impact of this divide on BPS professionals.	
	Trust dynamics and communication (section 5.4.3).	Trust dynamics (section 5.4.3.1).	(i) BPS specialists' trust in architects.		Inferences about trust and communication (section 5.4.3.3).
			(ii) Architects' trust in BPS specialists.		
		Communication (section 5.4.3.2).	(i) Different worldviews, languages and ambiguities.		

Predicted to lead to ineffective collaborative relationships (sections 5.4.1.3, 5.4.2.1, 5.4.3.1, 5.4.3.2 and 5.4.3.3)

Barriers extracted and inferences made in ***this third category*** *were re-tested in the questionnaires.*

However, this quantitative research stage did not occur in isolation from the preceding qualitative one. Rather, the questionnaires were designed based on interview quotes and statements voiced by the interviewees.

Two self-completion questionnaires were designed. Questionnaire 1[20] was designed to re-test barriers mentioned by architects interviewed, and to ascertain whether these barriers are recognisable amongst the wider population of architects in England and Wales. Similarly, questionnaire 2[21] was designed based on barriers voiced by BPS specialists interviewed also to obtain confirmation from the wider population of BPS specialists in England and Wales.

The following barriers were tested in both questionnaires 1 and 2. Reasons for re-testing these barriers in both questionnaires are discussed in the relevant sub-sections 5.5.1.1-5.5.1.4.

- Negative attitudes toward BPS (section 5.5.1.1).
- Stereotyping (section 5.5.1.2).
- Negative attitudes toward Part L and compliance (section 5.5.1.3).
- Trust dynamics between architects and BPS specialists (section 5.5.1.4).
- Different goals of collaborating team members and opportunism (section 5.5.1.4).

The barrier entitled ‘clients discouraging early collaboration’ was re-tested in questionnaire 1 aimed at architects; as this barrier was only mentioned by architects interviewed (section 5.5.2).

The barrier of ‘communication’ was re-tested in questionnaire 2 aimed at BPS specialists. This is because problems in interpersonal communication; and the dangers of ineffective interpersonal communication during collaboration, were only recognised and voiced by BPS specialists interviewed (section 5.5.3).

Finally, the impact these non-technical barriers shown in table 5.7 may have on collaborative relationships between architects and BPS specialists was also re-tested in questionnaire 2; as it was the BPS specialists in particular who demonstrated a concern that their collaborative relationships with architects were not as effective as they potentially could be.

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[20] Appendix E.

[21] Appendix F.

5.5.1 BARRIERS ADDRESSED IN BOTH QUESTIONNAIRES 1 AND 2

This section deals with barriers which were equally addressed in both questionnaires. Sections 5.5.1.1 to 5.5.1.4 show how quotes from the architects' and BPS specialists' interviews have been used to design statements[22] to be tested in both questionnaires. A table is included in each sub-section showing how the ideas in original interview quotes have been used to design statements and/or questions for the questionnaires.

5.5.1.1 Negative attitudes toward BPS

In sections 5.4.1.1 and 5.4.1.3 of this chapter, it was speculated that architects may have negative attitudes toward BPS. However, this could not be confirmed or generalized based on this qualitative data.

It was decided to probe this potential non-technical barrier further using quantitative attitude measurement. A series of statements addressing architects' attitudes toward BPS were designed. These were based on the interview quotes in table 5.8; each of which outlined a particular benefit or drawback of BPS for architects, and therefore reasons to either encourage or discourage their use of BPS.

Although the attitude statements were based on the interview quotes in the preceding column, the reader may notice that in several cases the idea conveyed in the attitude statement is occasionally the opposite of the idea conveyed in the interview quote; from which the statement is originally derived. This was repeated several times throughout the questionnaire-designs, to ensure that similar numbers of positively-worded and negatively-worded statements were included in the questionnaire, and to reduce respondent bias; following the recommendation in De Vaus (2002). Instances where interview quotes represent the opposite idea to the corresponding questionnaire statements are highlighted in yellow throughout tables 5.8-5.14 to follow.

Finally, although the non-technical barrier of 'negative attitudes toward BPS' is primarily concerned with architects' attitudes toward BPS, the same statements were also included in questionnaire 2; aimed at BPS specialists. This was to compare

[22]A series of Likert-scale statements were designed to test all the non-technical barriers in the questionnaires, with the exception of the barrier entitled 'stereotyping,' where one 'yes-or-no' question was designed followed by an open-ended question (table 5.9). The Likert-scale is explained in detail in section 5.5.4 to follow.

architects' responses with BPS specialists'; and to determine whether there is a difference between the architects' attitudes and BPS specialists' impressions of architects' attitudes toward BPS.

Table 5.8. Interview quotes used to design attitude statements; used to test architects' attitudes toward BPS.

INTERVIEW QUOTES	ATTITUDE STATEMENTS TO BE TESTED IN THE QUESTIONNAIRES
"It [BPS] *helps designers make the right kind of* ***early decisions*** *like where to place their buildings, how to orientate them, what the depth of plan should be, percentage of glazing, what the mix of renewables might be."*	'Architects should conduct BPS themselves because it better improves **EARLY STAGE ARCHITECTURAL DECISION-MAKING.'**
"Architects probably find it [BPS software] ***too complicated to use."***	'Architects are **EASILY ABLE TO UNDERSTAND HOW BPS SOFTWARE WORKS.'**
*"Architects…****they're not trained as building scientists,*** *whereas services engineers are. So they understand the whole language."*	'Architectural education and training **SUITABLY PREPARES BUILDING DESIGNERS TO CONDUCT BPS CALCULATIONS THEMSELVES.'**
"We [architects] ***haven't really got the training for it."***	
"I think architects, ***if they were to do simulations themselves, would almost need to retrain."***	
"You know everyone wants a sort of logo*…****you know architects****…you loathe the risk associated with everything that you do and without the right ability you would be putting yourself at risk by trying to attempt to do it without being able to do it properly."*	'Architects should not conduct BPS themselves because it is not their **PROFESSIONAL LOGO.'**
*"Architects…****they're very busy, so they've got a huge amount of things to look at anyway,*** *in terms of the concept, the detailed drawing, the structural drawing and managing the whole design process."*	'Architects should not conduct BPS themselves because **THEY DO NOT HAVE ENOUGH TIME FOR IT.'**

Table 5.8 continued.

INTERVIEW QUOTES	ATTITUDE STATEMENTS TO BE TESTED IN THE QUESTIONNAIRES
"If they [architects] *did them* [simulation] *themselves, probably* ***you'd take away the work of services engineers,*** *you know what I mean?"*	'If architects were to conduct BPS themselves, **IT WOULD TAKE AWAY THE WORK OF BPS SPECIALISTS.'**
"Yes I think architects should be able to conduct BPS calculations themselves." ***"In one sense they should, they need to be aware of it*** [BPS]. *But if you ever take a conceptually-minded architect and say* 'you need to learn a simulation tool' ***I think that it would kill some creativity.***	'BPS is of most benefit to the architectural design process **IF ARCHITECTS CONDUCT IT THEMSELVES.'**
"The calculations should fit into the design process as early as we sensibly can, but it's rare that we get the opportunity to ***work with a simulationist*** *before we make a planning application."*	'BPS is of most benefit to the architectural design process **IF BPS SPECIALISTS ARE APPOINTED AT SOME STAGE IN THE DESIGN PROCESS AND COLLABORATE WITH THE ARCHITECTS.'**
"Architects…it's to allow them to do some kind of simulation right at the beginning. It's not ***instead of*** *the more detailed simulation with tools like IES and TAS and that kind of thing.* ***There's no reason why it couldn't engender cross-team working between architects and engineers."***	'BPS is of most benefit to the architectural design process if **ARCHITECTS** conduct it **DURING EARLY STAGES;** and BPS specialists follow it up with detailed calculations **AT LATER STAGES.'**
"Depending ***on the complexity of the project*** *obviously."*	'Which professional conducts BPS DEPENDS **ENTIRELY ON THE COMPLEXITY OF THE PROJECT.'**

5.5.1.2 Stereotyping

In section 5.4.1.2, an inference was made predicting that architects and BPS specialists may have stereotypical impressions of each other. Although this prediction was based on an interview quote voiced by an architect (table 5.9), questions addressing this barrier of stereotyping were designed and included in both questionnaires, to confirm or deny this prediction. Including questions about stereotyping in both questionnaires was intended to determine **whether both groups** have stereotypical impressions of each other and, if so what these impressions may be. Furthermore, including these questions in both questionnaires was intended to facilitate the comparison of responses from architects and BPS specialists.

Table 5.9. Questions addressing the non-technical barrier of stereotyping.

<table>
<tr><th>INTERVIEW QUOTE</th><th>QUESTIONS IN THE QUESTIONNAIRES</th></tr>
<tr><td rowspan="2">“You only have to look at the stereotypical architect…and I’ve got a black shirt on myself but I mean I’m very conservative. But you just have to go into the shop over there [RIBA BOOKSHOP] and…she came out looking pretty cool. Do you know what I mean? If you went into the CIBSE for example, you’d get a different type of people.”</td><td>‘From your experience, would you say that stereotypical impressions of architects and BPS specialists’ practices, working methods and ideologies exist between members of the two disciplines?’</td></tr>
<tr><td>‘What stereotypical impressions do architects tend to have of BPS specialists?’ (Question included in questionnaire 1).

OR

‘What stereotypical impressions do BPS specialists tend to have of architects?’ (Question included in questionnaire 2).</td></tr>
</table>

5.5.1.3 Negative attitudes toward Part L and compliance

In section 5.4.2.3 it was inferred that interviewed architects have negative attitudes toward Part L of the building regulations. A series of attitude statements was designed to re-test this, based on the interview quotes shown in table 5.10. Each of these interview quotes addressed a particular positive or negative feature of Part L; contributing toward attitude-formation.

Although this barrier was primarily inferred from the architects interviewed; these statements were also included in questionnaire 2 aimed at BPS specialists. This was to determine whether there is a significant difference between architects’ and BPS specialists’ attitudes toward Part L; or whether the two groups have comparable attitudes.

Table 5.10. Interview quotes used to design attitude statements; used to test architects' and BPS specialists' attitudes toward Part L of the building regulations.

INTERVIEW QUOTES	ATTITUDE STATEMENTS TO BE TESTED IN QUESTIONNAIRES
“I'm 80% negative about Part L, *but I'm sure every architect has the same opinion.”* ***“The beautiful bits of architecture that you see in magazines aren't always compliant.”***	'Part L of the building regulations plays **A KEY AND POSITIVE ROLE** in helping to create a comfortable built environment for users.'
“I'm not sure building regulations are as good as they are written. ***They could be quite constraining.”*** ***“It's constraining our flair and freedom.*** *I get tired of it!”*	Part L encourages **DESIGN-FLAIR AND CREATIVITY.'**
“It's a ***minefield actually!”***	'Part L is **VERY TOUGH** and targets are **TOO HIGH** to achieve in order to attain compliance.'
“Part L ***keeps changing.”*** *“Bearing in mind that Part L* ***is going to keep changing and getting more and more onerous.*** *There's not much hope for it.”*	'Part L is **CHANGED TOO FREQUENTLY,** and it is difficult to keep up with the changes.'
“If you want 40% improvements over Part L, if you run the software ***and start to fiddle the figures as it were, you can get that to work.”***	'Compliance with Part L is generally **AN HONEST MEASURE** of effective building performance.'

5.5.1.4 <u>Trust dynamics between architects and BPS specialists and opportunism</u>

In section 5.4.3.1, interpersonal trust dynamics between collaborating architects and BPS specialists were questioned. It was inferred based on interview quotes from both groups that interpersonal trust dynamics between architects and BPS specialists may be negative.

Therefore, in both questionnaires, a series of five statements was designed to question trust dynamics between architects and BPS specialists (table 5.11); based on the interview quotes shown in the left-hand side column. Included within this set were three statements each addressing a particular dimension of trust according to Hartman's (1999) model of integrity, competence and intuitive trust (table 5.6 of this chapter).

One statement questioned whether respondents feel that members of the other group engage in opportunistic behaviour. This is because opportunism is strongly interlinked with the concept of integrity trust, and was implicitly referred to during the interviews. However, by including this statement addressing opportunism, this also addressed the barrier discussed in section 5.4.2.1 of this chapter. Here, using opportunism was discussed as a means of favouring and attempting to achieve one's own long-term organisational and professional goals, rather than the short-term goals of the project.

By including the same statements addressing trust dynamics and opportunism in both questionnaires, both architects' levels of trust toward BPS specialists and BPS specialists' levels of trust toward architects could be interpreted. Using the same statements in both questionnaires was also intended to facilitate comparisons between the responses of architects and BPS specialists about this barrier.

Table 5.11. Interview quotes used to design statements addressing trust dynamics between architects and BPS specialists.

INTERVIEW QUOTES	STATEMENTS TO BE TESTED IN THE QUESTIONNAIRES
*"**If** the services engineer does his job."*	'Generally, there is a **TRUSTFUL DISPOSITION** between collaborating architects and BPS specialists.'
"I expect [the services engineer] *to work with me. But there's got to be a trust there. I've got to have an expectation that **he will do his best."***	'Architects always believe that BPS specialists **EXERT THEIR FULL POTENTIAL** in the collaborative effort, and do what is fully required of them.' *(Question included in questionnaire 1).* OR 'BPS specialists always believe that architects **EXERT THEIR FULL POTENTIAL** in the collaborative effort, and do what is fully required of them.' *(Question included in questionnaire 2).*
*"I don't think an engineer would trust results from an architect! Because unless I believe in the **technical competence** of the person who's modelling, why would they? The person has to carry the same credentials and experience so, 'are you as good as our modeller?' or 'are you as good as me?'"*	'Architects and BPS specialists working together always fully believe in the **COMPETENCE OF EACH OFTHER;** and their respective **KNOWLEDGE, SKILLS AND ABILITY** to do their respective tasks.'
"Perhaps they've got another level to prove [simply because] *the work is coming from an architect."*	'Architects and BPS specialists sometimes do not trust each other, as a result of **PREJUDICES, BIASES AND MISPERCEPTIONS** of the others' work.'
*"A very sceptical side of me would be saying 'someone else will have done this calculation to demonstrate compliance, and gone for the easiest and maybe **manipulated some software to demonstrate compliance.'** So I'd be very sceptical of someone else's work in that respect.'"*	'Architects and/or BPS specialists often engage in **OPPORTUNISTIC BEHAVIOUR.'**
"If we were viewing someone else's work…who's maybe trying to evaluate a building for…for some other reason [beyond compliance] *then I think I'd be reassured that it's being done correctly, **because there'd be no ulterior motive behind them."***	

5.5.2 BARRIERS ADDRESSED IN QUESTIONNAIRE 1

This section deals with a barrier which was addressed in questionnaire 1 only, aimed at architects.

5.5.2.1 Project clients discouraging early collaborations between architects and BPS specialists

In section 5.4.2.1 of this chapter, the inference that project clients tend to discourage early collaborations between architects and BPS specialists was discussed; based on quotes from the architects' interviews. These quotes were used to design the statements shown in table 5.12. This inference was only tested in the architects' questionnaire because it was only discussed by architects in the interviews. Moreover, it would not have been relevant to question BPS specialists about this barrier because BPS specialists generally do not interface with project clients directly and on a regular basis; whereas architects do.

Table 5.12. Showing how interview quotes from the architects have been used to design statements used in questionnaire 1; addressing whether project clients encourage or discourage early stage collaborations between architects and BPS specialists.

<table>
<tr><th>INTERVIEW QUOTES</th><th>STATEMENTS TO BE TESTED IN THE QUESTIONNAIRE</th></tr>
<tr><td>"Trying to convince a client to think sustainably…some [clients] are quite resistant to it; it's perceived as having a cost implication."</td><td rowspan="3">'Most of the time clients will have HIGH SUSTAINABILITY AGENDAS, and will generally encourage architects to integrate BPS as early as possible; to inform their decision-making.'</td></tr>
<tr><td>"There's a certain amount of education about sustainability that needs to happen with clients."</td></tr>
<tr><td>"Measurable targets toward sustainability tend to not to be there with many clients."</td></tr>
<tr><td>"But the client just drives so much of it, they really do."</td><td rowspan="2">'Clients usually see a building project as A COMMERCIAL EXERCISE and are generally looking to drive the MAXIMUM FINANCIAL VALUE OUT OF THE PROJECT DESIGN. They therefore encourage early BPS integration to save on long-term building life-cycle costs.'</td></tr>
<tr><td>"If the client didn't have to they wouldn't have spent the money."</td></tr>
<tr><td>"The client has to pay suddenly for two consultants right at the beginning rather than the one that's managing it."</td><td rowspan="3">'Involving a BPS specialist earlier in the design process means that THE CLIENT WOULD HAVE TO PAY MORE MONEY towards managing more consultants.'</td></tr>
<tr><td>"The client doesn't want to employ half a dozen consultants."</td></tr>
<tr><td>"It is rare that we get the opportunity to work with a simulationist before we make a planning application…there's no reason why it can't be done other than the client's reluctance to have a cast of thousands around the table, when they don't even know for themselves whether they have got a viable project on their hands."</td></tr>
<tr><td>"We asked for the consultant to work to stage E and really do a properly detailed design, and the client didn't want to spend the money. So when they did the thermal modelling they only modelled what were considered the two worst facades."</td><td rowspan="2">'Clients are unaware of BPS and THE IMPORTANCE OF INTEGRATING IT IN THE ARCHITECTURAL DESIGN PROCESS.'</td></tr>
<tr><td>"They modelled two of the main elevations of the building. I wanted to model the whole building but the client didn't want to spend the money, unfortunately."</td></tr>
</table>

5.5.3 BARRIERS ADDRESSED IN QUESTIONNAIRE 2 (BPS SPECIALISTS ONLY)

This section deals with barriers which were addressed in questionnaire 2 only, aimed at BPS specialists.

5.5.3.1 Communication

The barrier of communication was discussed in section 5.4.3.2 of this chapter, and was included in the BPS specialists' questionnaire because this barrier was primarily recognised and voiced by BPS specialists interviewed. Interviewed architects, on the other hand, did not demonstrate any concern about interpersonal communication between themselves and BPS specialists. Quotes from the BPS specialists addressing each facet of interpersonal communication, as well as the statements developed from each of these quotes, are shown in table 5.13.

Table 5.13. Showing how interview quotes from BPS specialists interviewed have been used to design statements in questionnaire 2; addressing the barrier of ineffective interpersonal communication.

INTERVIEW QUOTES	STATEMENTS TO BE TESTED IN THE QUESTIONNAIRE
*"The **channels of communication** tend to be fairly open."*	**'CHANNELS** of communication between architects and BPS specialists **TEND TO BE OPEN.'**
*"The **understanding and interpretation*** [of information] *is difficult…it doesn't seem to have the impact or the required result at the end of the process."*	'Architects are **FULLY ABLE TO UNDERSTAND AND INTERPRET** the information that BPS specialists communicate to them.'
*"I mean generally the means of communication are **face-to-face meetings,** but despite that, there is some sort of misunderstanding or misinterpretation of the information."*	'Information communicated to architects through face-to-face meetings tends to be **MORE EFFECTIVE** than telephone communication or email.'
*"It seems **difficult to maybe communicate the messages over the telephone or by email,** as opposed to you and me talking now. "*	

Table 5.13 continued.

INTERVIEW QUOTES	STATEMENTS TO BE TESTED IN THE QUESTIONNAIRE
*"The problem with architects on occasion is that **they lack the technical ability to engage with engineers.** So perhaps engineers feel like they shouldn't engage with architects…"*	'Architects are always **FULLY ABLE TO ENGAGE IN CONVERSATION** with BPS specialists.'
*"The problem with architects on occasion is that **they lack the technical ability to engage with engineers.** So perhaps engineers feel like they shouldn't engage with architects…"*	'Architects' **LACK OF TECHNICAL KNOWLEDGE HINDERS EFFECTIVE COMMUNICATION** with BPS specialists.'
***"I don't think maybe we communicate the results and the impact of results.** And certainly we don't go into the **details of cause and consequence** either. It's all solution."*	'BPS specialists always communicate the results of their calculations in ways that are **FULLY COMPREHENSIBLE** to architects.'
"The understanding and interpretation [of information] *is difficult…**it doesn't seem to have the impact or the required result at the end of the process."***	'BPS results communicated to architects **DO NOT ALWAYS SEEM TO HAVE THE DESIRED IMPACT** on the building design.'

5.5.3.2 Relationships between architects and BPS specialists

Throughout the interviews, BPS specialists frequently demonstrated concerns that their collaborative relationships with architects were ineffective; as a consequence of preceding non-technical barriers discussed throughout section 5.4. Ineffective collaborative relationships between architects and BPS specialists were predicted to develop as a consequence of;

- Negative attitudes toward BPS and stereotyping (discussed in sections 5.4.1.1 and 5.4.1.2).
- Different goals of collaborating team-members and opportunism (discussed in section 5.4.2.1).
- Poor trust dynamics between architects and BPS specialists and ineffective communication (discussed in sections 5.4.3.1 and section 5.4.3.2).

To determine whether BPS specialists in England and Wales indeed feel that their professional relationships with architects they collaborate with are ineffective, a series of statements were developed from BPS specialists' interview quotes to re-test this (table 5.14).

Table 5.14. Showing how interview quotes from BPS specialists interviewed have been used to design statements in questionnaire 2; questioning whether BPS specialists feel their professional relationships with architects are effective.

INTERVIEW QUOTES	STATEMENTS TO BE TESTED IN THE QUESTIONNAIRE
"Generally we have a good relationship [with architects], *but that's more our company ethos and how we work, because we want to build relationships."*	'Generally, professional relationships between architects and BPS specialists tend to be **EASY AND STRAIGHTFORWARD.'**
***"On a personal level** the relationship basically is normally friendly and certainly **there's a mutual respect, or a respect for how I get involved.** But I do find that once I've got through that personal relationship, I find actually that dealing sometimes with architects is very difficult."*	'Generally, there tends to be a **MUTUAL RESPECT** between architects and BPS specialists, and **AN APPRECIATION** for the work that each professional does.'
*"Certainly **the older architects are harder to deal with professionally** however they're easier to deal with on **a personal level."***	'Relationships between architects and BPS specialists may be quite friendly on a personal level, but **ON A PROFESSIONAL LEVEL** the relationship can be **QUITE DIFFICULT.'**
*"Whereas I'll find some of the **younger architects have more of an understanding of**… I suppose what we can call **a modern science behind a building…** you know the services and everything… there are many different newer ways of heating, cooling and lighting a building."*	'Working with younger architects (early to mid-career) tends to be easier for BPS specialists, because younger architects **HAVE A BETTER UNDERSTANDING OF BUILDING PHYSICS.'**
*"I think the younger an architect is, in their career, **the more switched on they are to some of the other disciplines that are involved in the building design."***	
*"Certainly the older architects are harder to deal with professionally however they're easier to deal with on a personal level, **they've seen it… been there… done it all before… and don't get so phased by inherent problems that happen**. They've had problems for many years, which they have more or less solved, or have come to the compromise to get the solution**… and I found that maybe as we get older they mellow out a bit."***	'Working with younger architects (early to mid-career), who are **LACKING IN PRACTICAL EXPERIENCE,** tends to be difficult for BPS specialists.'

Table 5.14. continued.

INTERVIEW QUOTES	STATEMENTS TO BE TESTED IN THE QUESTIONNAIRES
"But certainly ***the older architects are harder to deal with professionally however they're easier to deal with on a personal level."***	'Working with older architects (late career stages; close to retirement) can be difficult for BPS specialists because older architects are **FIRMLY ESTABLISHED IN THEIR WORKING PROCESSES**; which do not accommodate for BPS requirements.'
"Sometimes ***getting information out of them*** [older architects] ***can be difficult."***	
"The older guys just seem a bit more… "yeah, well just give them whatever they want to hear," ***instead of being quite thorough with it."***	
"There seems to be ***no urgency****, and* ***a lack of accuracy with it."***	'Architects **ALWAYS** provide BPS specialists with **THE RIGHT INPUT DATA** for BPS calculations, e.g. accurate u-values, thermal bridging calculations and chosen material properties.'
"I've never seen a thermal bridging calculation other than the one we've done ourselves. Architects never do them."	
"Accurate u-value calculations? A lot of assumptions are made and that's a reliance then on software, *as opposed to trying to remember when they* [architects] *went through their studies, and the mathematics side of the calculation being considered… reliance so much on the inaccurate information from manufacturers. And then I don't know maybe that's nothing to do with building simulation,* ***but it doesn't help if you're either not given the information to start with, or the information you're given isn't correct anyway."***	
"I think there are often architects who often ***don't understand what it is that we are trying to do,*** *from the sort of first principle perspective."*	'Architects **FULLY UNDERSTAND THE AIMS** of BPS specialists' work; making the relationship a fruitful one.'

Table 5.14. continued

INTERVIEW QUOTES	STATEMENTS TO BE TESTED IN THE QUESTIONNAIRE
"I doubt that sometimes the architects ***absorb any of the information,*** *because* ***it's just another report that has been commissioned and undertaken, and I don't know if it's ever going to influence anything in the design."***	'Architects **DO NOT ALWAYS ABSORB** any of the information given back to them from BPS specialists' calculations. To them it is 'just another report' that has been commissioned and undertaken; but **MAY NOT NECESSARILY** influence the building design.'
"Sometimes, they [architects] *don't want to change the outlook of their building. And you are struggling… depending on that particular decision, because they want the building to look very fancy very good outside…I know that sometimes architects gives trouble."*	'Generally, architects have a **FLEXIBLE WAY OF WORKING** with BPS specialists, and are **OPEN TO ANY SUGGESTIONS OR RECOMMENDATIONS** that are made as a result of the calculations.'
"The thermal modeller is the most important person, because he's the person who's going to decide either that approach, which is being suggested by the M&E consultant… are going to work or not… is it a good design or not."	'Architects tend to perceive BPS specialists' role as **AN INTEGRAL DESIGN TEAM MEMBER**; who directly impacts the building design.' 'Architects tend to perceive BPS specialists' role in the design team as a **NECESSITY REQUIRED** to prove that their building 'works.''

5.5.4 USING THE DEVELOPED STATEMENTS AS LIKERT-SCALE QUESTIONS IN THE QUESTIONNAIRES

Having developed a series of statements to confirm the existence of each non-technical barrier in the wider England and Wales context, a five-point Likert-scale was incorporated alongside each statement. The Likert-scale is a psychometric itemized rating scale named after the psychologist who developed it (Likert 1932). Likert-scales are commonly employed in questionnaires for the measurement of attitudes, personality traits or opinions (Himmelfarb 1993; Fink 1995a; Albaum 1997). The Likert-scale allows measurement of an individual's support or opposition toward the statement being tested; as well as the strength of support or opposition.[23]

[23] Support can be *'strongly agree'* or just *'agree.'*

In both questionnaires, balanced scales were used following the recommendation in the literature (Malhotra 2004; Malhotra and Peterson 2006); as balanced scales reduce the possibility that responses may be skewed in one direction or another. Therefore the number of support categories *(strongly agree or agree)* on the scale were equal to the number of opposition categories *(strongly disagree or disagree).* The middle point designated an impartial *'neither agree nor disagree.'* An example of the Likert-scale used to respond to each of the statements being tested is shown in figure 5.5.

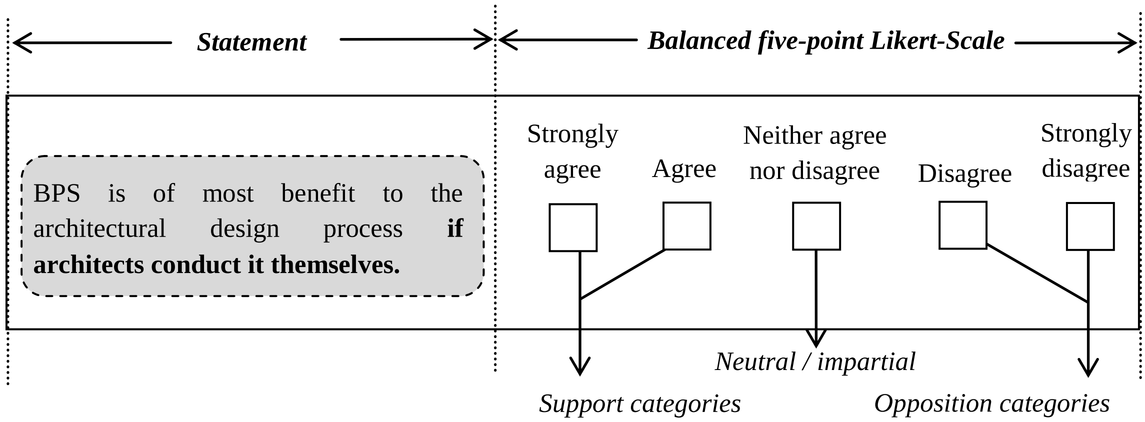


Fig. 5.5. Example of a balanced five-point Likert-scale question used in questionnaires 1 and 2.

5.5.5 ADDITIONAL BACKGROUND INFORMATION FROM ARCHITECTS AND BPS SPECIALISTS

In addition to the Likert-scale questions designed to test non-technical barriers extracted in section 5.4, few further questions were included in the questionnaires to collect background information from architects and BPS specialists. These questions were concerned with:

- Approaches currently followed to integrate BPS in the architectural design process (questionnaires 1 and 2).
- The RIBA Work Stage at which BPS is used to inform design decision-making (questionnaires 1 and 2).
- BPS specialists' educational backgrounds (questionnaire 2 only).

- How BPS is used in the architectural design process (questionnaire 2 only) [24].

5.5.5.1 Approaches currently followed to integrate BPS in the architectural design process (questionnaires 1 and 2)

This consisted of one multiple-choice question designed to ascertain whether architects in England and Wales predominantly rely on a collaborative approach with BPS specialists to inform design decision-making, or whether architects tend to conduct BPS calculations themselves (table 5.15).

Table 5.15. Showing questions about the approaches currently followed to integrate BPS in the architectural design process, included in both questionnaires 1 and 2.

ARCHITECTS (QUESTIONNAIRE 1)	BPS SPECIALISTS (QUESTIONNAIRE 2)
Which of the following approaches is most commonly used in your architectural practice to incorporate BPS?	**Which of the following approaches best describes the way you work with architects?**
☐ AN IN-HOUSE APROACH; BPS is conducted either by yourself or by another member of your architectural practice. ☐ A COLLABORATIVE APPROACH; BPS specialists from outside your architectural practice are appointed at some stage during the design process to conduct BPS. ☐ A COMBINATION OF THE ABOVE APPROACHES. ☐ Other (please specify here).	☐ AN IN-HOUSE APROACH; You are a BPS specialist working as part of an architectural practice. ☐ AN IN-HOUSE APPROACH; You are a BPS specialist working as part of a multi-disciplinary practice. ☐ A COLLABORATIVE APPROACH: You are a BPS specialist working as a member of a consultancy that specialists in mechanical design, HVAC design or sustainability consultations. Architectural practices consult with you to evaluate building performance at some stage throughout their design processes. ☐ Other (please specify here).

[24] Socio-demographic data, such as participants' age, years of experience, gender, location were not collected. This was a measure intended to ensure respondent-anonymity and therefore increase response rates, as discussed in chapter 6 (section 6.5).

5.5.1.2 RIBA Work Stage at which BPS is used to inform design decision-making (questionnaires 1 and 2).

This consisted of three multiple choice questions relating to the RIBA Work Stage at which BPS is integrated in the architectural design process. These questions were included to find whether BPS is used for early stage design decision-making in architectural practices in England and Wales; or whether uptake of BPS tends to be postponed until detailed design stages. Respondents to both questionnaires were asked to answer each question in table 5.16 by selecting the appropriate RIBA Work Stage in figure 5.6 to each question.

Table 5.16. Showing questions included in both questionnaires 1 and 2, about the RIBA Work Stages at which BPS is used to inform design decision-making.

ARCHITECTS (QUESTIONNAIRE 1)	BPS SPECIALISTS (QUESTIONNAIRE 2)
In your practice, at which RIBA Work Stage (A-L) is BPS initially incorporated and used in building projects?	**At which of the RIBA Work Stages (A-L) are you INITIALLY CONSULTED WITH to begin BPS calculations; simulating design performance.**
In your opinion, at which RIBA Work Stage (A-L) does initial incorporation of BPS promise most benefit?	**In your opinion, at which of the RIBA Work Stages (A-L) does INITIAL COLLABORATION with the architects promise most benefit to building performance?**
To gain the most benefit of BPS, BPS specialists should be kept on board a project UNTIL which RIBA Work Stage (A-L)?	**In your opinion, until which of the RIBA Work Stages (A-L) do you think BPS specialists should be kept ON BOARD A BUILDING PROJECT, as part of the design team?**

PREPARATION		DESIGN			PRE-CONSTRUCTION			CONSTRUCTION		USE
A	B	C	D	E	F	G	H	J	K	L
☐ Appraisal	☐ Design Brief	☐ Concept	☐ Design Development	☐ Tech. Design	☐ Production Information	☐ Tender Documentation	☐ Tender Action	☐ Mobilisation	☐ Construction to Practical Completion	☐ Post Practical Completion

Figure 5.6. Diagram of RIBA Work Stages incorporated into the questionnaires and used to answer the three questions shown in table 5.16.

5.5.1.3 BPS specialists' educational backgrounds (questionnaire 2 only)

The questions in this section were intended to interrogate BPS specialists' educational backgrounds further. The decision to include this set of questions was based on an observation noted during the qualitative research stage; that BPS specialists interviewed came from a variety of different educational and professional backgrounds. These questions were therefore included to further clarify whether there is a predominant formalised educational route traditionally undertaken by building professionals in England and Wales who become BPS specialists. A corresponding question in questionnaire 1; interrogating architects' educational routes was not designed, as it was assumed that the majority of architectural respondents would have undergone the educational route formalised by the Royal Institute of British Architects which would have permitted their inclusion into the UK traditional guild of architects[25].

Table 5.17. Questions about BPS specialists' educational backgrounds included in questionnaire 2 only.

QUESTIONS (BPS SPECIALISTS ONLY)	
Which of the following best describes your educational background (undergraduate degree)?	☐ Architecture ☐ Architectural engineering ☐ Architectural technology ☐ Building services engineering ☐ Renewable energy and sustainable technologies / Renewable energy systems engineering / Renewable energy and resource management ☐ Mechanical engineering / Mechanical and electrical engineering ☐ Heating, ventilation and air-conditioning (HVAC) / Heating, ventilation, air-conditioning and refrigeration (HVACR). ☐ Physics ☐ Other (please specify here)

[25] As indicated in chapter 6 (section 6.2.1), architects recruited into the quantitative research stage, and who therefore responded to the questionnaires, were all enlisted under the RIBA Chartered Members Directory.

Table 5.17. continued.

QUESTIONS (BPS SPECIALISTS ONLY)	
Did your degree deal exclusively with buildings?	☐ Yes, exclusively ☐ It predominantly dealt with buildings, but included other disciplines as well ☐ No, not at all.
Did you follow up this background degree with a postgraduate diploma or degree?	☐ Yes ☐ No
Please specify here what field of study your postgraduate diploma / degree was in.	

5.5.1.4 How BPS is used in the architectural design process (questionnaire 2 only).

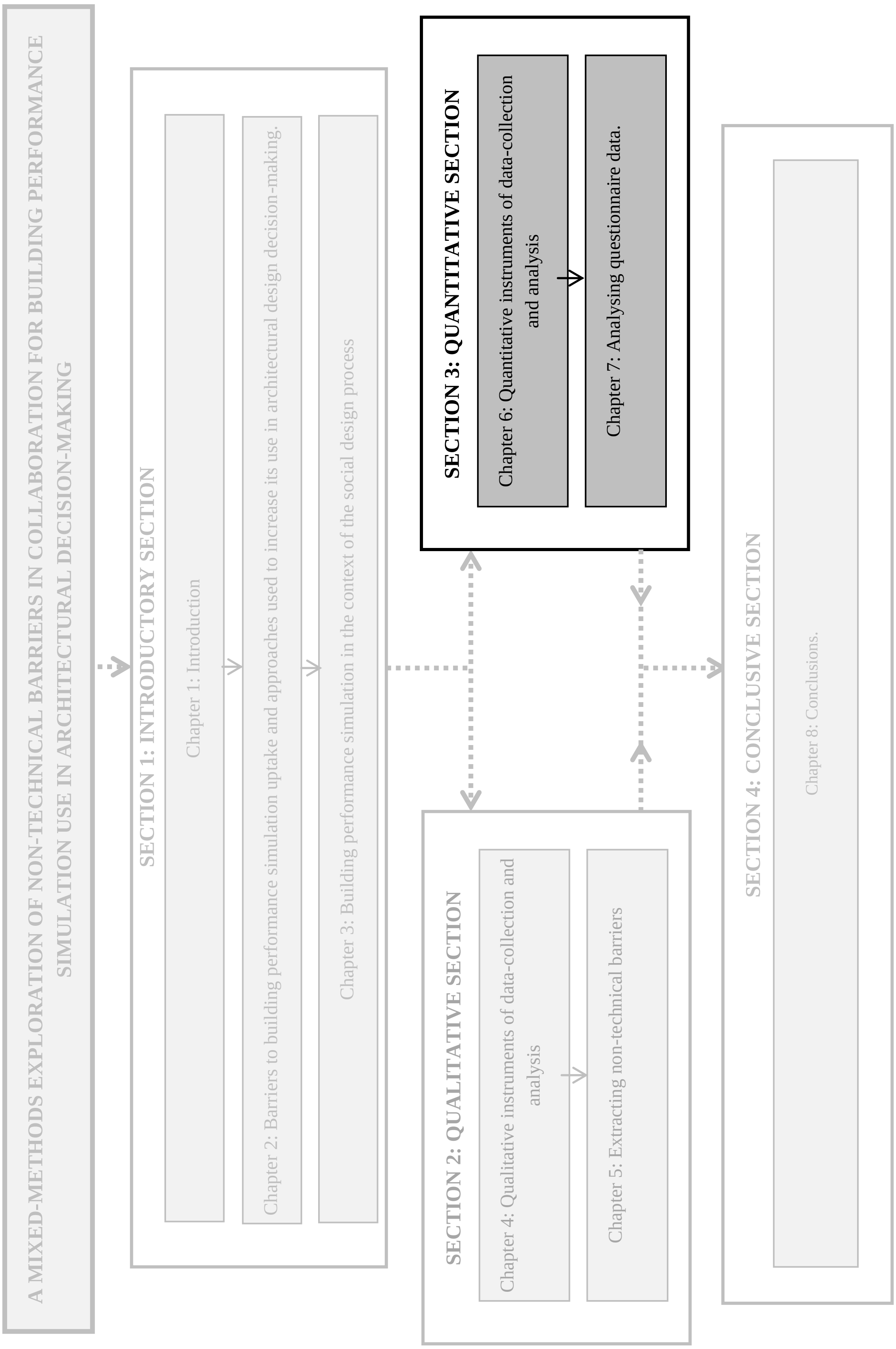
These consisted of two multiple-choice questions, asking BPS specialists about the range of services and types of modelling they tend to provide to architects, and the BPS software packages which they use to provide these services. Questions addressing this are shown in table 5.18.

Table 5.18. Questions about how BPS is used and the types of BPS software used by BPS specialists in England and Wales (questionnaire 2 only).

QUESTIONS (BPS SPECIALISTS ONLY)	
Generally, which of the following best encompasses the range of services that you or your practice provides to architects? (You may choose more than one).	☐ Dynamic simulation modelling for design purposes; to assist with building design decisions with regards to energy and performance throughout the RIBA Work Stages ☐ Modelling for compliance purposes; to ensure that the designed building satisfies regulatory requirements (Part L) and benchmark standards. ☐ A combination of both: modelling for design and compliance purposes; although the majority tends to be design work. ☐ A combination of both: modelling for design and compliance; although the majority tends to be compliance work. ☐ Other energy performance assessments (e.g. EPCs, DEC assessments, etc.) ☐ Services modelling ☐ Other types of work not mentioned above (please specify here).
What software do you mainly use to carry out your BPS calculations and/or energy assessments? (You may choose more than one).	☐ EnergyPlus + a plug-in interface such as OpenStudio ☐ DesignBuilder ☐ IES Virtual Environment ☐ TAS Thermal Analysis Simulation Software ☐ Autodesk Ecotect ☐ Autodesk Green Building Studio ☐ SBEM + iSBEM user interface ☐ ESP-r ☐ BIM Modelling software such as Autodesk Revit ☐ TRNSYS Transient System Simulation Tool ☐ Bentley Hevacomp Dynamic Simulation ☐ Other (please specify here)

Following the design of the Likert-scale statements and questions included in the questionnaires, the distribution of the two questionnaires to samples of architects and BPS specialists in England and Wales is discussed in chapter 6. Statistical tests performed to analyse the returned responses are also detailed in this chapter, to confirm the existence and prevalence of the extracted non-technical barriers in England and Wales.

SECTION 3; QUANTITATIVE SECTION



6. QUANTITATIVE INSTRUMENTS OF DATA-COLLECTION AND ANALYSIS

"He uses statistics as a drunken man uses lampposts – for support rather than for illumination" – Andrew Lang.

6.1 INTRODUCTION

This chapter marks the start of the second empirical stage of this thesis; the quantitative stage. The purpose of this quantitative stage was to answer the third 'sub'-question of the overarching research question;

> ***'Can we confirm the existence and prevalence of non-technical barriers* [extracted in chapter 5] *amongst architects and BPS specialists practising in England and Wales?'***

To answer this third 'sub'-question, two questionnaires were designed based on the interviews with architects and BPS specialists in the preceding qualitative research stage. Interview quotes were used to design a set of statements to re-test each non-technical barrier extracted in section 5.4 of chapter 5; to confirm the existence of these barriers and to determine whether they are experienced amongst the wider population of architects and BPS specialists in England and Wales.

These two questionnaires were distributed to samples of architects and BPS specialists in England and Wales; calculated based on the procedures described in section 6.2 of this chapter. The questionnaires were also piloted locally to pre-test their design as well as their reliability and validity (section 6.3). In section 6.4, the data-collection procedure through online distribution of the questionnaires is discussed, and response rates of architects and BPS specialists are discussed in section 6.5. Finally, the procedures of statistical analyses followed to analyse these returned responses are presented in section 6.6 of this chapter.

6.2 POPULATIONS AND SAMPLES OF ARCHITECTS AND BPS SPECIALISTS

As mentioned in chapter 5 earlier (section 5.5), two questionnaires were designed; questionnaire 1 for architects and questionnaire 2 for BPS specialists. Accordingly, it was also necessary to construct two samples which were representative of the populations of architects and BPS specialists in England and Wales.

Equal-probability systematic sampling; a random sampling technique which ensures that all members of the population have an equal chance of being selected, was used to generate:

Sample A: of architects; respondents to questionnaire 1.

Sample B: of BPS specialists; respondents to questionnaire 2.

However, constructing these two samples architects first entailed determining the population sizes of architects and BPS specialists in England and Wales (sections 6.2.1 and 6.2.2 respectively.), and then deriving the representative samples from these two populations (section 6.2.3).

6.2.1 DETERMINING THE POPULATION OF ARCHITECTS IN ENGLAND AND WALES

The RIBA Chartered Members Directory (RIBA 2011b) was assumed to be a comprehensive compilation of UK architects, from which the sample of architects in England and Wales could be extracted. This is not to suggest that the entire population of practising UK architects are all listed within this directory. A more accurate register of all UK architects is maintained by the Architects Registration Board (ARB); as "*ARB's register is the only statutory register of architects in the UK. Every architect whose name appears on the register has met the standards set by the ARB for education, experience and practice, and has the legal right to use the title **'architect'**"* (ARB 2012).

However, during the time at which the questionnaires were distributed (October 2011-March 2012), in frequent cases the e-mail addresses of each architect on the ARB register could not be found. Often the only contact address available was a postal address or a phone number. These were considered inadequate contact details for this research because the questionnaires were to be distributed online[1]. Thus, if a sample was constructed from the ARB register, the assumption of random-sampling required in many of the statistical tests would not have been met[2]. On this basis, the RIBA Chartered Members Directory was used for its provision of full contact details; including email addresses, for each enlisted architect.

[1] Online distribution of questionnaires is detailed in section 6.4.
[2] An assumption of several statistical tests includes random sampling; which must be satisfied before the statistical tests can be undertaken.

Another limitation faced during sampling was that there was no accurate way to ensure that the sample had knowledge, interest or experience in BPS. The only possible way to infer this would have been by checking the website of the architectural practice each sampled architect was employed for. However, unless use of BPS was explicitly stated within the practice interests and ethos, there was no way of accurately determining whether BPS was used. Furthermore, an indication that BPS is used within the architectural practice does not necessarily mean that the sampled architect necessarily has any knowledge of it. Moreover, if such an approach had been followed, architects sampled on this basis could not be considered 'random.' Despite these limitations, which are acknowledged to be a source of sampling error[3], the population of practising architects on the RIBA Chartered Members Directory was found to be 2304 architects (N_A=2304).

6.2.2 DETERMINING THE POPULATION OF BPS SPECIALISTS IN ENGLAND AND WALES

The population of BPS specialists within the UK building industry was less identifiable than that of architects. While associations such as the RIBA and the ARB have firm criteria of who an architect is based on *"education, experience and practice"* (ARB 2012), a parallel set of criteria determining who a 'BPS specialist' is could not be found.

A parallel association representing BPS specialists is the International Building Performance Simulation Association (IBPSA) (IBPSA 2012). However, both the scale of operation and role of involvement of IBPSA differs phenomenally from that of ARB or RIBA for architects. The role and efforts of IBPSA are mainly channelled in the research direction; as stated in the mission statement; *"IBPSA is founded to advance and promote the science of building performance simulation in order to improve the design, construction and operation of new and existing buildings worldwide"* (IBPSA 2012). Moreover, IBPSA operates at an international scale; although IBPSA-England and IBPSA-Scotland function as subordinate regional affiliates of IBPSA-world. Within IBPSA-England, no comprehensive list of BPS specialists practising in England could be found on the affiliate website (IBPSA England 2012). A regional affiliate 'IBPSA-Wales' does not exist. Therefore, while IBPSA is most symbolic of the interests and praxis of BPS specialists, a population of BPS specialists working in England and Wales could not be obtained from this association.

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[3] Sampling error is calculated in section 6.2.4.

Instead, a directory provided by the Register of Low Carbon Consultants, provided by the Chartered Institute of Building Services Engineers (CIBSE) was used to construct a comparable population of BPS specialists (CIBSE 2012). According to the definition provided by CIBSE, 'Low Carbon Consultants' listed in this register are *"...professionals competent to minimize energy use and carbon emissions from buildings both in design and operation"* (CIBSE 2011). No specific mention of BPS is included in this description. However, it was assumed that the majority of professionals who specialise in reduction of carbon emissions from buildings will need to have knowledge of BPS software to facilitate their work. Although this list does not provide an accurate and comprehensive construction of the population of UK BPS specialists; it was considered the closest possible listing available with full contact details. This register was therefore used to determine the population of BPS specialists in England and Wales; which was found to be 1029 BPS specialists (N_{BPS} = 1029).

6.2.3 CONSTRUCTING THE TWO SAMPLES

The two sample sizes were calculated using equation 6.1 as provided by Czaja and Blair (1996). It is important to note that this equation is for large populations of several thousand; and does not take the original population size into account. Therefore, the correction factor for finite populations (equation 6.2) provided in (Czaja and Blair 1996) was used, as the two samples were being derived from smaller populations; of several hundred rather than several thousand.

$$\boldsymbol{Sample\ size} = \frac{\boldsymbol{Z^2 \times p \times (1-p)}}{\boldsymbol{m}^2}$$

Such that:

Z = the confidence level. 95% confidence level means Z = 1.96.

p = worst case percentage, expressed as a decimal. Conservative value = 0.5.

m = margin of error, expressed as a decimal. 95% confidence level means m = .05.

Equation 6.1. Used to calculate the sample sizes of architects and BPS specialists from their respective populations.

$$New\ sample\ size\ = \frac{sample\ size}{\left[\frac{(sample\ size - 1)}{population}\right] + 1}$$

Equation 6.2. Correction factor for finite populations.

Based on equation 6.1 with the correction factor (equation 6.2), and for a confidence level of 95%[4], the sample of architects required which would be representative of the total population was 329 architects (n_A = 329). The sample of BPS specialists representative of the population of BPS specialists was 280 (n_{BPS} = 280).

In equal probability systematic sampling, a sampling interval is needed to systematically select members of the sample from the population; and to ensure that each member of the sample has an equal chance of being sampled. Equation 6.3 (Czaja and Blair 1996) was used to determine the interval size; for the selection of members to be included in architects' and BPS specialists' samples.

$$Interval\ size\ = \frac{N}{n}$$

Such that:

N = Total population

n = Sample size (calculated from equation 6.1).

Equation 6.3 Used to calculate interval sizes, to determine members of the population of architects and BPS specialists to be included within the samples.

According to equation 6.3, a sampling interval of 7 was used to derive the sample of 329 architects from the total population of 2304 architects. A random starting point was chosen at the third architect listed. Architects selected for participation were numbered 3, 10, 17, 24, 31, 37, 44, etc., until 329 architects had been sampled. For the BPS

[4] A confidence level of 95% means that the researcher has 95% certainty associated with the statistics generated from the sample. In other words, if the same questionnaire was conducted 100 times, the data retained would be in the same range in at least 95 of those questionnaires. Confidence levels are selected by the researcher; and a confidence level of 95% is commonly used in social science statistics (Czaja and Blair 1996).

specialists, a sampling interval of 4 was chosen based on equation 6.3. A random starting point was chosen at the second BPS specialist on the list. Subsequent BPS specialists sampled were those numbered 2, 6, 10, 14, 18, 22, etc., until 280 BPS specialists had been sampled and contacted.

6.2.4 SAMPLING ERROR

Sampling error is the proportion of inaccuracy in constructing the sample. The greater the size of the sample constructed, the lower the likelihood of sampling errors (Czaja and Blair 1996). In reality, sampling errors are inevitable; as the only way to completely avoid sampling error is by sampling the entire population into the study (Fink 1995b). Equation 6.4 provides a rough estimate of the percentage of sampling error for a 95% confidence interval (Czaja and Blair 1996).

$$\boldsymbol{Sampling\ error\ = \frac{1}{\sqrt{N}}}$$

Where N = sample size.

Equation 6.4 Used to calculate sampling error.

Based on equation 6.4, an estimated sampling error for the architects' sample was calculated to be 0.0551, or 5.51%. For BPS specialists, sampling error was calculated to be .0597, or 5.597%.

6.3 PRE-TESTING THE QUESTIONNAIRES

A pilot study was conducted to pre-test both questionnaires and to estimate the approximate time required to complete the questionnaires. Similar to the interview pilot (chapter 4, section 4.2.3.3), the questionnaire pilot was also carried out locally at the Welsh School of Architecture. Architects and BPS specialists among staff and postgraduate students were considered subsets of both professional groups targeted in this research. Piloted respondents were known by the researcher to have an adequate understanding of the research topic to allow them to fully comprehend the questionnaires and complete them. Therefore, miscomprehension of any questions was likely to be due to errors in questionnaire design rather than lack of respondent-knowledge.

Sixteen pilot respondents pre-tested the questionnaires in total. Eight architects tested questionnaire 1 and eight respondents who routinely conduct BPS tested questionnaire 2. Pilot respondents were asked to make note of any comments which arose and to record the amount of time taken to complete their respective questionnaires. Face-to-face meetings were then conducted with each pilot respondent for feedback and observations.

Recurrent observations related to questionnaire length and wording were made. Pilot respondents noted that it took them between forty minutes up to one hour to complete their questionnaires; whereas the researcher had aimed for the questionnaire to be completed between twenty to thirty minutes. A reduction was therefore made in the content of the final versions of the questionnaires. Some questions were eliminated and others were merged. Also based on feedback from the pilot, few statements designed from the interviews[5] were re-worded and biased statements were neutralised.

6.3.1 QUESTIONNAIRES' VALIDITY AND RELIABILITY

The pilot study was also useful in ascertaining the validity of the two questionnaires. Validity is broadly defined as, *"the degree to which an assessment measures what it is supposed to measure,"* (Sushil and Verma 2007). A number of different types of validity can be tested to determine whether the questionnaire design effectively gauges the concept being assessed in the questions; e.g. face validity, content validity, convergent validity and construct validity (Bryman 2001). However, most of these validation types and techniques frequently rely on comparing the questionnaire design and/or early results to pre-existing theories, or similar instruments of measurement. Construct validity is one such example; whereby validation is achieved by deducing hypotheses from pre-existing theories underlying the research topic or question (Bryman 2001). Convergent validity is another type of questionnaire validation, in which the newly-designed questionnaire is compared to a pre-existing questionnaire used to measure the concept in question (Bryman 2001).

However, it was not possible to apply validation techniques such as construct and convergent validity to the two questionnaires described in this chapter. This is because the questionnaires were designed to re-test qualitative inferences arrived at in the

[5] Chapter 5, section 5.5.

previous empirical research phase, but did not have any foundation in pre-existing literature discussing collaboration between architects and BPS specialists. Moreover, because there is no empirical work in this area; there are virtually no empirical instruments developed to test non-technical barriers in collaboration between architects and BPS specialists; making this the first attempt. Despite being an evident limitation in this research stage, **employment of questionnaires to test non-technical barriers in collaboration constitutes an addition to the body of knowledge.**

Nevertheless, face validity of the two questionnaires were ascertained during the pilot stage of the research. Face validity is essentially a subjective type of validation, which involves having the research instrument assessed by experts in the field; such as researchers. Because the pilot study was conducted at an academic and research facility, amongst researchers who have experience in the practical field as well; they were found suitable to test the validity of the questionnaires at face value.

Moreover, the reliability of the questionnaires was also tested. Bryman (2001) defines the reliability of a questionnaire as, *"the consistency of a measure of a concept."* Measuring internal reliability in a questionnaire is particularly important for questions which consist of multiple statements measuring a single item (e.g. negative attitudes toward BPS, or trust dynamics between architects and BPS specialists).

Internal reliability is ascertained by measuring the correlations between each of the statements; as the expectation is that the responses given to multiple statements testing the same overarching question would essentially correlate highly with each other. Because testing reliability can only be conducted once at least some responses have been returned[6], internal reliability of the questionnaires was ascertained after the questionnaire had been distributed[7] and returned by thirty respondents. At this point, data-collection was paused and once the internal reliability was checked and deemed appropriate, the researcher proceeded with further data-collection.

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[6] Internal reliability could not be fully-ascertained at the pilot stage because modifications were made in the questions based on the feedback from the pilot respondents. Moreover, few of the piloted respondents did not fully complete the questionnaire. In their understanding that the exercise was conducted to test the questionnaire designs, few preferred not to complete the questionnaires and waited until the face-to-face meeting to provide oral feedback to each of the questions in the questionnaires. Although this was a beneficial approach, it meant that the responses could not be tested for internal reliability for lack of aggregate statistical data produced in the pilot stage. Therefore, questioning internal reliability was postponed until the early stages of questionnaire-distribution.

[7]Data-collection is discussed in the subsequent section of this chapter (section 6.4).

Internal reliability is commonly ascertained using a correlation co-efficient called Cronbach's alpha (α); which examines the degrees of correlation between several statements or questions intended to measure the same underlying concept. The calculation for Cronbach's α is incorporated into the statistical analysis software[8] used to analyse the returned responses[9]. If there is strong internal consistency between the questionnaire-items, a strong correlation co-efficient is yielded. A correlation coefficient above .7 or above is commonly considered an acceptable measure of internal consistency.

In most quantitative studies; it is common that only one value is quoted for Cronbach's α. However, in this study; two questionnaires were designed and distributed; which consisted of several barriers being tested. Therefore, it was necessary to compute Cronbach's α for each barrier area addressed in both questionnaires. The results in table 6.1 show that both questionnaires are internally consistent.

Table 6.1. Cronbach's α measuring internal reliability of each set of statements testing non-technical barriers in both questionnaires.

QUESTIONNAIRE 1; ARCHITECTS		QUESTIONNAIRE 2; BPS SPECIALISTS	
CONSTRUCT BEING TESTED	**Cronbach's α**	**CONSTRUCT BEING TESTED**	**Cronbach's α**
Negative attitudes toward BPS	.715	Negative attitudes toward BPS	.749
Attitudes toward Part L of the building regulations	.758	Attitudes toward Part L of the building regulations	.841
Trust dynamics between architects and BPS specialists	.713	Trust dynamics between architects and BPS specialists	.724
The client discouraging early collaborations between architects and BPS specialists.	.991	-	N/A
-	N/A	Communication between architects and BPS specialists	.702
-	N/A	Relationships between architects and BPS specialists	.705

[8] PASW Statistics 18, commonly known as 'SPSS.'

[9] Statistical analyses performed on the returned responses are defined and described in detail in section 6.6 of this chapter.

6.4 DATA-COLLECTION PROCEDURE

Both questionnaires were launched on the online survey tool SurveyMonkey[10] on 17th October 2011; and both were available for 166 days. To distribute the questionnaires, members of both samples were contacted via email requesting their participation in the study; with a web-link to the questionnaire.

Online distribution of questionnaires was chosen for the advantages it offers. Online questionnaires could easily be distributed across a geographically widespread area (Wright 2006). They are also both time and cost-efficient; particularly in comparison to postal questionnaires[11]. Online questionnaires could be completed either immediately or in respondents' own time. Response-return was also flexible; respondents did not have to go through the hassle of depositing the questionnaire at a pre-allocated spot; or returning it via post. Instead, completed questionnaires were returned immediately at the click of the 'submit' button at the end of the survey. Moreover, the online tool allowed incorporation of custom designs, visual images and interactive methods of answering questions. Such interactivity tends to encourage respondents to make the effort in completing the questionnaire, and increases participation (De Vaus 2002).

Using online survey software also bore advantages on the analytical process. Each response returned fed into automatically-constructed reports and preliminary descriptive statistics. Responses were also automatically initially-coded and exported in a file-format compatible with the statistical analysis software package used[12]. These features unquestionably facilitated the process of data-input into the statistical analysis software package.

However, one of the known limitations of online questionnaires is low-response rate (Kaplowitz et al. 2004; Wright 2006)[13]. The threat of low response rate was heightened in the case of this research because both samples consisted of busy professionals with heavy workloads and responsibilities. Random and unsolicited emails requesting voluntary research participation were easily ignored or overlooked. Three measures were therefore taken in the questionnaire-designs to overcome threats of low-response rate:

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[10] www.surveymonkey.com

[11] Distributing postal questionnaires involves printing out and posting hundreds of questionnaires; which is a time-consuming and expensive process.

[12] Statistical analysis is discussed in section 6.6.

[13] Response rates for the two questionnaire are discussed in section 6.5.

- **No personal information was collected from respondents; such as name, ethnicity, age and years of experience,** as recommended by Fowler (2002). Attitudes and opinions were elements of central interest in both questionnaires. However, these may be considered sensitive information; particularly because these were opinions of **another branch of the building industry and another professional's work.** A potentially strongly-opinionated participant may choose to withhold his/her viewpoints or possibly to 'tone them down;' if fearing recognition, or if attribution of the opinion to oneself was harmful to his/her career.

  Refraining from collecting personal information was initially considered an opportune trade-off to increase participation and honest conveyance of opinions. However, it was later recognised that not collecting ***any*** personal information at all meant that basic sample demographics, such as age, gender or years of experience could not be provided; which limited the analysis considerably. During the analytical stage comparisons could only be conducted based on profession; whereas collecting more personal information may have allowed further trends to be uncovered; based on years of experience or gender for example. **This has been recognised as a research-limitation to be taken into consideration in future research conducted in this area.**

- **The majority of questions designed were closed-ended** [14] to reduce completion-time. Often, when faced with many open-ended questions, respondents may become bored and discard the questionnaire.

- **Reminder emails;** having been sent initial emails requesting participation, reminder emails were further sent to sampled respondents.

6.4.1 ETHICAL CONSIDERATIONS

Despite administering the questionnaires in complete anonymity; measures were taken to ensure that data was collected ethically. These measures were approved by the

[14] These were predominantly the Likert-scale statements designed based on the interview quotes; as shown in chapter 5 (section 5.5).

Research Ethics Committee at the Welsh School of Architecture before distribution; in October 2011 under the reference of EC1110.090[15].

A brief introduction to the research project was provided in the body of the emails requesting respondents' participation. Once the questionnaire was accessed via the web-link enclosed in the email; respondents could then read more detailed information on the introductory page of the questionnaire. The following additional information was provided to respondents; and those who agreed to proceed with the questionnaire were requested to acknowledge and accept the forthcoming points as a way of providing their fully-informed consent;

- **Assurance of voluntary participation:** Respondents were informed that their participation in the survey was voluntary. They were notified that they could withdraw their participation at any time; and were informed how to do so within the template of the online survey.

- **A prediction of questionnaire completion-times:** Having tested the questionnaires' completion times in the pilot, an estimate of between twenty to thirty minutes for completion was provided as a guideline.

- **How the data would be used:** Respondents were informed that the responses they provide would only be used to *"produce aggregate statistical data."*

- **Access to the data:** Respondents were assured that only members of the research team would have access to the data-collected. Given widespread concerns of internet privacy and security, participants were informed that the online survey settings were configured to ensure that results were not available to the public.

- **Contact details:** As the researcher's own university email address was used to send requests out to sampled participants; each participant duly received the researcher's contact details.

[15] Approval of the Welsh School of Architecture Research Ethics Committee is shown in Appendix G.

6.5 RESPONSE RATES

218 responses to questionnaire 1 were returned from sampled architects, and 175 of these responses were deemed suitable for analysis (table 6.2). 148 responses to questionnaire 2 of the questionnaire were returned, all of which were deemed suitable for statistical analysis (table 6.2).

Table 6.2 Architects' and BPS specialists' response rates.

		ARCHITECTS	BPS SPECIALISTS
SAMPLE APPROACHED		**329**	**280**
TOTAL RESPONSES RETURNED		**218**	**148**
	Unanswered	*43*	*0*
	Partially answered	***38*** *Analysed*	***22*** *Analysed*
	Fully answered	***137***	***126***
RESPONSE RATE		**53.2%**	**52.8%**

6.5.1 IMPLICATIONS OF NON-RESPONSE ON RESULTS' GENERALIZATION

323 responses were collected for both questionnaires; yet this response rate only slightly exceeds 50% for both architects' and BPS specialists' populations. Baruch (1999) argues that non-response is inevitable, and that academic researchers should not expect a response rate of 100%. However, as no demographic data was collected from either sample, there was no way of ascertaining whether the samples were fully representative of the two populations, or whether the non-response experienced had resulted in biased samples of architects and BPS specialists.

To address this issue of non-response, literature on the subject was examined for potential solutions. Three possible solutions were found:

<u>Solution 1; using correction factors</u>

Barclay et al. (2002) recommend in cases of non-response that characteristics of both respondent and non-respondent groups are examined to ascertain the degree of differences between the two groups, and the degree to which they both represent the population. If sample-bias is found to be an issue due to non-response, correction factors can be used on the results to make them represent the entire population.

However, in the case of this research, correction factors could not be used because;

- There was no accurate enumeration of the original populations of architects and BPS specialists from which samples derived could be considered representative, as discussed in sections 6.2.1 and 6.2.2.

- No personal information or demographic information regarding age, gender or years of experience in the building industry was collected, as discussed in section 6.4. It was therefore not possible to examine characteristics of either the respondent or non-respondent groups.

<u>Solution 2; comparing the response rates of this research to response rates of questionnaires in the same research area</u>

Baruch (1999) highlights that in academic research; there is no standard benchmark for minimum acceptable response rates. However, in his survey of academic journal publications from sociology and behavioural sciences which claimed generalization from questionnaire results; an average response rate of 55.6% was reported (Baruch 1999). According to Baruch (1999) this should be used as the norm for acceptable response rates in studies based on questionnaires. Thus, the response rates obtained for architects and BPS specialists in this research study are similar to Baruch's (1999) benchmark average of 55.6%; making them acceptable response rates.

Furthermore, in BPS literature using questionnaires, comparable instances were found in the studies of Attia et al. (2012), Pilgrim et al. (2003) and Raslan and Davies (2010). Attia et al. (2012) and Pilgrim et al. (2003)'s contributions are similar to the one in this thesis as they both examine specialised populations of architects and engineers. Moreover, Attia et al. (2012) also use two questionnaires; one aimed at architects and one aimed at BPS specialists. However, comparable values for acceptable response rates could not be ascertained from either of these studies. In Attia et al. (2012) sampling issues were not addressed; despite having a total of over 800 responses. The authors state that their research is *"based on an open sample"* and therefore, *"cannot be proven to be representative of the engineering or architectural community"* (Attia et al. 2012). Sampling issues were also not addressed in Pilgrim et al.'s (2003) study which was also based on what was described as an open sample[16]. However, the response rates of the two questionnaires presented in this chapter were found to lie within a similar range as

[16] A total of only 62 analysable responses were retained from a total sample of 82 building industry professionals.

the response rate quoted in Raslan and Davies' (2010) questionnaire-based study. This was approximately 56%; or 280 returned responses from a total sample of 500 potential participants.

Solution 3; examining inter-relationships between variables rather than analysing each variable individually

Blair and Zinkhan (2006) argue that results'-generalization from a reduced sample is only of concern when variables are examined in isolation from the others in the questionnaire, and then absolute levels of these variables are used to make claims about the population. However, when relationships and associations between variables are examined (e.g. correlations) **sampling bias arising from non-response are self-adjusted** (Blair and Zinkhan 2006). Therefore, the issue of collecting data from a representative sample is less of an issue for generalization when the analysis is relational.

Blair and Zinkhan's (2006) argument provided further reassurance that; despite the reduced response rate, the results yielded from the statistical tests may be representative of architects' and BPS specialists' populations in England and Wales; as in most of the statistical analysis in chapter 7, variables were analysed relationally[17]. Reassurance was also gained because rates of non-response for both architects' and BPS specialists' samples are similar; implying that chances of bias in both samples are also similar. Similar chances of bias in both samples make the results from architects and BPS specialists more comparable. Nevertheless, where associations between the variables were not examined or responses from the two samples were not compared; **it is highlighted in the relevant parts of chapter 7 that the analysis pertains to the sample of architects and/or BPS specialists from which the data was collected only.**

6.5.2 COMPARISON OF ARCHITECTS' AND BPS SPECIALISTS' RESPONSE SPEED

Although architects' and BPS specialists' response rates represent similar proportions of the two populations, **a notable contrast was visible in the speed at which architects and BPS specialists returned their questionnaires.** Architects' responses were returned at a much slower rate; and over a longer time-period than BPS specialists' responses. This difference is illustrated in the line-graph tracking questionnaires returned in figure 6.1.

[17] The data-analysis procedure and statistical tests used in chapter 7 are presented in section 6.6 to follow.

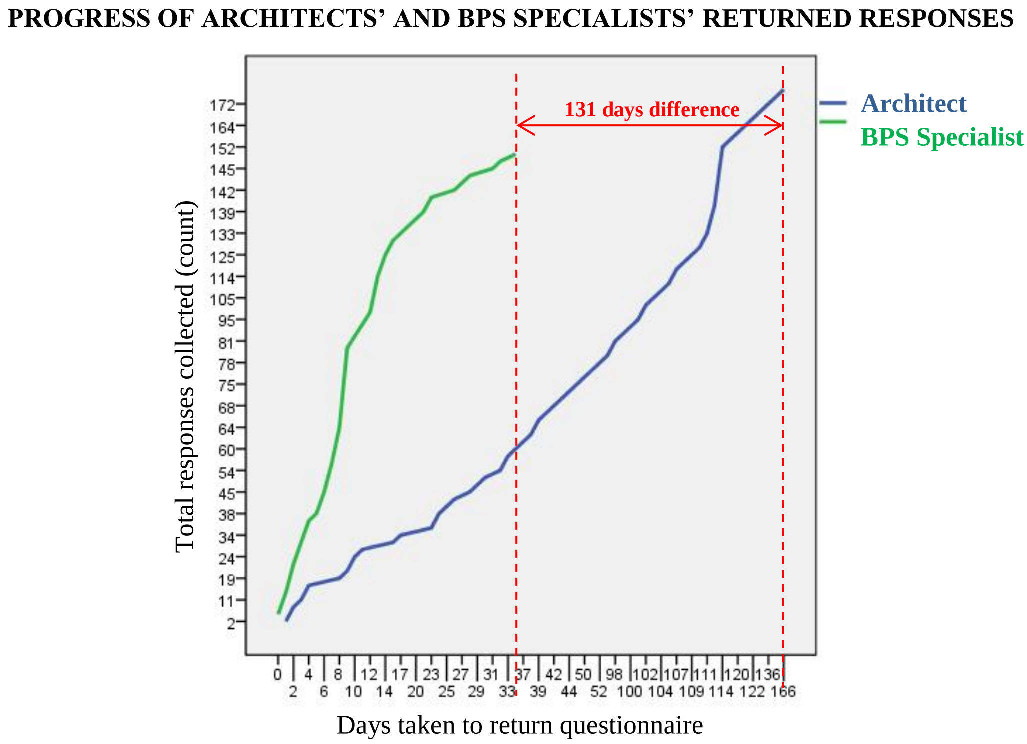


Fig. 6.1. Contrasting architects' and BPS specialists' response rates.

Moreover, throughout the data-collection process, a more positive reaction was experienced from sampled BPS specialists than architects. Several expressions of interest were made through email from BPS specialists; noting the pertinence of the research topic, detailing their own experiences collaborating with architects and requesting a copy of the results once they become available[18]. However, no comparable expressions of interest were received from architects.

The contrast in these response rates and expressions of interest might indicate that BPS specialists sampled are more conscious of non-technical barriers in collaboration than architects. This is probably because they are keener on finding solutions; explaining their enthusiasm in the emails.

6.5.3 TREATMENT OF MISSING DATA

The final issue to deal with arising from response rates was how to treat missing questionnaire data. As shown in table 6.2 earlier, 38 architects and 22 BPS specialists partially-completed their respective questionnaires. For the architects' data-set, missing

[18] Examples of these emails are shown in Appendix H.

fields constituted 11.3% of the data-set. For the BPS specialists, of 8.4% of the data-set was missing.

Although these are relatively large percentages, these missing data-fields were random in the data-sets of both architects and BPS specialists. **In this case therefore, the 'exclude cases pairwise' option in the statistical analysis software was used in the forthcoming statistical tests.** This option means that any missing values were only dropped from individual statistical tests in which they appeared; rather than from the entire data-set. The alternative option of excluding cases which were partially-completed from the entire data-set [19]; and therefore only including fully-completed responses given by respondents in the analysis was undesirable, as this would have resulted in a larger reduction of the sample size included in the analysis.

6.6 DATA-ANALYSIS PROCEDURE AND STATISTICAL TESTS

The quantitative nature of the data collected in the questionnaires pre-determined the statistical nature of the analysis undertaken. Statistical analyses were performed using the package **P**redictive **A**nalysis **S**oft**W**are (PASW Statistics 18)[20].

Returned responses to the questionnaires were analysed in three stages:

1. Data common to both architects' and BPS specialists' questionnaires were analysed together, to allow architects' and BPS specialists' results to be compared. These data were concerned with the following non-technical barriers:

- Negative attitudes toward BPS
- Stereotyping
- Negative attitudes toward Part L and compliance
- Trust dynamics between architects and BPS specialists and opportunism.

2. Data which was present in the architects' questionnaire were analysed. These were primarily concerned with the role of the client discouraging early collaborations between architects and BPS specialists.

3. Data which was present in the BPS specialists' questionnaire were analysed. These were concerned with:

[19] This is known in the statistical analysis software as 'excluding cases listwise.'
[20] Formerly known as 'SPSS.'

- Communication between architects and BPS specialists.
- BPS specialists' perceptions of their relationships with architects.

Because the data analysed at stages 1 and 3 consisted of a large number of variables which could not be analysed individually, the first procedure undertaken at each of these stages was **exploratory factor analysis.** This is a form of data-reduction used to summarise the data and quickly reveal meaningful information from it. The rationale and steps of exploratory factor analysis are explained in detail in section 6.6.1. Once the data had been summarised, composite scores were generated for each factor following the procedure explained in section 6.6.2, to determine the samples' central tendencies, and to conduct further statistical tests on the newly-summarised data. These statistical tests are defined in section 6.6.3.

Only a small number of variables were analysed at stage 2 (analysing data present in the architects' questionnaire only). Therefore, an exploratory factor analysis was not needed at this stage; and the variables were analysed by forming a composite variable (section 6.6.2) to understand the extent to which architects agree or disagree that project clients discourage early collaborations between architects and BPS specialists.

6.6.1 DATA-REDUCTION; EXPLORATORY FACTOR ANALYSIS

Exploratory factor analysis is the process of grouping individual variables around a central theme; or a factor (Field 2005). This clustering of variables is based on the correlation co-efficients between them. High inter-correlations between variables suggest that they may be collectively examining an underlying factor; and these variables are accordingly grouped together. This grouping allows the original raw data to be reduced to a much smaller number of underlying factors; albeit the smallest possible number of factors which best summarise the original data-set. This data-reduction is a multi-step process;

6.6.1.1 <u>Step 1: Preliminary analysis.</u>

The first step in the analysis is to ensure that the data available is suitable for factor analysis; with respect to variable inter-correlations and sample size.

Variable inter-correlations

In order for factor analysis to be suitable to the data-set; there must be high inter-correlations between the variables, and these correlations must be statistically significant. Variable inter-correlations are examined through a correlation matrix; which is generated by the statistical analysis software.

An example of the correlation matrix is shown in figure 6.2. It consists of two parts; the top part shows correlation co-efficients and the bottom part shows significance values. It is recommended in the literature that variables with correlation co-efficients either below or above the range of .3-.9 should be removed (Field 2005). Variables which have a majority of significance values greater than .05 are therefore non-significant correlations, and should also be removed (figure 6.2).

		Variable 1	Variable 2	Variable 3	Variable 4	Variable 5	Variable 6	Variable 7	Variable 8	Variable 9	Variable 10
CORRELATION CO-EFFICIENTS	Variable 1	1.000	.549	-.194	-.398	-.311	-.460	-.580	.449	.696	.811
	Variable 2	.549	1.000	-.167	-.194	-.232	-.163	-.035	.078	.222	.149
	Variable 3	-.394	-.467	1.000	.765	.402	.480	.326	-.875	-.130	-.071
	Variable 4	-.598	-.594	.365	1.000	.226	.130	.777	-.306	-.357	.429
	Variable 5	-.311	-.232	.402	.526	1.000	.435	.340	-.439	-.528	-.358
	Variable 6	-.260	-.163	.480	.130	.435	1.000	.271	-.105	-.130	-.181
	Variable 7	-.580	-.435	.326	.877	.340	.671	1.000	-.841	.732	.422
	Variable 8	.649	.378	-.475	-.806	-.939	-.805	-.741	1.000	.304	-.376
	Variable 9	.696	.722	-.330	-.457	-.428	-.530	.432	.304	1.000	.151
	Variable 10	.111	.149	-.071	.029	-.058	-.181	.122	-.076	.151	1.000
SIGNIFICANCE VALUES	Variable 1		.000	.001	.000	.000	.000	.094	.210	.001	.034
	Variable 2	.000		.003	.001	.000	.003	.280	.100	.000	.007
	Variable 3	.001	.003		.003	.000	.000	.000	.109	.018	.121
	Variable 4	.000	.001	.003		.000	.016	.000	.462	.179	.317
	Variable 5	.000	.000	.000	.000		.000	.000	.259	.000	.170
	Variable 6	.000	.003	.000	.016	.000		.000	.042	.018	.001
	Variable 7	.094	.280	.000	.000	.000	.000		.010	.305	.022
	Variable 8	.210	.100	.109	.462	.259	.042	.010		.475	.104
	Variable 9	.001	.000	.018	.179	.000	.018	.305	.475		.007
	Variable 10	.034	.007	.121	.317	.170	.001	.022	.104	.007	

These variables should be removed because the majority of their correlation coefficients are less than .3

These variables should be removed for having a majority of significance values greater than .05.

Fig. 6.2. Example of a correlation matrix consisting of variables' correlation coefficients and significance values.

Analysis of sample size

The sample size from which the data has been derived must also be analysed in this preliminary stage. The larger the size of the sample, the more reliable the results of the factor analysis. The sample size is analysed using two statistical tests.

- The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy (Kaiser 1974): The cut-off point for the KMO statistic is .5; a result below .5 indicates that the sample is not large enough for factor analysis. On the other hand, the closer the value generated for the KMO statistic to 1, the greater the probability that reliable factors will be yielded from this sample. This is a value generated by the statistical analysis software.
- The Bartlett's test of spherecity (Bartlett 1954): To confirm that the sample is suitable; and that factor analysis can therefore applied to this sample, this test must yield a significant result; i.e. $p < .05$. This test is also run by the statistical analysis software.

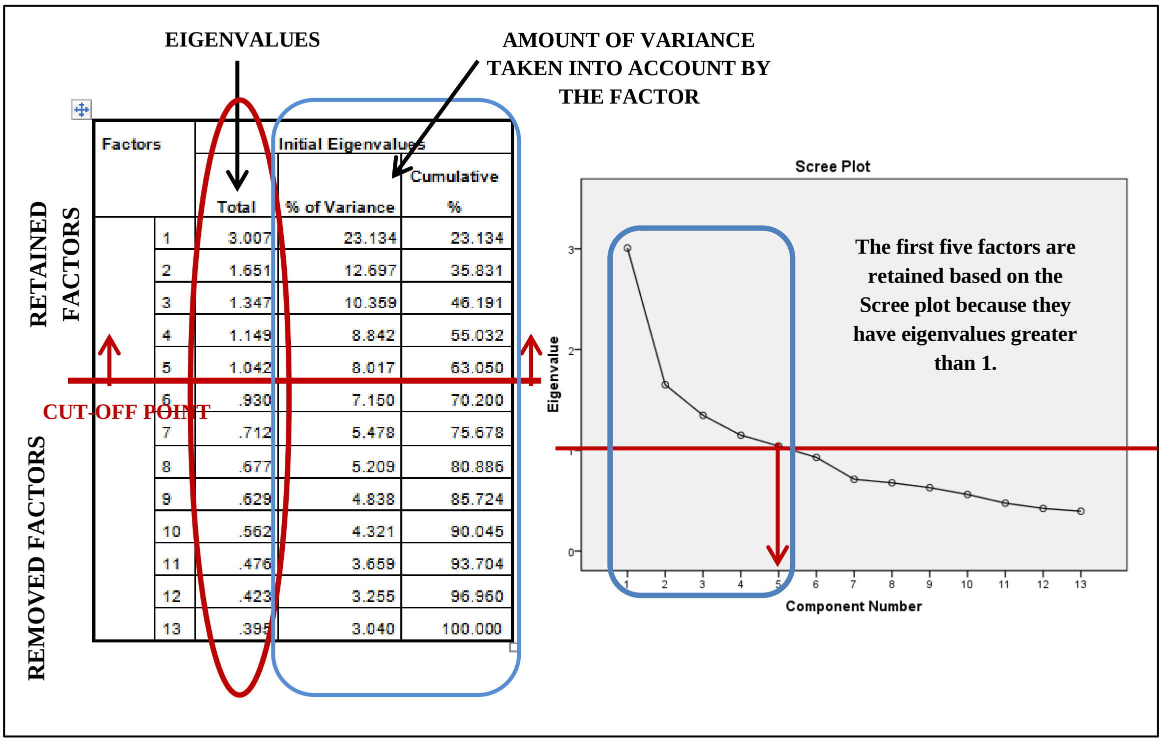
6.6.1.2 Step 2; Mathematical process of factor extraction

Once the variables and sample have been analysed and deemed appropriate for factor analysis, the next step is **to extract the underlying factors which best summarise all the variables.** Factor extraction can be done using two mathematical procedures; either Principal Components Analysis (PCA) or Factor Analysis (FA) (Field 2005; Pallant 2007). However, (PCA) is the most widely employed procedure of factor extraction in social science research because it is simpler mathematically (Stevens 1996; Pallant 2007); hence PCA was also used in this research.

The PCA calculation generates several factors. Also generated alongside each factor is a numerical value called an eigenvalue; as shown in figure 6.3. The eigenvalue of a factor is basically a value which indicates the total amount of variance accounted for by that factor (Pallant 2007). A factor with a large eigenvalue indicates that this factor takes a large amount of variance into account[21]; meaning that this factor is comprehensive enough to summarise all the information in the associated variables. In factor analysis; factors with associated eigenvalues greater than the value of 1 are retained (Kaiser 1960); and these are the factors which are considered to best summarise all the raw

[21] A large variance is needed to retain factors because the objective of exploratory factor analysis is to summarise the original data-set into the smallest possible number of factors which best describe the data. Therefore each factor should account for the **maximum amount of variance** within the data; which is why only large eigenvalues are retained.

variables. The extracted factors and their eigenvalues are also shown in a Scree Plot in the statistical analysis package. In the Scree Plot, the factors are plotted on the X-axis and their eigenvalues on the Y-axis. By drawing a line at the value of 1 on the Y-axis; this shows the number of factors which are to be included within the factor analysis. Extracting factors using the Scree Plot is also is illustrated in figure 6.3.



Factors	Initial Eigenvalues Total	% of Variance	Cumulative %
1	3.007	23.134	23.134
2	1.651	12.697	35.831
3	1.347	10.359	46.191
4	1.149	8.842	55.032
5	1.042	8.017	63.050
6	.930	7.150	70.200
7	.712	5.478	75.678
8	.677	5.209	80.886
9	.629	4.838	85.724
10	.562	4.321	90.045
11	.476	3.659	93.704
12	.423	3.255	96.960
13	.395	3.040	100.000

Fig. 6.3. Factor extraction using eigenvalues and the Scree Plot.

The factors and eigenvalues shown in figure 6.3 are known as the unrotated factor solution. The main problem of this unrotated factor solution is that most variables will load highly onto the most important factor, and the other factors will have much smaller factor loadings (Field 2005). The unrotated factor solution is difficult to interpret because of this characteristic, and needs to be corrected to make it easier to differentiate between the factors. The way to correct it is by **rotating the solution.** According to Field (2005); *"if a factor is a classification axis along which variables can be plotted, then factor rotation effectively rotates these factor axes such that variables are loaded maximally to only one factor."* Factor rotation therefore does not modify the data; it changes our viewpoint and the way we interpret the data. This alternate viewpoint is considered a more accurate way of viewing the output.

In the outputs of the statistical analysis package, the table of initial eigenvalues shown earlier in figure 6.4 is accompanied by another set of columns which present the rotated factors and their eigenvalues; as shown in figure 6.4. A number of methods of rotation are available within PASW Statistics 18. In this research, a method called Varimax rotation was used because it provides solutions which are easier to interpret and describe than the solutions provided by other rotation methods (Tabachnick and Fidell 2007).

Unrotated solution **Rotated solution**

Factors	Initial Eigenvalues			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.007	23.134	23.134	2.160	16.612	16.612
2	1.651	12.697	35.831	1.924	14.798	31.409
3	1.347	10.359	46.191	1.493	11.482	42.891
4	1.149	8.842	55.032	1.366	10.506	53.397
5	1.042	8.017	63.050	1.255	9.653	63.050
6	.930	7.150	70.200			
7	.712	5.478	75.678			
8	.677	5.209	80.886			
9	.629	4.838	85.724			
10	.562	4.321	90.045			
11	.476	3.659	93.704			
12	.423	3.255	96.960			
13	.395	3.040	100.000			

Fig. 6.4. Showing the unrotated and rotated factor solutions.

6.6.1.3 <u>Step 3; Output; factor loadings</u>

As mentioned in the general description (section 6.6.1), exploratory factor analysis works by clustering variables together into factors. This clustering is known in factor analysis as **factor loading;** and variables which are grouped around the same factor are known to ‘load onto that factor.’

In order to find the variables which load highly onto each factor; a figure called the ‘factor loading’ is provided. The factor loading is basically a correlation co-efficient which demonstrates the correlation between each variable and the factor onto which it has loaded. Variables which have a factor loading greater than .4 are known to 'load highly onto the factor.' By examining the variables which load highly onto the extracted factors, the meaning or underlying theme of that factor can be interpreted; as shown in the example in figure 6.5.

VARIABLES	COMMUN-ALITIES	FACTORS	
		1	2
VARIABLE 1: BPS does not come under the umbrella of 'real' architecture.	.682	.789	
VARIABLE 2: The numerical nature of BPS is too regulatory and controlling.	.608	.760	
VARIABLE 3: The 'language' of BPS is too difficult to understand for architects.	.598	.670	
VARIABLE 4: Preparation for BPS inputs, and interpreting BPS outputs, are very bureaucratic tasks.	.625	.551	
VARIABLE 5: Architects generally tend to have positive attitudes towards BPS.	.585	-.704	.503
VARIABLE 6: BPS is of most benefit to the architectural design process if BPS specialists collaborate with architects.	.710		-.756
VARIABLE 7: BPS is of most benefit to the architectural design process if architects conduct it themselves.	.666		.738

The communality of a variable is the proportion of each variable with the others.

Communalities above the value of .3 confirm that the variables share common variance.

Factor loading values

Variables 1-5 load highly onto Factor 1.
These variables all indicate negative attitudes towards BPS. Therefore, factor 1 can be interpreted to measure the underlying theme entitled 'Negative attitudes towards BPS.'

Variables 5-7 load highly onto Factor 2.
These variables all indicate positive attitudes towards BPS. Therefore, factor 2 can be interpreted to measure the underlying theme entitled 'Positive attitudes towards BPS.'

Fig. 6.5. How factor loadings can be used to interpret the underlying theme addressed by each extracted factor.

The example of the output shown in figure 6.5 also demonstrates how the procedures of exploratory factor analysis have summarised a data-set of seven original variables into two factors which best describe the data. However, exploratory factor analysis does not 'analyse' the data; meaning that no conclusive outcomes can be deduced by applying factor analysis to the data alone. Therefore, further statistical tests are needed to deduce conclusive findings from this newly-summarised data (sections 6.6.2-6.6.3).

6.6.2 GENERATING COMPOSITE SCORES FOR EACH FACTOR

Following the exploratory factor analysis, a composite score was generated for each factor, to determine the sample's central tendency, and therefore their extent of agreement or disagreement to the factor. Generating composite scores meant that further statistical tests could also be conducted to investigate each factor further.

For illustrative purposes, factor 1 shown in figure 6.5 in this section is used to show how the variables which loaded highly onto this factor were used to generate composite scores for this factor. This factor was named 'Negative attitudes toward BPS' and consisted of five variables which had loaded highly onto it.

The original responses to each of these five variables were first coded on an interval scale[22]; such that strongly agree = 1, agree = 2, etc. until strongly disagree = 5. This means that the closer the coded response is to 1, the higher the strength and extent of agreement; as shown in figure 6.6.

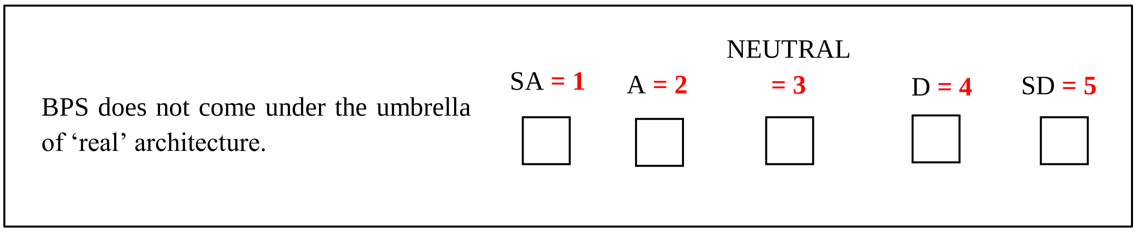


Fig.6.6. System used to code Likert-scale variables.

Each of the coded values for each of the variables were summed and divided by five; to generate a new composite score for each respondent (figure 6.7). This new score represents the respondent's level of agreement or disagreement to factor 1, as shown in the example in figure 6.7.

[22] In this research, Likert-scale data was treated as interval data; assuming that the distances between each point on the Likert-scale are equidistant; and could therefore be measured. All arithmetic operations can be performed on this data, and central tendency of the data is measured using the mean.

	SA	A	N	D	SD	**Coded values:**
BPS does not come under the umbrella of 'real' architecture.	☑	☐	☐	☐	☐	**1**
The numerical nature of BPS is too regulatory and controlling.	☐	☑	☐	☐	☐	**2**
The language of BPS is too difficult for architects to understand.	☐	☐	☐	☐	☑	**5**
Preparation for BPS inputs, and interpreting BPS outputs, are very bureaucratic tasks.	☐	☐	☐	☑	☐	**4**
Architects generally DO NOT tend to have positive attitudes toward BPS.	☐	☐	☑	☐	☐	**3**

Newly-generated composite score for factor 1 = 3

Fig. 6.7. Calculating a composite score for each respondent for factor 1.

6.6.3 STATISTICAL TESTS

Following the exploratory factor analysis and calculation of composite scores for each extracted factor, three types of statistical tests were used to analyse the newly summarised data:

- Independent samples t-test
- One way ANOVA
- Pearson's correlation.

Each of these is defined and explained in table 6.3.

Table 6.3. Statistical tests used in chapter 7.

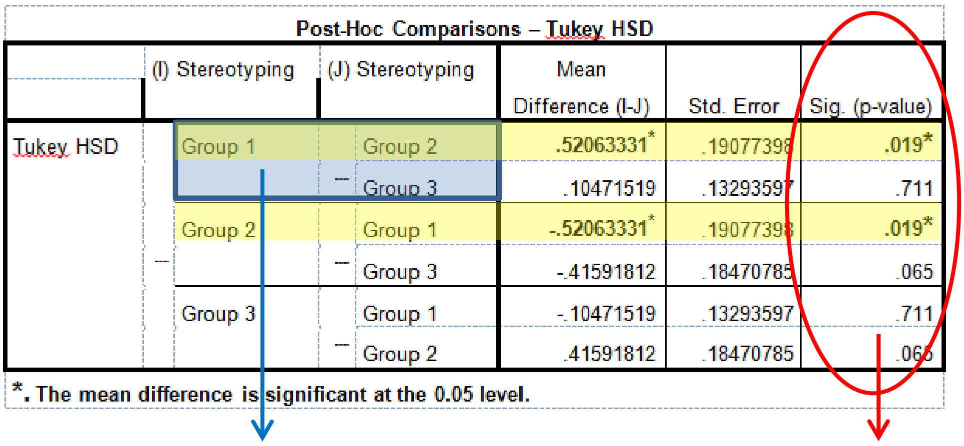
TEST	WHEN IT IS USED	RESULTS	
		Reported statistics	Significance[23] (p-value)
INDEPENDENT SAMPLES T-TEST	To compare the mean scores of **two different; independently sampled groups of people.**	- The t-statistic: value obtained from the t-test. It represents the difference between the mean scores of the two groups; taking any variation in the scores into consideration. This is often reported alongside the degrees of freedom used to compute the output[24]; e.g: $t(261) = 4.596$ - Means (M) and standard deviations (SD): for each of the two groups.	- The p-value: indicates whether the difference reported in the test statistic is statistically significant. A p-value between .00 and .05 indicates that there is a significant difference between the means of the two groups.
ONE-WAY ANALYSIS OF VARIANCE (ANOVA)	Similar to the t-test, but it is used to compare mean scores of **more than two groups of people;** i.e. three or more.	- The F-statistic: value obtained from the one-way ANOVA. This value is reported with two associated degrees of freedom; e.g.: $F(3,130) - .389$ - Means (M) and standard deviations (SD): for each of the two groups.	- The p-value: is also used to report whether there is a statistically significant difference between the groups. Although a p-value lower than .05 shows that there is a significant difference, **it does not tell us where this significant difference lies (i.e. between which of the three or more groups).** For example, if the ANOVA is being used to compare between three groups of people, the p-value will not indicate if this significant difference lies between: a) Group 1 and group 2 b) Group 1 and group 3 c) Group 2 and group 3. - Post-Hoc comparisons using Tukey HSD test: applied to the results of the ANOVA once a significant difference has been found, to allocate the specific groups between which significant differences can be found. In other words, Post-Hoc comparisons allow us to determine whether the significant difference lies between: a) Group 1 and group 2 b) Group 1 and group 3 c) Group 2 and group 3 (figure 6.8).

[23] Statistical significance is an indication of how likely the obtained result may have occurred by chance. A significant result means that the result is unlikely to have occurred by chance, and is therefore a true result. An insignificant result means that a similar result is unlikely to be obtained if the same test were to be repeated.

[24] Degrees of freedom (df) are the maximum number of values in the final calculation which are free to vary. They are used to minimise the error in the statistical results. When performing the calculation by hand, degrees of freedom are obtained by looking them up in standardised tables. However, using PASW Statistics 18 means that the software does this process while computing the final output.

Table 6.3. continued. Statistical tests used in chapter 7.

TEST	WHEN IT IS USED	RESULTS	
		REPORTED STATISTICS	SIGNIFICANCE (p-value)
PEARSON'S CORRELATION	Used to determine **whether there is a relationship between two variables;** and the direction and strength of this relationship.	<u>- Pearson's correlation co-efficient (r):</u> This is a measure of the strength of the association between the two variables being measured. The value reported typically lies between –1 and +1. A positive number indicates a positive correlation; i.e. as one variable increases the other also increases. The closer the numerical value is to either -1 or +1, the stronger the correlation. If the value is 0 or close to 0, there is no relationship between the two variables.	<u>- The p-value:</u> is used to report whether the correlation found is a significant result. When the p-value is lower than .05, this indicates that the correlation is significant.



Post-Hoc Comparisons – Tukey HSD

	(I) Stereotyping	(J) Stereotyping	Mean Difference (I-J)	Std. Error	Sig. (p-value)
Tukey HSD	Group 1	Group 2	.52063331*	.19077398	.019*
		Group 3	.10471519	.13293597	.711
	Group 2	Group 1	-.52063331*	.19077398	.019*
		Group 3	-.41591812	.18470785	.065
	Group 3	Group 1	-.10471519	.13293597	.711
		Group 2	.41591812	.18470785	.065

*. The mean difference is significant at the 0.05 level.

The test compares Group 1 with both Groups 2 and 3.

Column to be used to determine the groups between which a statistically significant difference in the means can be found.

Based on the significance (p-value) in the final column, we can conclude that there is a significant difference in the means between Groups 1 and 2.

Fig. 6.8. Example of Post-Hoc comparisons using a Tukey HSD test used to compare the differences between more than three groups. In this case there is a significant difference between groups 1 and 2 (highlighted fields).

6.7 SUMMARY OF QUANTITATIVE INSTRUMENTS

In this chapter, instruments of data-collection and analysis used in the second empirical stage of this research were described. Details pertaining to sampling, data-collection and procedures of statistical analysis were addressed between sections 6.2-6.6. The procedures of statistical analysis and statistical tests defined in section 6.6 were applied in chapter 7; to confirm the existence of non-technical barriers extracted in chapter 5, and to arrive at conclusive findings about each of these barriers.

7. ANALYSING QUESTIONNAIRE DATA

"Why speculate when you can calculate?" – John Baez.

7.1 INTRODUCTION

In this results chapter; data collected from the questionnaires are analysed following the procedures described in chapter 6 (section 6.6). Following a summary of background data from both questionnaires presented in section 7.2, barriers which were mutually addressed in both architects' and BPS specialists' questionnaires are analysed in comparison in section 7.3. In section 7.4, a barrier which was only present in the architects' questionnaire is analysed. On the other hand, in section 7.5, barriers which were only addressed in the BPS specialists' questionnaire are analysed and presented.

Finally, in the conclusive section of this chapter, results for each of the non-technical barriers addressed in these questionnaires are summarised and listed. Results which could not be generalized are also presented for the sample of architects and BPS specialists from which the quantitative data was drawn. The statistical results for each non-technical barrier in this chapter are then triangulated in chapter 8 with the corresponding qualitative inferences made in chapter 5 to form overarching research findings.

7.2 BACKGROUND DATA FROM ARCHITECTS' AND BPS SPECIALISTS' QUESTIONNAIRES

Data concerning respondent-demographics; such as age, years of experience or gender were not collected, therefore it was not possible to compute a full profile of the respondents. However, background data was collected from both questionnaires concerning;

- Approaches architects followed to allow BPS to inform their decision-making (i.e. whether they collaborate with BPS specialists or conduct BPS in-house).
- The point in the design process at which BPS is initially incorporated in architectural decision-making.
- BPS specialists' educational backgrounds.
- Software used by BPS specialists to perform their calculations.

These summary and descriptive statistics from the architects' and BPS specialists' respective questionnaires are presented in sections 7.2.1 and 7.2.2.

7.2.1 BACKGROUND DATA FROM ARCHITECTS' QUESTIONNAIRE

Approaches followed by architects in England and Wales to integrate BPS in the design process and allow it to inform their decision-making

The bar-chart shown in figure 7.1 shows the approaches followed by architects practising in England and Wales used to integrate BPS in their design decision-making.

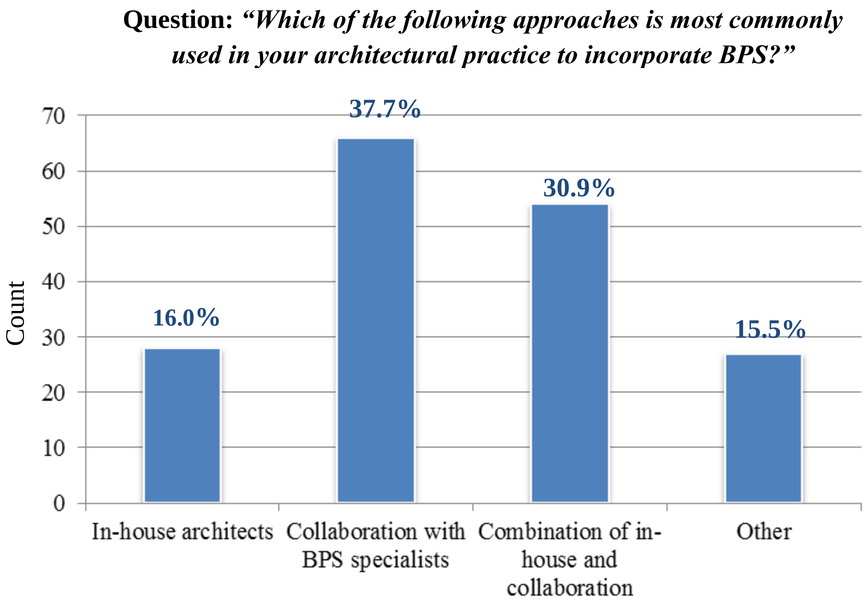


Fig. 7.1. Approaches used by architects in England and Wales to integrate BPS in their design decision-making.

This data indicates that a collaborative approach is most commonly followed for BPS integration rather than an in-house approach relying entirely on architects. It is also indicated that architects often combine in-house BPS calculations with collaborations with external BPS specialists. These data underline the importance of collaborations between architects and BPS specialists in England and Wales; in total 68.6% of architects follow an approach which includes a collaborative element; as opposed to only 16.0% of architects who conduct BPS calculations themselves. Moreover, the statistics further corroborate the starting point upon which this PhD research is based (highlighted in chapter 2, section 2.5.2); **that architects predominantly rely on**

collaborations with BPS specialists to allow BPS to inform their design decisions. This is proven true for architects in England and Wales.

<u>When do architects in England and Wales initially incorporate BPS to inform their design decisions, and when do they ***think*** they should initially incorporate BPS?</u>

The graph shown in figure 7.2 shows architects' responses to two questions; addressing **when BPS is initially used** in their architectural practices, and **when they think BPS should actually be used** in the architectural design process[1].

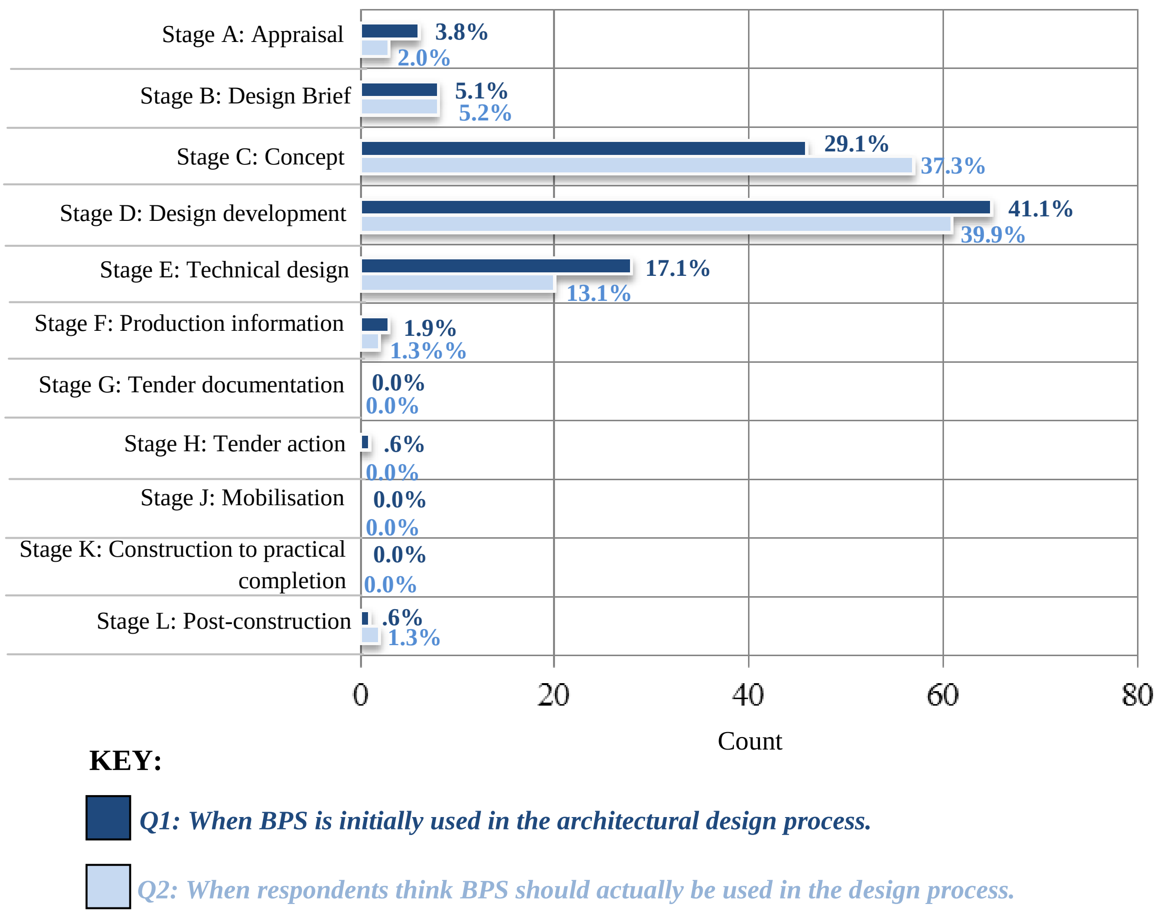


Fig. 7.2. The RIBA Work Stage at which architects in England and Wales initially incorporate BPS; and the RIBA Work Stage at which they think initial incorporation of BPS offers most benefit.

[1] The RIBA Work Stages are used here as a common and systematic break-down of the stages of the design process commonly recognised in England and Wales.

These statistics indicate that BPS is mostly incorporated between RIBA Work Stages C and D (70.2%) in architectural practices in England and Wales. This result aligns with the widespread concern voiced in much BPS literature cited in chapter 2; that BPS is commonly utilised at later stages when the design has already been fixated (Attia and De Herde 2011; Donn 2001; Massen et al. 2003 to cite a few).

However, the architects' responses to the second question arguably demonstrate greater cause for concern. In this question, respondents were asked when they ***think*** BPS should initially be incorporated; for increased benefit to the design process. Here, there was a difference (+8.2%) in architects' choice of RIBA Work Stage C; and a difference in their selection of RIBA Work Stage D (-1.2%). However, the fact that most responses were still centralised around Work Stages C and D; rather than Stages A or B for example, suggests that the architects in general do not feel a change in their working practices is necessary; with respect to when to use BPS in design decision-making.

7.2.2 BACKGROUND DATA FROM BPS SPECIALISTS' QUESTIONNAIRE

BPS specialists' educational backgrounds

The pie-chart in figure 7.3 shows a break-down of BPS specialists' educational backgrounds. It indicates that BPS specialists in England and Wales originate from a variety of backgrounds; rather than having undergone a single formalised educational route. However, the majority originate from building services engineering and mechanical engineering backgrounds. Those who originated from 'other' backgrounds mentioned that they had undergraduate degrees in civil engineering, aerospace engineering, interior design, environmental science and environmental management.

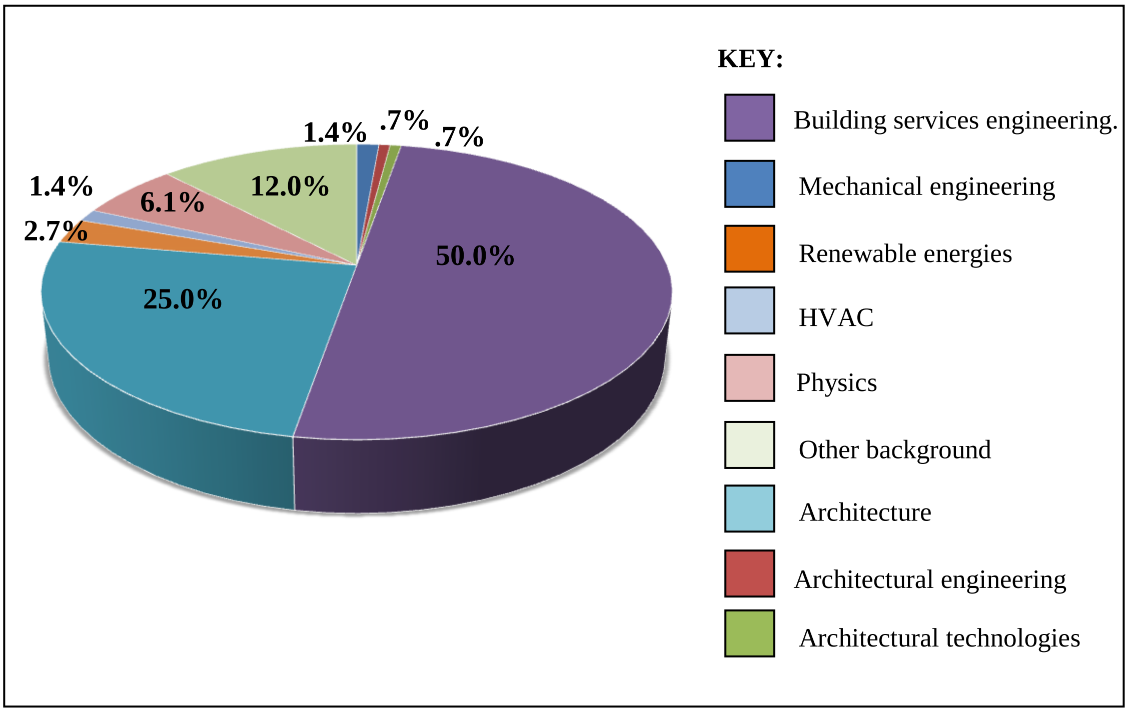


Fig. 7.3. BPS specialists' educational backgrounds

<u>Uses of BPS within the design process</u>

The bar-chart shown in figure 7.4 to follow indicates the uses of BPS within the design process. It is important to note that this was a question in which respondents were allowed to choose multiple answers. 61% of the respondents chose combinations of choices 1-4. This therefore indicates that 61% of architects in England and Wales routinely undertake a combination of both modelling for design purposes and compliance purposes; rather than being focused entirely on either BPS for design purposes or BPS for compliance purposes.

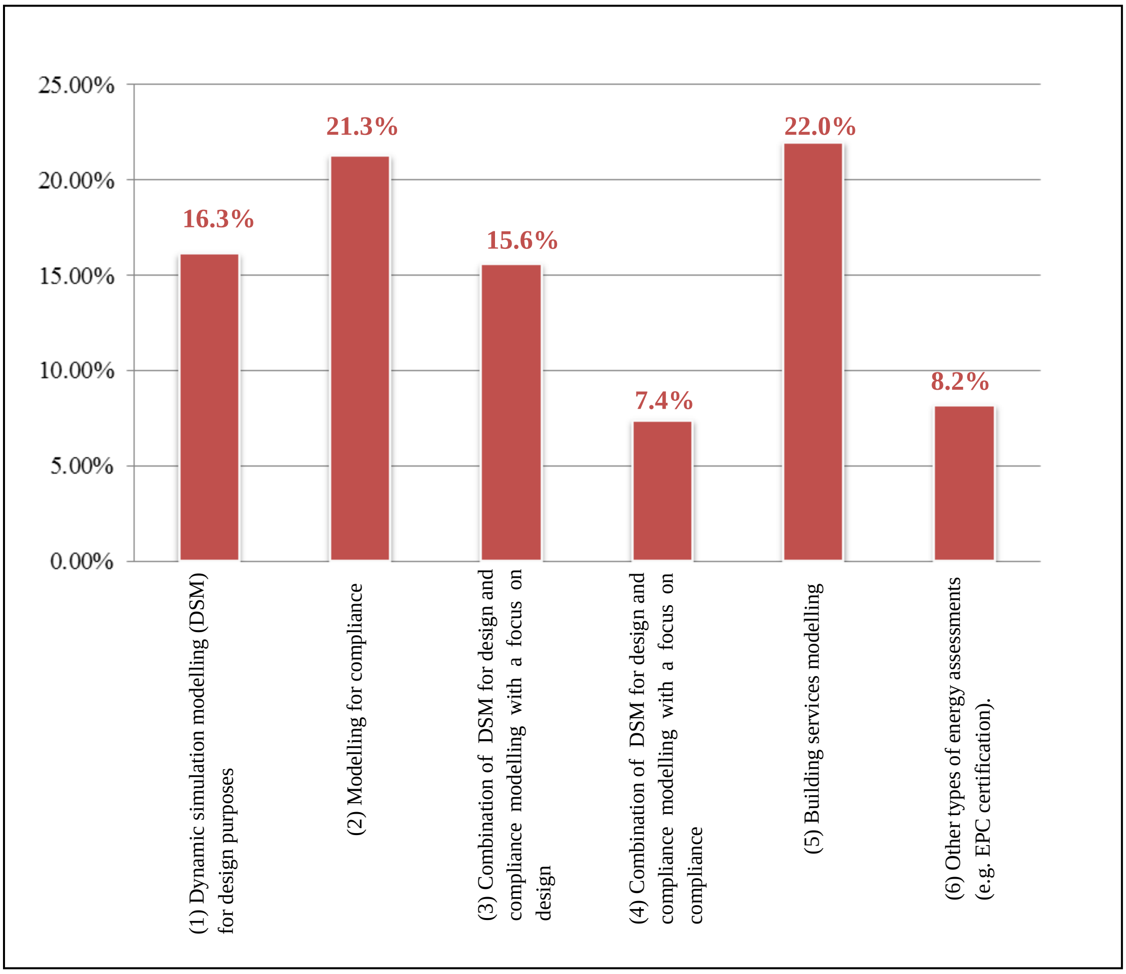


Fig. 7.4. Types of BPS modelling services provided by BPS specialists in England and Wales

7.3 DATA COMMON TO BOTH ARCHITECTS' AND BPS SPECIALISTS' QUESTIONNAIRES

In this section, barriers which were commonly addressed in both architects' and BPS specialists' questionnaires are examined and compared. Comparing the differences between architects' and BPS specialists' responses allows arrival at conclusions pertaining to the following non-technical barriers discussed earlier in chapter 5.

- Architects' attitudes towards BPS.
- Perceptions of the purpose of BPS as a compliance requirement.
- Trust dynamics between architects and BPS specialists.

A series of Likert-scale variables addressing these three thematic categories are therefore compared and discussed in section 7.3.1. In section 7.3.2, the barrier of stereotyping is examined in detail based on the quantitative results. This barrier was initially questioned in chapter 5 but there was not enough qualitative data to confirm that architects and BPS specialists have stereotypical impressions of each other[2].

7.3.1 ARCHITECTS' ATTITUDES TOWARDS BPS, PERCEPTIONS OF THE PURPOSE OF BPS FOR COMPLIANCE AND TRUST BETWEEN ARCHITECTS AND BPS SPECIALISTS.

Twenty-two variables common to both architects' and BPS specialists' questionnaires, collectively addressed architects' attitudes towards BPS, perceptions of BPS as a compliance requirement and trust dynamics between architects and BPS specialists. Figure 7.5 presents the extents of agreement to each variable for architects and BPS specialists; and their percentages. A framework of statistical analyses is illustrated in figure 7.6 for navigational purposes; to map the sequence of statistical tests performed on these twenty-two variables.

[2] The barrier of stereotyping was not questioned on a Likert-scale; which is why it has been presented in a separate subsection of section 7.3. Instead, it was posed to respondents in a 'yes-or-no' type question followed by an open-ended question asking respondents to detail what stereotypical impressions architects and BPS specialists tend to have of each other.

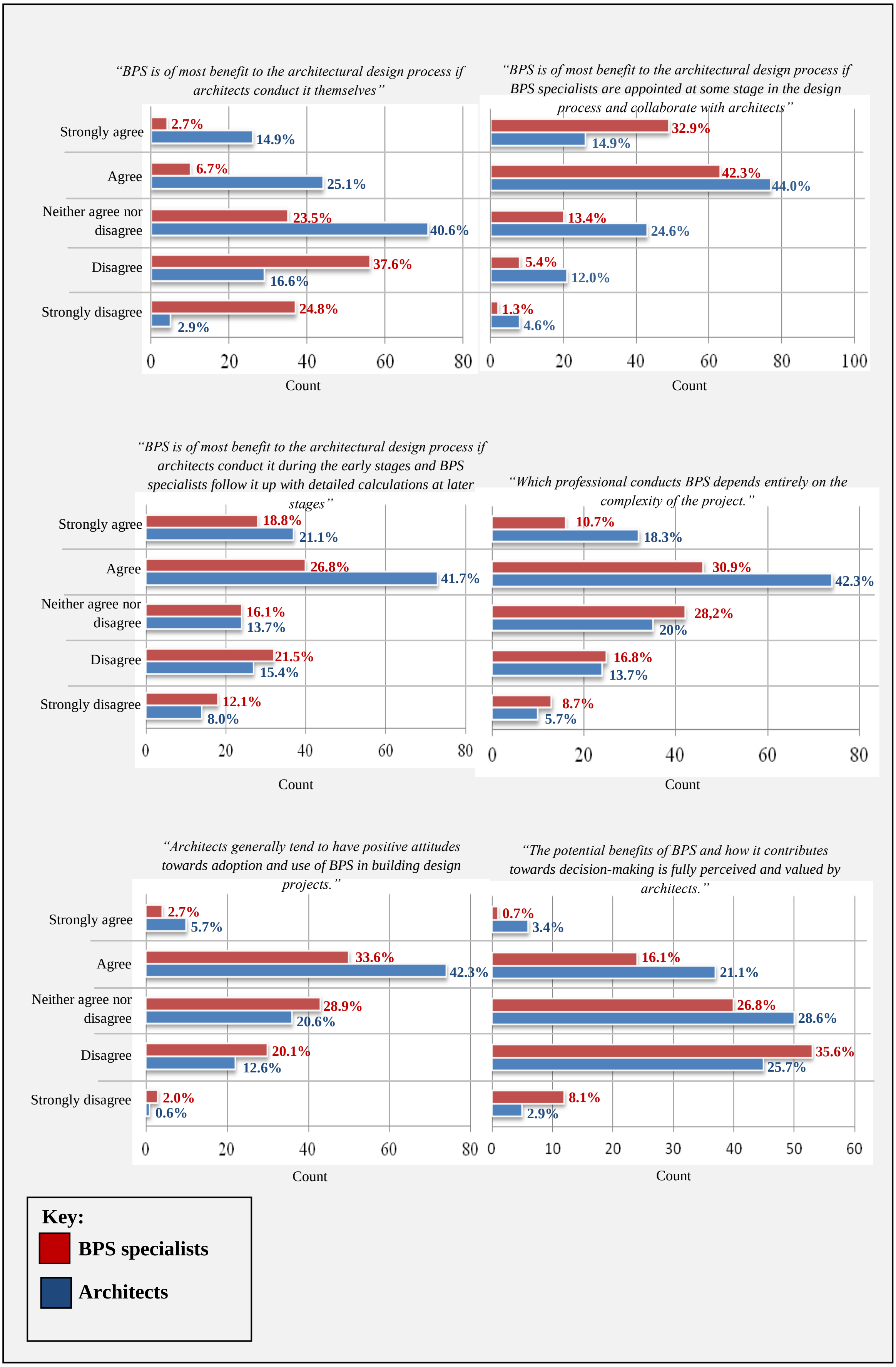


Fig. 7.5. Likert-scale variables common to both architects' and BPS specialists' questionnaires, analysed between sections 7.3.1.1-7.3.1.4.

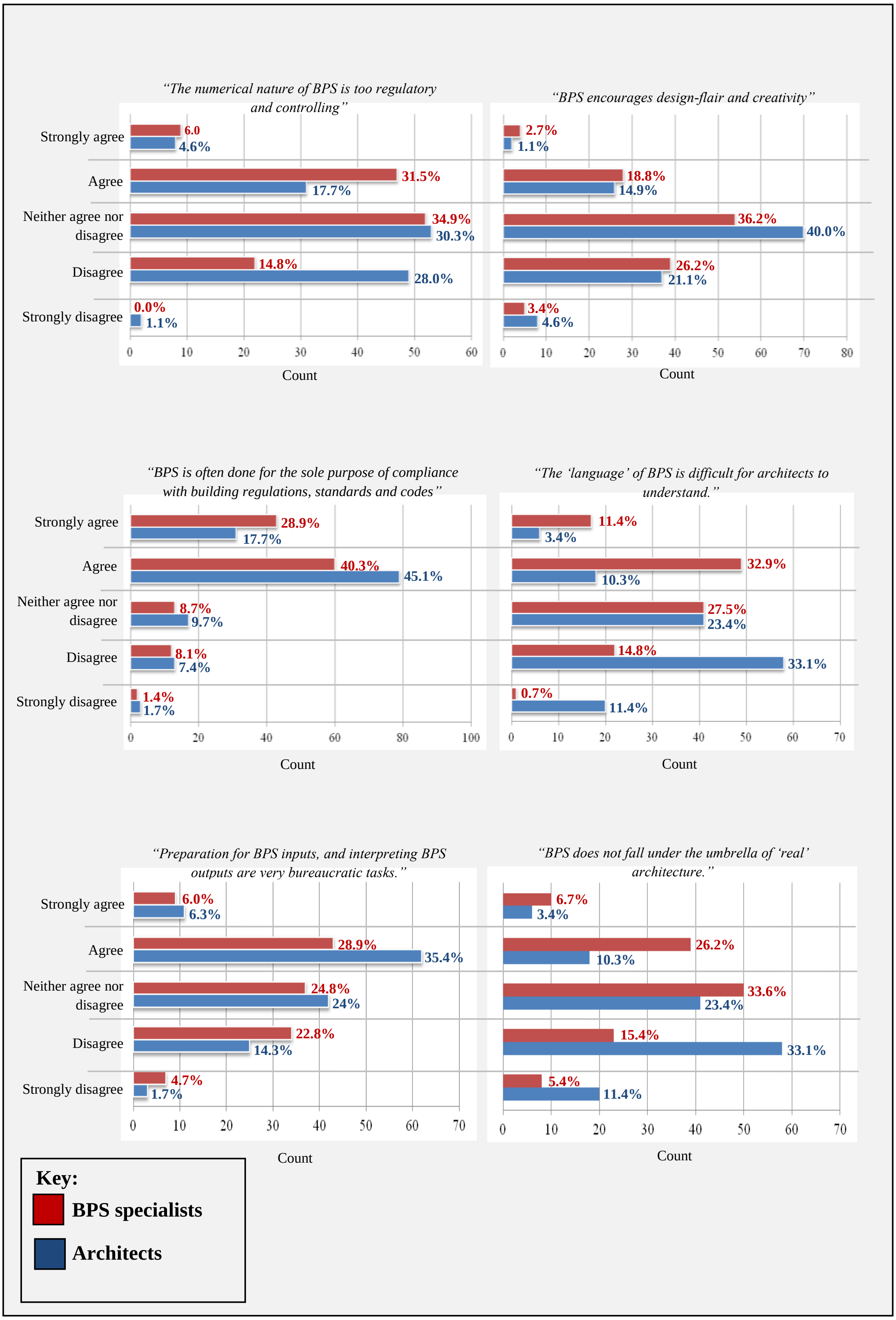


Fig. 7.5. contd. Likert-scale variables common to both architects' and BPS specialists' questionnaires; analysed between sections 7.3.1.1-7.3.1.4.

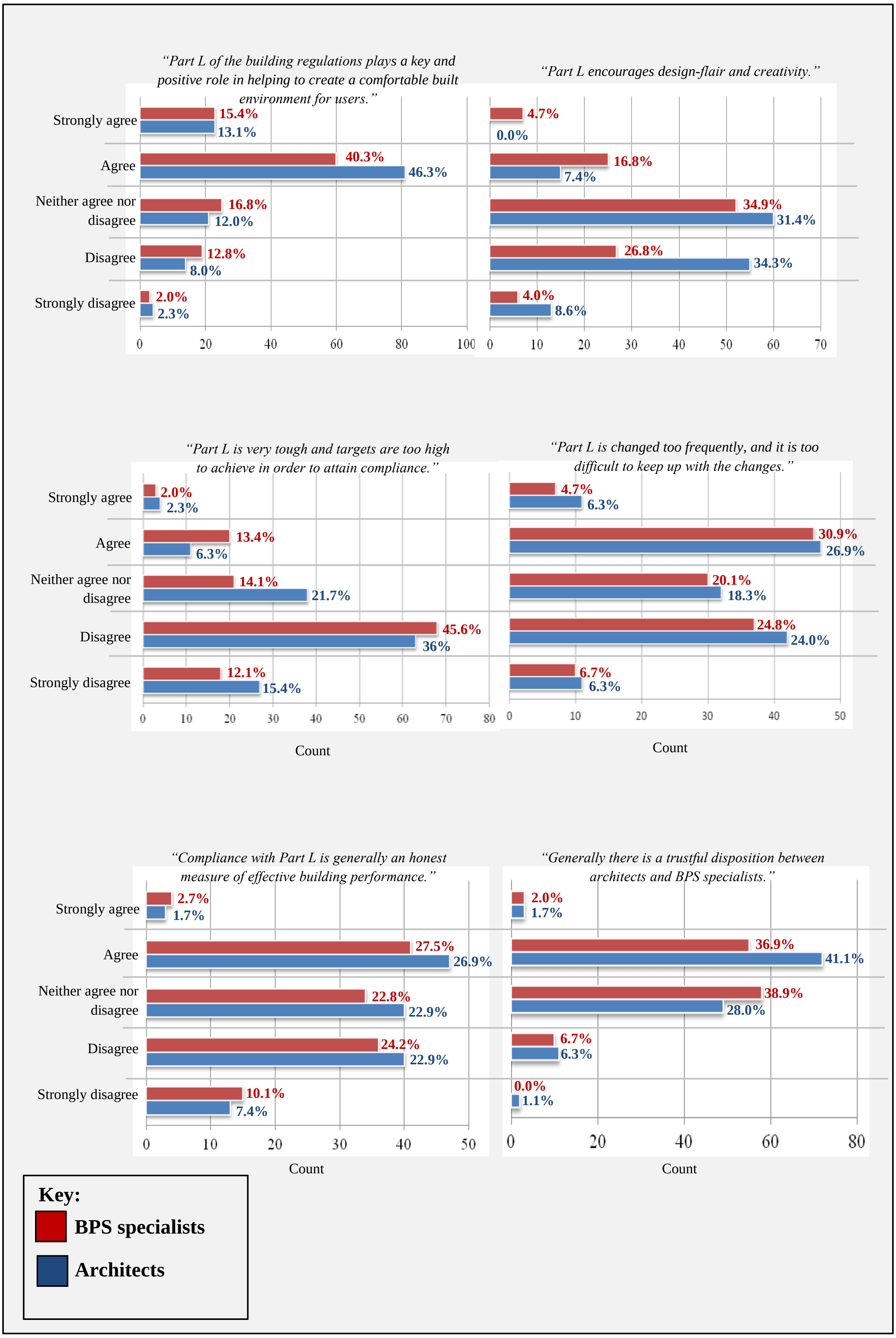


Fig. 7.5. contd. Likert-scale variables common to both architects' and BPS specialists' questionnaires; analysed between sections 7.3.1.1-7.3.1.4.

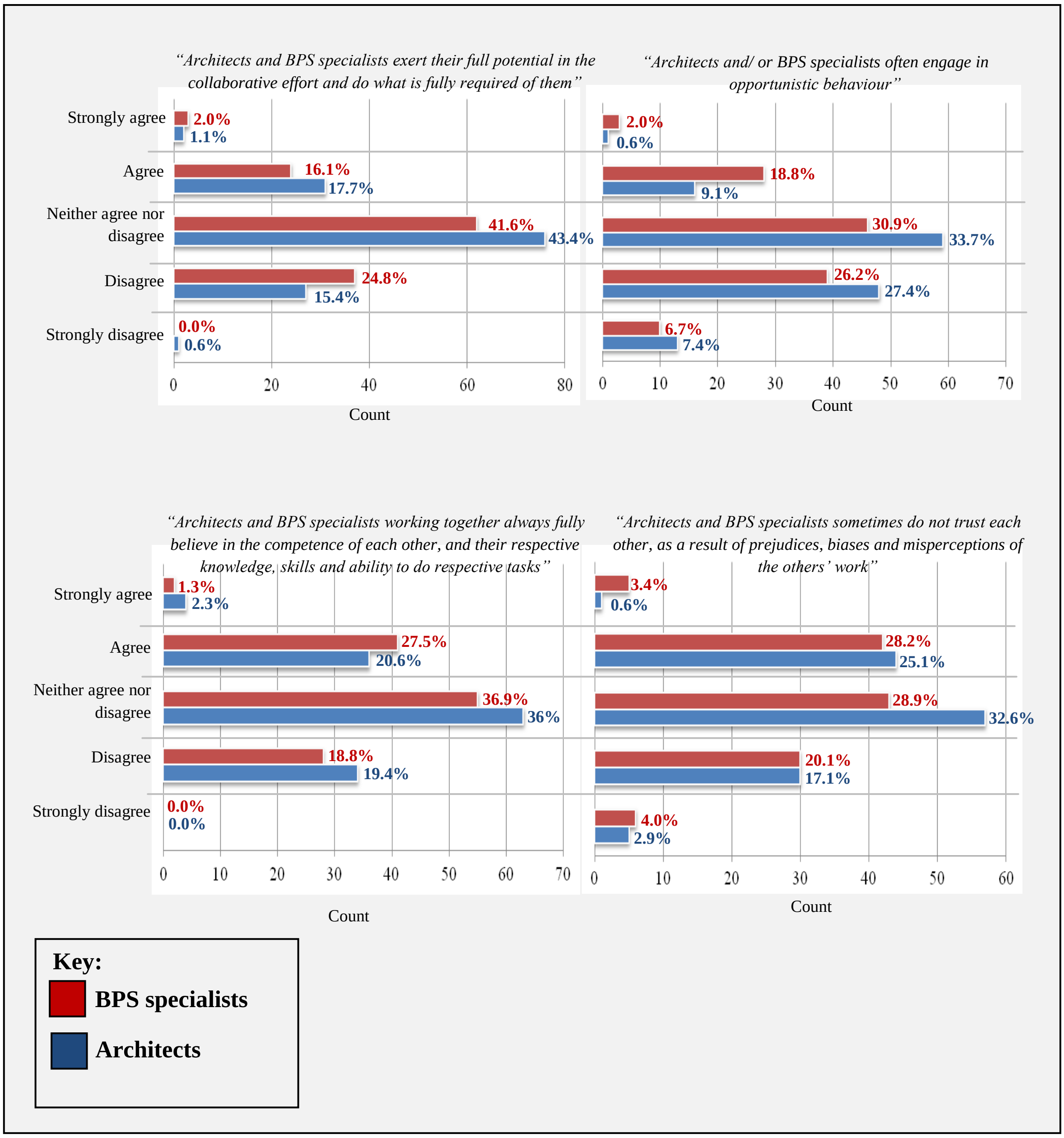


Fig. 7.5. contd. Likert-scale variables common to both architects' and BPS specialists' questionnaires; analysed between sections 7.3.1.1-7.3.1.4.

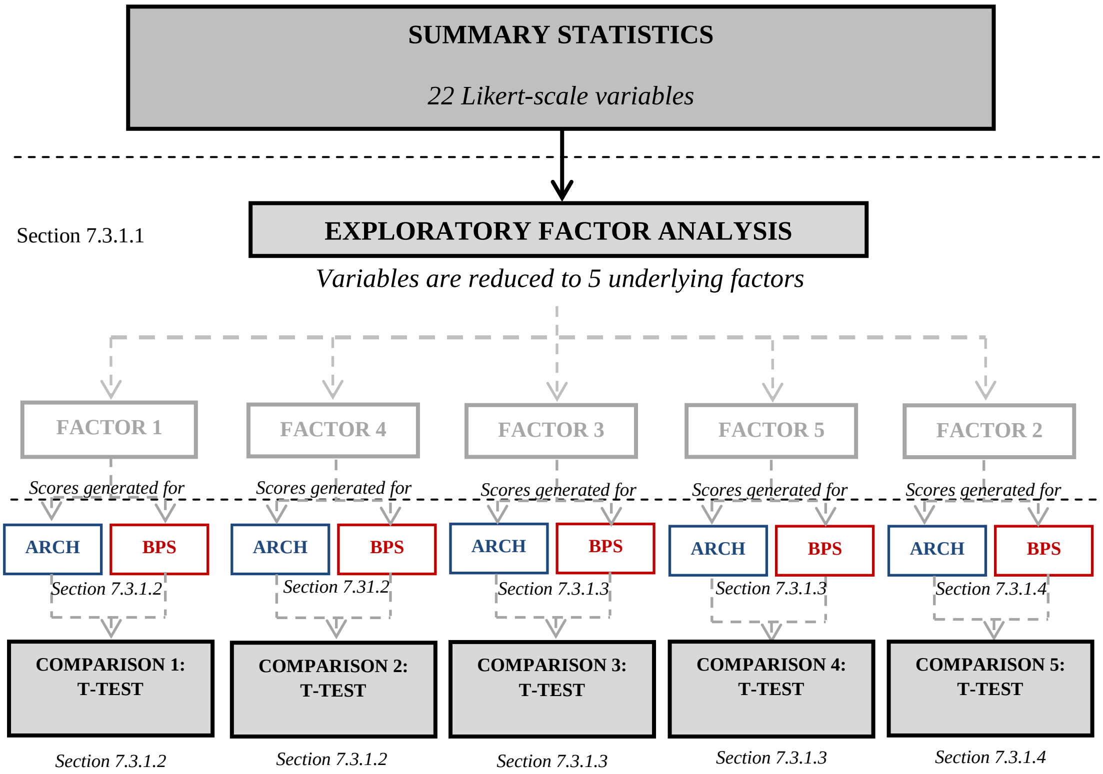


Fig. 7.6. Framework of statistical analyses conducted between sections 7.3.1.1-7.3.1.4

7.3.1.1 Exploratory factor analysis

Exploratory factor analysis was conducted to summarise the twenty-two variables shown in figure 7.5 from the combined sample of architects and BPS specialists (N = 323); and reduce them to a set of underlying factors[3].

Preliminary analysis

A correlation matrix[4] was generated to show the inter-correlations of the original variables, and the significance values of these inter-correlations. Nine variables were eliminated for having a majority of non-significant correlations (table 7.1). Therefore, thirteen variables were retained for analysis (table 7.2).

[3] The methodology of exploratory factor analysis was described earlier in section 6.6.1 of chapter 6.

[4] Similar to the example shown in figure 6.2 in chapter 6.

Table 7.1. Variables excluded from the exploratory factor analysis based on the correlation matrix.

VARIABLES EXCLUDED FOR HAVING A MAJORITY OF NON-SIGNIFICANT CORRELATIONS
'Architects and BPS specialists working together always fully believe in the competence of each other, and their respective knowledge, skills and ability to do respective tasks.'
'BPS is of most benefit to the architectural design process if architects conduct it during the early stages and BPS specialists follow it up with detailed calculations at later stages.'
'Which professional conducts BPS depends entirely on the complexity of the project.'
'Part L of the building regulations plays a key and positive role in helping to create a comfortable built environment for users.'
Part L is very tough and targets are too high to achieve in order to attain compliance.'
'Part L is changed too frequently, and it is too difficult to keep up with the changes.'
'Compliance with Part L is generally an honest measure of effective building performance.'
'Architects and BPS specialists exert their full potential in the collaborative effort and do what is fully required of them.'
'Architects and/ or BPS specialists often engage in opportunistic behaviour.'

The total combined sample size of architects and BPS specialists (N = 323) was also found suitable based on the KMO statistic and Bartlett's test of spherecity. The KMO statistic yielded was .700; which is a *'good'* result based on Hutcheson and Sofroniou's (1999) scales of suitability[5]. A significant result was yielded from Bartlett's test of spherecity (p = .000); confirming suitability of the sample-size.

Factor extraction

Five factors were extracted from the analysis as their eigenvalues were greater than 1. Variables which loaded highly onto each of the five factors extracted are shown in table 7.2.

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[5] Hutcheson and Sofroniou's (1999) scales of suitability: KMO values between .5-.7 are *'mediocre,'* values between .7-.8 are *'good,'* values between .8-.9 are *'great'* and a KMO value above .9 is *'superb.'*

Table 7.2. Factor loadings and communalities for the remaining thirteen variables included in this factor analysis (N = 323).

VARIABLES	COMMUN-ALITIES	FACTORS 1	2	3	4	5
BPS does not come under the umbrella of 'real' architecture.	**.682**	**.789**				
The numerical nature of BPS is too regulatory and controlling.	**.608**	**.760**				
The 'language' of BPS is too difficult to understand.	**.598**	**.670**				
Preparation for BPS inputs, and interpreting BPS outputs, are very bureaucratic tasks.	**.625**	**.551**				**.474**
The potential benefits of BPS, and how it contributes towards decision-making, are fully perceived and valued by architects.	**.683**				**.784**	
Architects generally tend to have positive attitudes towards BPS.	**.585**	**-.704**				
Generally, there is a trustful disposition between architects and BPS specialists.	**.416**		**.574**			
Architects and BPS specialists sometimes do not trust each other; as a result of prejudices, biases and misperceptions of the others' work.	**.578**		**-.503**	**.429**		
BPS encourages design-flair and creativity.	**.673**			**.754**		
Part L of the building regulations encourages design-flair and creativity.	**.630**			**.748**		
BPS is of most benefit to the architectural design process if BPS specialists are appointed at some stage in the design process and collaborate with architects.	**.710**				**-.756**	
BPS is of most benefit to the architectural design process if architects conduct it themselves.	**.666**				**.738**	
BPS is often done for the sole purpose of compliance with building regulations, standards and codes.	**.741**					**.835**

Factor interpretations

Labels assigned to each factor based on thematic interpretation are shown in table 7.3. By examining the variables which loaded onto each factor, the underlying theme of each factor was interpreted.

Table 7.3. Thematic interpretation of each of the five factors extracted in the factor analysis conducted in this section.

FACTOR	NO. OF VARIABLES LOADED ONTO THIS FACTOR	THEMES ADDRESSED BY THE VARIABLES	LABEL ASSIGNED TO FACTOR BASED ON THEMATIC INTERPRETATION
1	5	Architects' negative attitudes towards BPS.	**'Architects' negative attitudes towards BPS.'**
2	2	Trust between architects and BPS specialists.	**'Positive trust.'**
3	3	Two variables question whether design-flair and creativity are permitted through **BPS and Part L compliance;** indicating that this factor is concerned with compliance modelling[6]. The third variable is concerned with poor intuitive trust; due to **prejudices and misperceptions.** However, this retained a much lower factor loading (.429) than the other two variables from factor 3; so only the first two variables were used to interpret the underlying theme of this factor.	**'Compliance modelling encourages design-flair and creativity.'**
4	3	Encouraging architects' self-uptake of BPS	**'Architects should conduct BPS.'**
5	2	BPS as a simplistic compliance exercise. BPS as a bureaucratic task.	**'BPS as a bureaucratic compliance exercise.'**

7.3.1.2 Architects' attitudes towards BPS; comparing architects' and BPS specialists' scores

In this section, the two factors extracted which addressed architects' attitudes towards BPS are examined. These were:

a) Factor 1; Architects' negative attitudes towards BPS

b) Factor 4; Architects should conduct BPS

Composite scores were generated for these two factors; combining the variables which loaded onto each factor; by averaging the scores of the variables which loaded highly onto these factors following the calculation described in section 6.6.2 of chapter 6. **Architects' and BPS specialists' composite scores for these two factors were**

[6] The divide between BPS for design purposes and compliance modelling was investigated in detail in chapter 5; section 5.4.2.3.

compared using independent samples t-tests. Assumptions of the t-test; random sampling, normal distribution and equal variances were satisfied for both sets of factor scores.

Factor 1: Do architects have negative attitudes towards BPS?

A statistically significant difference was found between the mean composite scores of architects and BPS specialists; $t(271) = -3.575$, $p = .000$. The means and standard deviations for each of the two groups are shown in table 7.4. Table 7.4 shows that architects in England and Wales **are likely to demonstrate negative attitudes towards BPS, whereas on average BPS specialists' feel that architects' attitudes toward BPS are more positive.**

Factor 4: Should architects conduct BPS?

There was also a significant difference between the mean composite scores for architects and BPS specialists for factor 4; $t(303) = 4.057$, $p = .000$. **This result indicates that architects demonstrate greater agreement that they should undertake BPS calculations themselves than BPS specialists.** Architects' and BPS specialists' means and standard deviations for this factor are also shown in table 7.4.

Table 7.4. Architects' and BPS specialists' means and standard deviations for factors 1 and 4 composite scores.

	ARCHITECTS		BPS SPECIALISTS	
	Mean	Standard deviation	Mean	Standard deviation
FACTOR 1 COMPOSITE SCORES; Architects' negative attitudes toward BPS	2.743	.6741	3.051	.7382
FACTOR 4 COMPOSITE SCORES; Architects should conduct BPS	2.541	.650	2.872	.640

7.3.1.3 Compliance factors and perceptions of BPS; comparing architects' and BPS specialists' scores

In this section, the two factors extracted which addressed compliance are examined. These are:

a) Factor 3; Compliance modelling encourages design-flair and creativity.

b) Factor 5; BPS as a bureaucratic compliance exercise.

Independent samples t-tests were performed to compare architects' and BPS specialists' means for the composite scores generated for these two factors.

Factor 3: Is compliance modelling perceived to encourage design-flair and creativity?

The results of the t-test indicated **a non-significant difference** in the means of architects and BPS specialists for factor 3 composite scores; $t(261) = -1.966$, $p = .051$. Both architects' and BPS specialists' means for this factor were centralised around the third point on the Likert-scale; denoting neutrality (table 7.5). Therefore, **on average neither group necessarily considers compliance modelling to encourage design-flair and creativity; but neither disagrees with this either.**

Factor 5: Is BPS viewed as a bureaucratic compliance exercise?

The results of the t-test for factor 5 composite scores also show **a non-significant difference in architects' and BPS specialists' means;** $t(271) = -3.442$, $p = .231$. The means for each of the two groups are located between the second and the third point on the Likert scale i.e. between agreement and neutrality (table 7.6). **The means indicate that on average architects and BPS specialists similarly agree that BPS is often viewed in practice as a compliance exercise, rather than a potential design-aid.**

Table 7.5. Architects' and BPS specialists' means and standard deviations for factors 3 and 5 composite scores.

	ARCHITECTS		BPS SPECIALISTS	
	Mean	**Standard deviation**	**Mean**	**Standard deviation**
FACTOR 3 COMPOSITE SCORES; Compliance modelling encourages design flair and creativity.	3.182	.572	3.040	.606
FACTOR 5 COMPOSITE SCORES; BPS as a bureaucratic compliance exercise.	2.591	.798	2.247	.718

Attitudes towards Part L of the building regulations

It was previously revealed in the qualitative analysis that interviewed architects demonstrated negative attitudes towards Part L of the building regulations. To identify whether attitudes toward Part L are predominantly positive or negative amongst the questionnaire-respondents, a new composite variable was computed combining the five original Likert-scale variables[7] which originally addressed attitudes toward Part L in the questionnaires. An independent samples t-test was conducted on this composite variable to compare architects' and BPS specialists' attitudes toward Part L. No significant difference was found in the means of the two groups; $t(271) = -.860$, $p = .391$. The means and standard deviations for architects and BPS specialists on this new composite variable are shown in table 7.6.

[7] These variables were originally included in the exploratory factor analysis (section 7.4.1). Three of them were removed at the preliminary analysis for having a majority of significant values greater than .05 (>.05); which indicated that these variables do not correlate with the rest of the variables in the correlation matrix.

Table 7.6 Showing architects' and BPS specialists' means and standard deviations for the composite variable addressing attitudes toward Part L of the building regulations.

	ARCHITECTS		BPS SPECIALISTS	
	Mean	**Standard deviation**	**Mean**	**Standard deviation**
COMPOSITE VARIABLE - Attitudes toward Part L of the building regulations	3.094	.534	3.037	.558

This result indicates that both architects and BPS specialists in this sample share similar attitudes toward Part L. The means are located for both groups around the third point on the Likert-scale, denoting neutrality. Therefore, we can infer that, on average both groups have neutral attitudes toward Part L of the building regulations.

Pearson's correlation was conducted to explore the relationship between attitudes towards Part L and attitudes towards BPS for the combined sample of architects and BPS specialists. A weak, ***positive*** correlation was found between the two variables (table 7.7). **Therefore, it is confirmed that a relationship exists between the two variables; associating positive attitudes towards BPS with positive attitudes towards Part L and vice versa, although this is a weak relationship.**

Table 7.7 Results of Pearson's correlation exploring the relationship between attitudes towards Part L and attitudes towards BPS.

SIG.	CORRELATION CO-EFFICIENT (r)	CORRELATION DIRECTION	CORRELATION STRENGTH
p = .000. Result is significant.	Correlation co-efficient (r) = .252 Number of observations (N) = 323	Positive.	Weak.

7.3.1.4 <u>Factor 2: Trust factors; do architects and BPS specialists trust each other?</u>

An independent samples t-test was conducted to compare architects' and BPS specialists' means for composite scores generated for this final factor; addressing trust dynamics between members of the two groups. **A non-significant difference was found between the means;** t(261) = .157, p = .876. This indicates that both groups have a similar opinion about trust dynamics between architects and BPS specialists. The means for both groups, shown in table 7.8, indicate **that on average both architects and BPS specialists have similar levels of trust toward each other; both are positive but skewed slightly towards the third point on the Likert-scale denoting neutrality.**

Table 7.8 Showing architects' and BPS specialists' means and standard deviations for factor 2 composite scores.

	ARCHITECTS		BPS SPECIALISTS	
	Mean	Standard deviation	Mean	Standard deviation
FACTOR 2 COMPOSITE SCORES; Positive trust	2.748	.529	2.759	.476

7.3.2 STEREOTYPING

The possibility that architects and BPS specialists collaborate based on stereotypical impressions about each other was predicted in chapter 5, section 5.4.1.2. The question of stereotyping was posed in both questionnaires. Summary statistics are shown in figure 7.7.

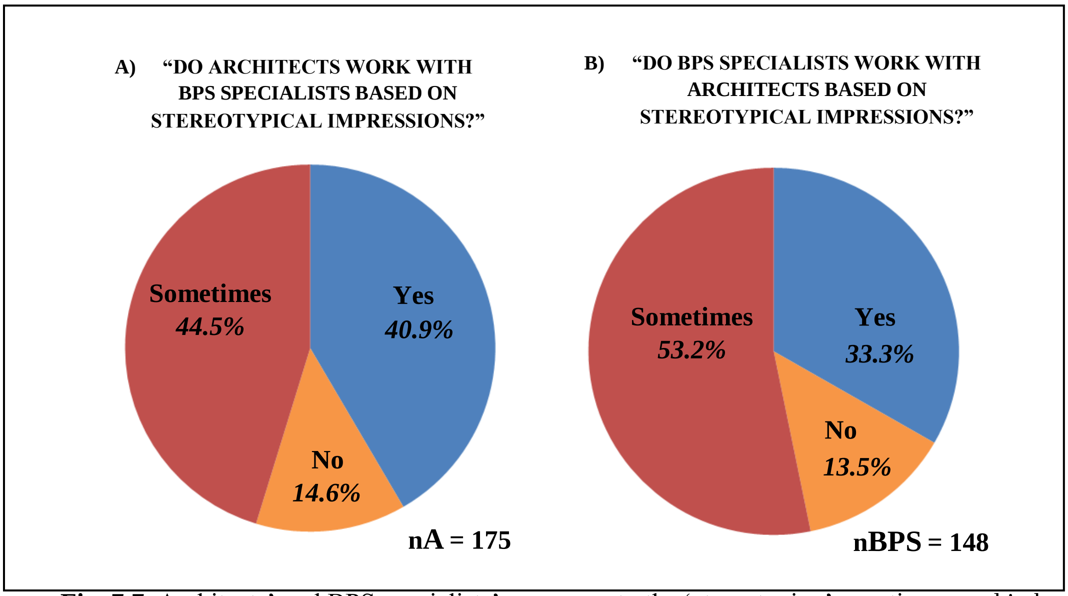


Fig. 7.7. Architects' and BPS specialists' responses to the 'stereotyping' question posed in both questionnaires.

The pie-charts in figure 7.7 reveal that both architects and BPS specialists believe that members of their profession work with members of the other group based on stereotypical impressions. 85.4% of architects responded with either ‘yes’ or ‘sometimes’ to the stereotyping question, and 86.5% of BPS specialists responded similarly.

7.3.2.1 What stereotypical impressions do architects have of BPS specialists?

Architects who think that members of their discipline work with BPS specialists based on stereotypical impressions were asked an open-ended follow up question; *‘what stereotypical impressions do architects generally tend to have of BPS specialists?’* Responses are grouped by similarity and ranked according to the number of times each stereotypical impression was re-iterated in table 7.9.

Table 7.9 Architects’ stereotypical impressions of BPS specialists.

STEREOTYPICAL IMPRESSION	FREQUENCY
Data specific ‘number-crunchers’	25
Inflexible; narrow-minded	19
‘Boffins’	17
Do not understand / are not interested in building design.	15
Architects vs. BPS specialists	14
Uncreative ‘linear thinkers’	13
A regulatory requirement	5
Uninterested in aesthetics	5
A necessity	4
‘Box-tickers’	4
Lazy	3
Bureaucratic	2
Time-consuming	1
Assistive role to architects	1
No view / don’t know	***8***

7.3.2.2 What stereotypical impressions do BPS specialists have of architects?

BPS specialists who believe that members of their profession work with architects based on stereotypical impressions were also asked *‘what stereotypical impressions do BPS specialists generally tend to have of BPS specialists?’* Responses are grouped and ranked in table 7.10.

Table 7.10 BPS specialists' stereotypical impressions of architects.

STEREOTYPICAL IMPRESSION	NO. OF TIMES THIS STEREOTYPICAL IMPRESSION WAS EXPRESSED
Impractical; only concerned with aesthetics	33
Egotistical - pretentious - arrogant - self-opinionated	18
Precious of their designs; do not want to change	14
Have no technical understanding of building physics	11
Having a stereotype of architects' physical image (e.g. they wear a lot of black)	8
Do not listen - do not take advice	7
Lack of appreciation / a compliance necessity or inconvenience	5
Uninterested in BPS	4
Their proposed solutions are always about glazing	4
They have no idea about energy conservation	3
Unrealistic	2
That the default solution to any problem is to put in more services	1
Art students	1
Uninspiring	1
Do not focus on details	1
Only see BPS as a 'tick-box' exercise	1
Do not perceive energy-efficiency as part of their remit	1
Space planners	1
Ignorant	1
Inflexible	1
Consider BPS as an inhibitor to design	1
Don't know / no opinion	1

7.3.2.3 Does stereotyping have an effect on trust between architects and BPS specialists?

A one-way Analysis of Variance (ANOVA) was conducted to ascertain whether levels of trust (investigated in factor 2) are affected by architects' and BPS specialists' beliefs about stereotyping. The ANOVA is a statistical test which is used to determine whether one independent, categorical variable has an effect on a dependent numerical variable. In this case:

- **The dependent, numerical variable:** is the composite score generated for factor 2; which is concerned with positive trust between architects and BPS specialists.

- **<u>The independent, categorical variable:</u>** is the 'stereotyping' variable, explored throughout section 7.3.2. This consists of three categories:

  - Category 1; consisting of both architects and BPS specialists who think that members of both professions work together based on stereotypical impressions.

  - Category 2; consisting of both architects and BPS specialists who think that members of both professions sometimes work together based on stereotypical impressions.

  - Category 3; consisting of both architects and BPS specialists who do not think that members of both professions work together based on stereotypical impressions.

A non-significant difference was found between the mean scores of these three groups; F(2,259) = .1.469, p = .232. The means and standard deviations for each of the three groups are shown in table 7.11. We can therefore conclude that levels of trust are not affected by architects' and BPS specialists' beliefs about stereotyping.

Table 7.11 Means and standard deviations of the three groups of the stereotyping variable, based on the ANOVA used to find whether beliefs about stereotyping have an effect on trust.

CATEGORIES	Mean	Standard deviation
Category 1: Members of both professions work together based on stereotypical impressions	2.683	.539
Category 2: Members of both professions sometimes work together based on stereotypical impressions	2.787	.431
Category 3: Members of both professions do not work together based on stereotypical impressions	2.811	.494

7.4 DATA FROM ARCHITECTS' QUESTIONNAIRES

In this section, one theme addressed in the architects' questionnaire only is examined. This theme is concerned with the role of the client, and whether clients tend to encourage architects' collaboration with BPS specialists for use of BPS to inform design decision-making, or whether clients tend to discourage this. The possibility that clients tend to reduce the potential for BPS to inform design decision-making, by discouraging early collaborations with BPS specialists, was discussed in chapter 5; section 5.4.2.1; as this concern was voiced repetitively by architects interviewed.

To determine whether the wider community of architects in England and Wales feel that clients encourage early collaborations with BPS specialists, allowing BPS to better inform design decision-making, or whether they agree with the interviewees that clients tend to discourage such early collaborations; a series of Likert-scale questions interrogating this was incorporated in the architects' questionnaire. Summary statistics; indicating architects' extents of agreement or disagreement with each statement concerning the client; are shown in figure 7.8; also showing percentages beside each bar.

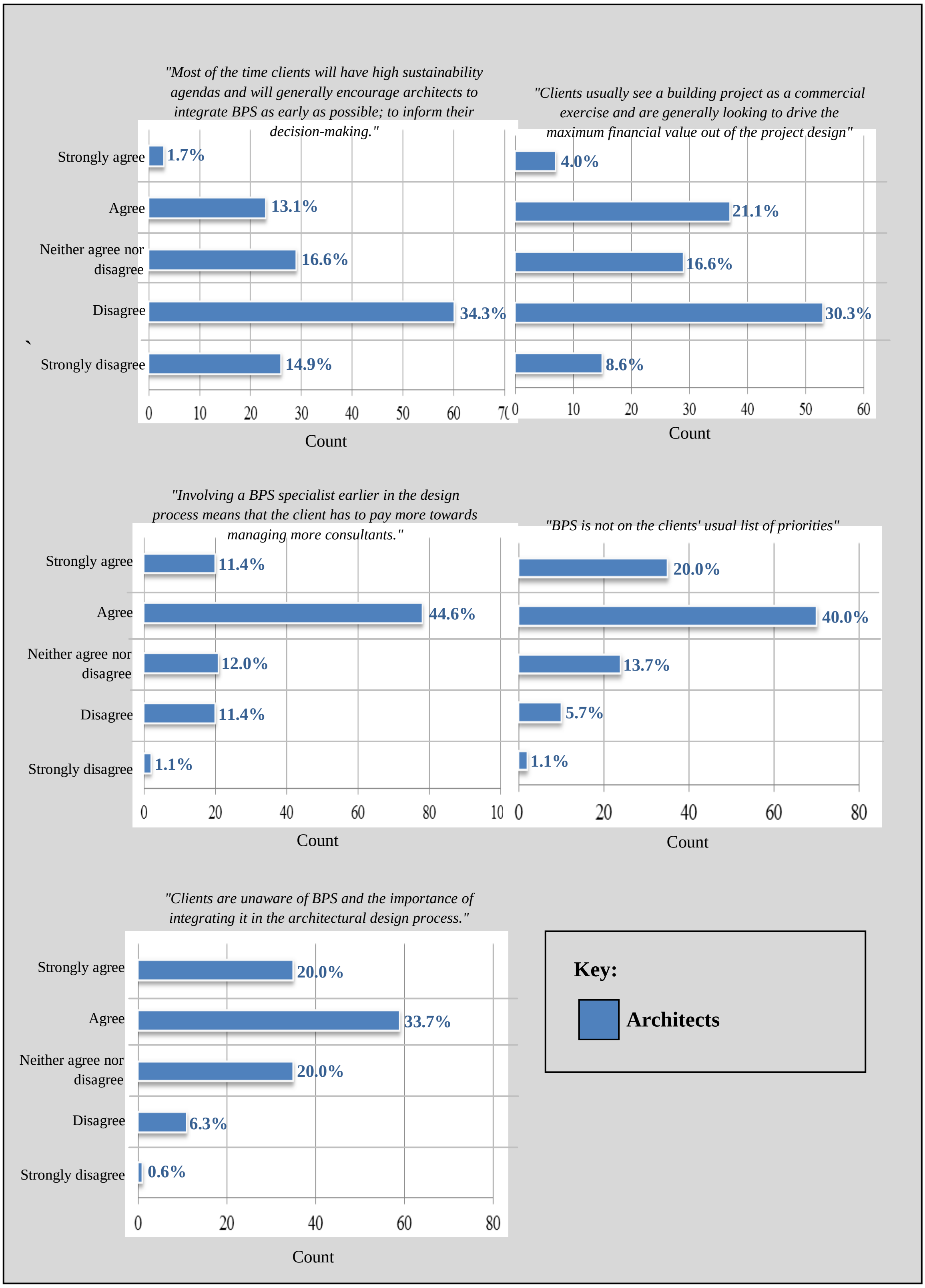


Fig. 7.8. Likert-scale variables investigating whether clients encourage or discourage early collaborations between architects and BPS specialists; for BPS to inform design decision-making.

The Likert-scale variables shown in figure 7.8 were combined to generate a composite variable. The mean of the composite variable (table 7.12) falls between the third point on the Likert-scale denoting neutrality, and the fourth point which denotes disagreement. **It can therefore be concluded that architects in this sample feel that clients tend to discourage early collaborations with BPS specialists, reducing the potential for BPS to inform design decision-making.** Architects in this sample therefore agree with the opinion voiced by architectural interviewees in the previous research stage.

Table 7.12. Showing the architectural sample's mean and standard deviation for the composite variable addressing whether they believe clients encourage collaborations with BPS specialists.

	ARCHITECTS	
	Mean	**Standard deviation**
COMPOSITE VARIABLE - Clients generally encourage BPS uptake in architectural decision-making through early collaborations with BPS specialists	3.636	.660

7.5 DATA FROM BPS SPECIALISTS' QUESTIONNAIRES

In section 7.5, barriers which were addressed in the BPS specialists' questionnaire are analysed. This consists of twenty-one Likert-scale variables; questioning BPS specialists' perceptions about their relationships with architects, and BPS specialists' perceptions about their communication with architects.

In section 7.5.1, these data are analysed through a series of statistical tests to determine whether BPS specialist feel their relationships with architects are positive and constructive. In section 7.5.2, communication is examined in more detail and the relationship between trust and communication is investigated.

7.5.1 RELATIONSHIPS BETWEEN ARCHITECTS AND BPS SPECIALISTS

Likert-scale statements describing relationships between architects and BPS specialists; analysed in this section are shown in figure 7.9. Each of these statements had previously been voiced by an interviewed BPS specialist in the previous research stage. By including these statements in the questionnaire; these could be used to ascertain whether the wider community of BPS specialists in England and Wales agree with interviewed BPS specialists or disagree with these statements. Extents of agreement and disagreement are shown in the bar-charts in figure 7.9; as well as percentages. This is followed by a flow-chart in figure 7.10 which details the series of statistical tests performed on these variables.

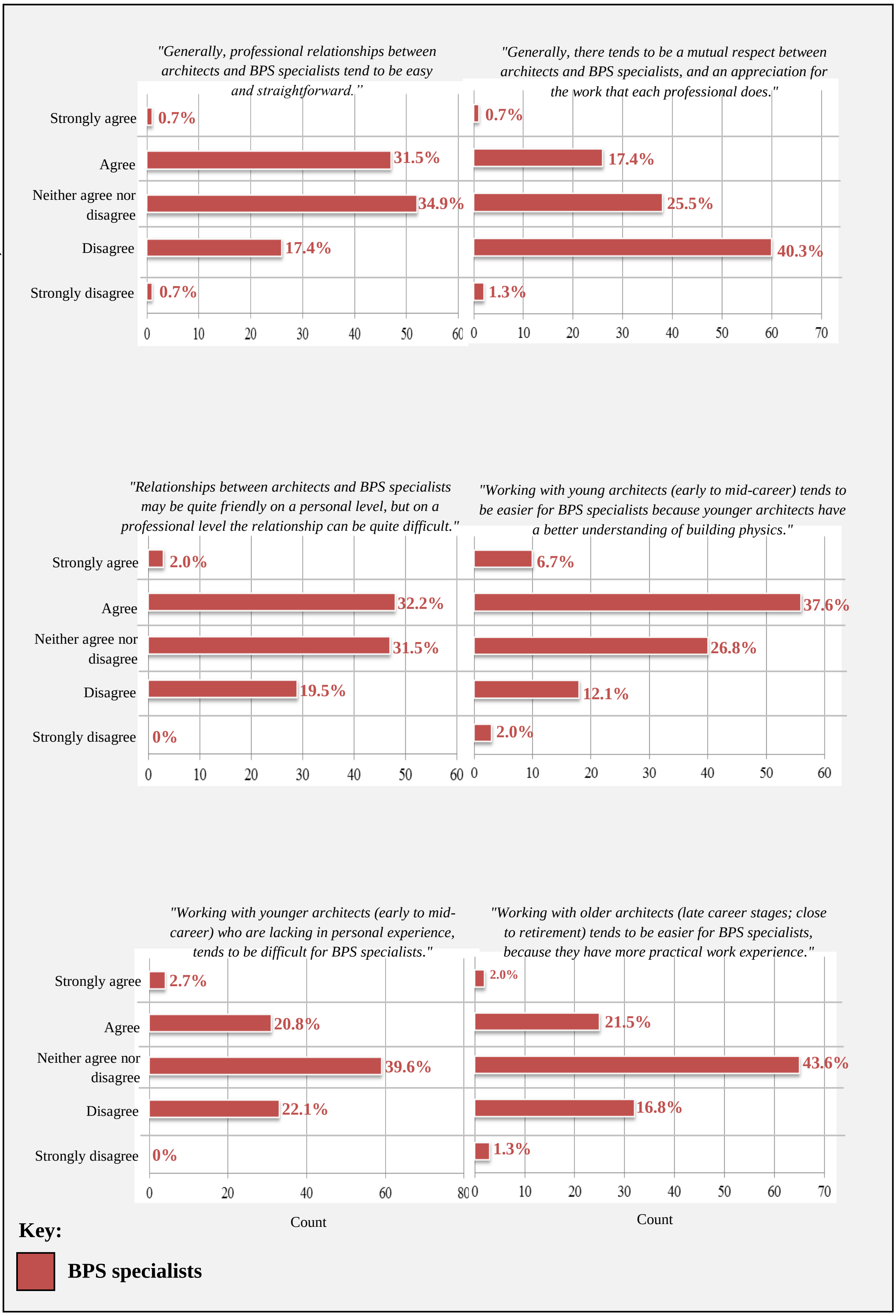


Fig. 7.9. Likert-scale variables analysed in section 7.5.1; which address BPS specialists' perceptions about their relationships with architects; and their perceptions about communication with architects.

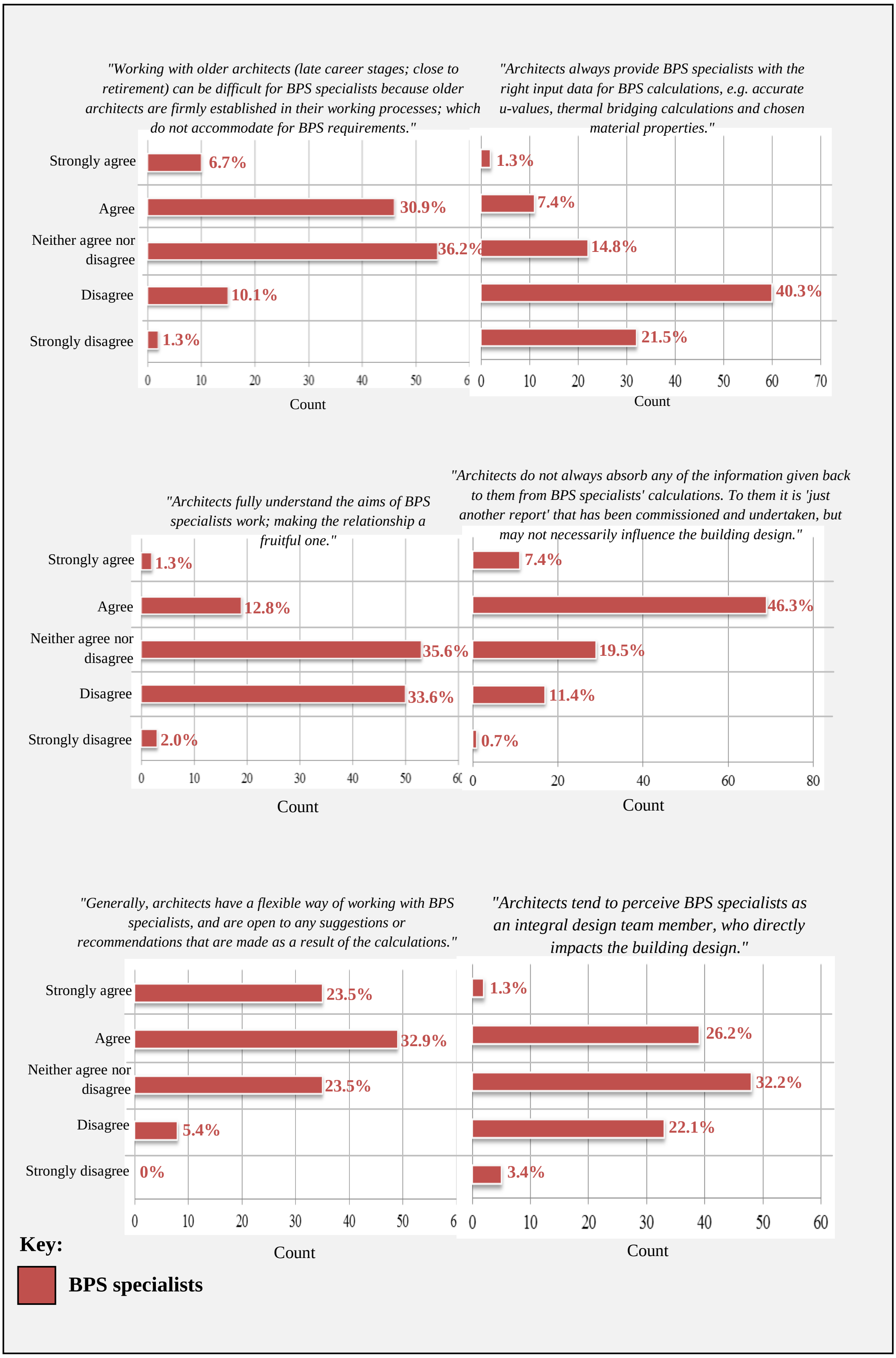


Fig. 7.9. contd. Likert-scale variables analysed in section 7.5.1; which address BPS specialists' perceptions about their relationships with architects; and their perceptions about communication with architects.

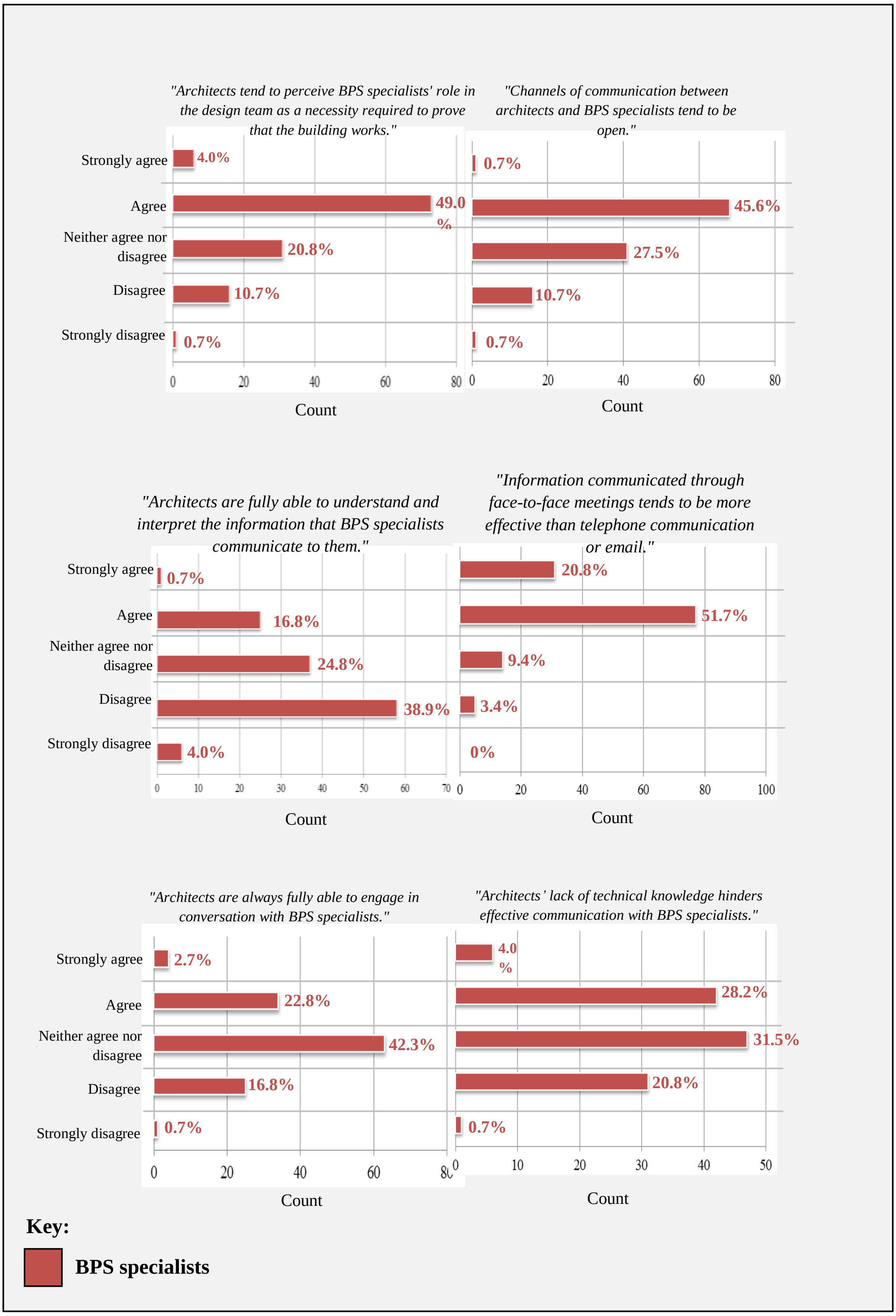


Figure 7.9. contd. Likert-scale variables analysed in section 7.5.1; which address BPS specialists' perceptions about their relationships with architects; and their perceptions about communication with architects.

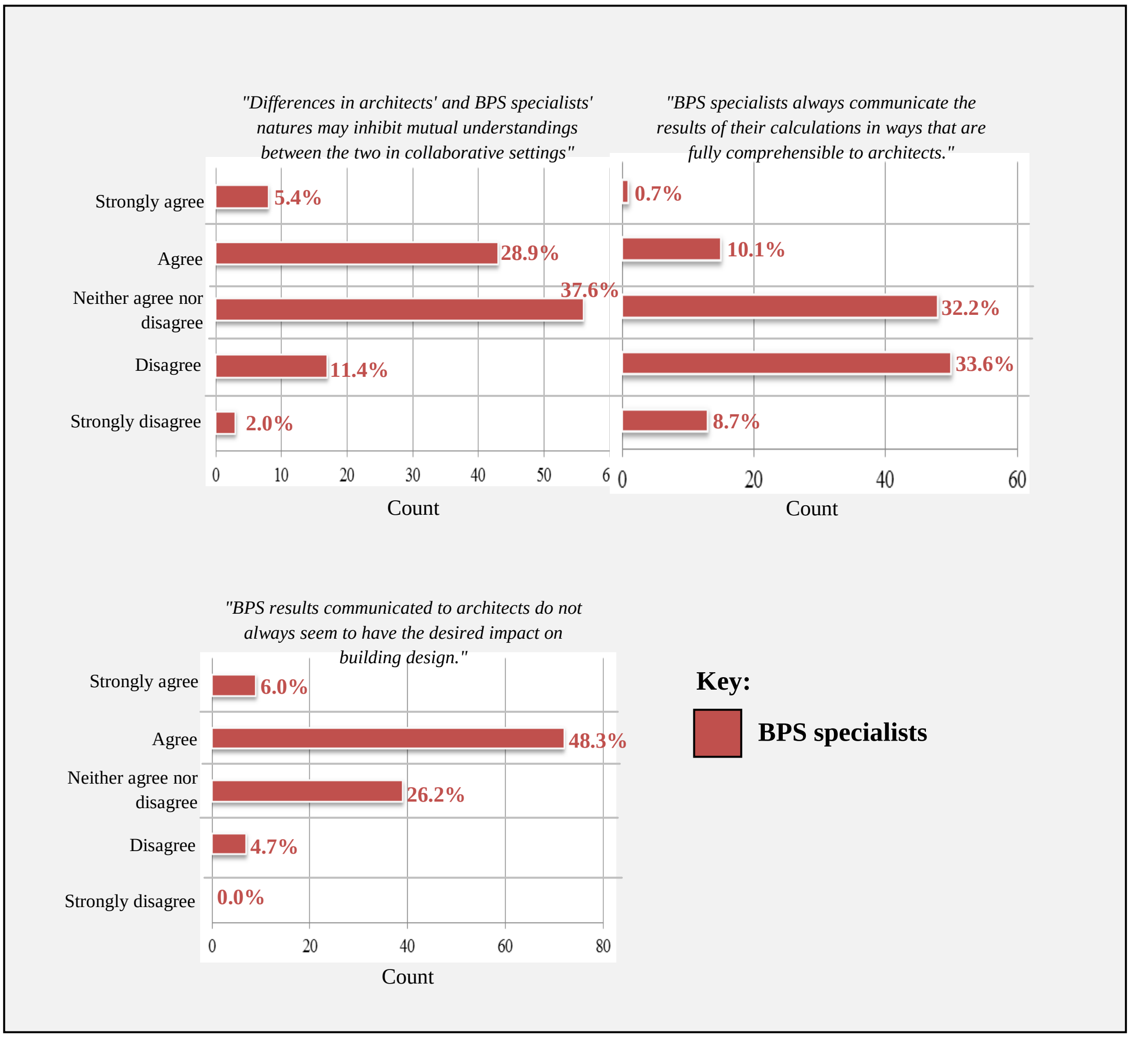


Figure 7.9. contd. Likert-scale variables analysed in section 7.5.1; which address BPS specialists' perceptions about their relationships with architects; and their perceptions about communication with architects.

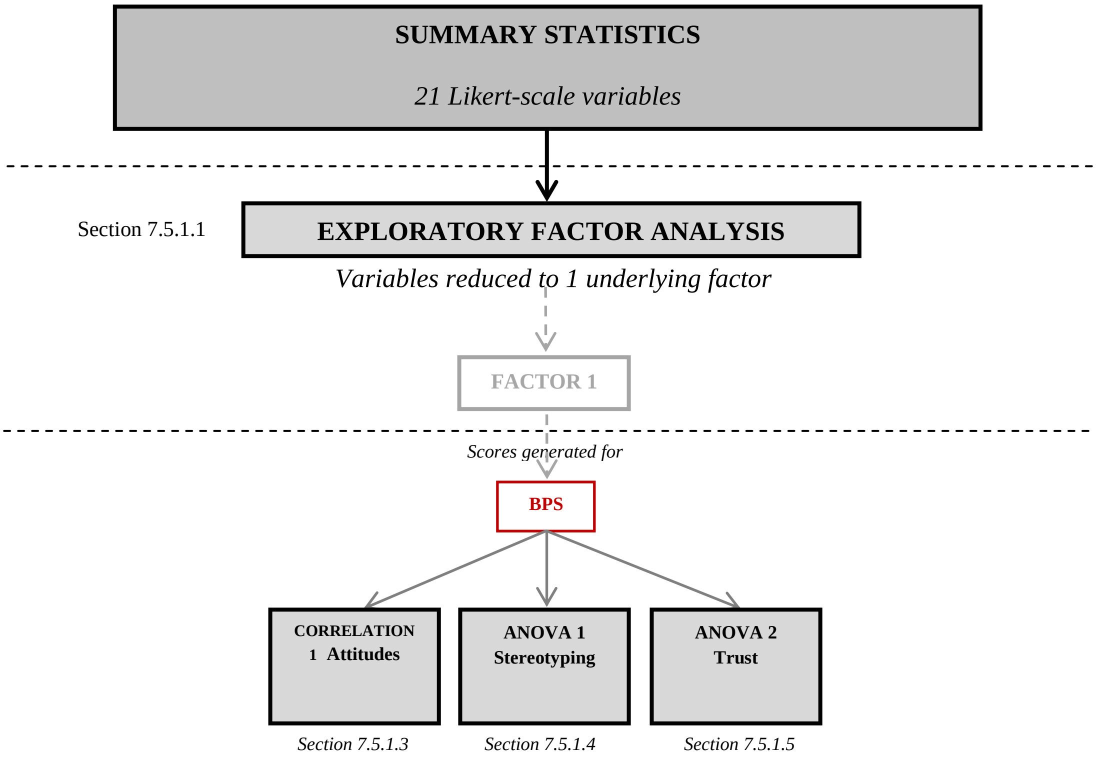


Fig. 7.10. Framework of statistical analyses conducted between sections 7.5.1.1-7.5.1.5.

7.5.1.1 Exploratory factor analysis

Factor analysis was used to reduce these twenty-one variables shown in figure 7.9 into a smaller set of underlying dimensions representing common themes in the data. The methodology of exploratory factor analysis in section 6.6.1 of chapter 6 was used here.

Preliminary analysis

The variables were screened using a correlation matrix to ascertain their suitability for factor analysis. Two variables were eliminated for having non-significant correlations. These are shown in table 7.13. The correlation matrix also revealed that an additional nine variables yielded a majority of correlation coefficients outside the acceptable range of .3-.9, and therefore were not suitable for factor analysis. These variables, which are also shown in table 7.13, were also removed. In total therefore; eleven variables were eliminated based on the correlation matrix; and ten were retained to be included in the factor analysis (table 7.14).

Table 7.13. Variables extracted from the factor analysis conducted in this section based on the correlation matrix.

VARIABLES EXCLUDED FROM THE EXPLORATORY FACTOR ANALYSIS CONDUCTED IN THIS SECTION BASED ON THE CORRELATION MATRIX.	
VARIABLES REMOVED FOR HAVING NON-SIGNIFICANT CORRELATIONS	‘Working with younger architects (early to mid-career) who are lacking in personal experience, tends to be difficult for BPS specialists.’
	‘Architects tend to perceive BPS specialists' role in the design team as a necessity required to prove that the building works.’
VARIABLES REMOVED FOR HAVING CORRELATION COEFFICIENTS OUTSIDE THE RANGE OF .3-.9.	‘Working with young architects (early to mid-career) tends to be easier for BPS specialists because younger architects have a better understanding of building physics.’
	‘Working with older architects (late career stages; close to retirement) tends to be easier for BPS specialists, because they have more practical work experience.’
	‘Architects always provide BPS specialists with the right input data for BPS calculations, e.g. accurate u-values, thermal bridging calculations and chosen material properties.’
	‘Architects do not always absorb any of the information given back to them from BPS specialists' calculations. To them it is 'just another report' that has been commissioned and undertaken, but may not necessarily influence the building design.’
	‘Information communicated through face-to-face meetings tends to be more effective than telephone communication or email.’
	‘Architects’ lack of technical knowledge hinders effective communication with BPS specialists.’
	‘Differences in architects' and BPS specialists' natures may inhibit mutual understandings between the two in collaborative settings.’
	‘BPS specialists always communicate the results of their calculations in ways that are fully comprehensible to architects.’
	‘BPS results communicated to architects do not always seem to have the desired impact on building design.’

The sample size (nBPS = 148) was also found suitable based on the KMO statistic and Bartlett's test of spherecity. The KMO statistic yielded was .874; which is a *'great'* result based on Hutcheson and Sofroniou's scales of suitability[8] (Hutcheson and Sofroniou 1999). This was also confirmed by the Bartlett's test of spherecity which yielded a significant result (p = .000).

Factor extraction

Principal Components Analysis was used for factor extraction; according to the associated eigenvalues of the factors. Only one factor had an eigenvalue greater than 1; albeit a very high one of 4.788; therefore this factor was considered the best to summarise the original variables. All the variables loaded highly onto this factor; their factor loadings are shown in table 7.14.

[8] Hutcheson and Sofroniou's (1999) scales of suitability: KMO values between .5-.7 are *'mediocre,'* values between .7-.8 are *'good,'* values between .8-.9 are *'great'* and a KMO value above .9 is *'superb.'*

Table 7.14. Factor loadings and communalities for the remaining ten variables included in this factor analysis (nBPS =148).

VARIABLES	COMMUN-ALITIES	FACTOR 1
Generally, architects have a flexible way of working with BPS specialists, and are open to any suggestions or recommendations that are made as a result of the calculations.	**.579**	**.761**
Architects tend to perceive BPS specialists as an integral design team member, who directly impacts the building design.	**.564**	**.751**
Generally, there tends to be a mutual respect between architects and BPS specialists, and an appreciation for the work that each professional does.	**.539**	**.734**
Channels of communication between architects and BPS specialists tend to be open.	**.526**	**.725**
Architects are fully able to understand and interpret the information that BPS specialists communicate to them.	**.524**	**.724**
Generally, professional relationships between architects and BPS specialists tend to be easy and straightforward.	**.511**	**.715**
Architects are always fully able to engage in conversation with BPS specialists.	**.441**	**.664**
Architects fully understand the aims of BPS specialists work; making the relationship a fruitful one.	**.478**	**.691**
Relationships between architects and BPS specialists may be quite friendly on a personal level, but on a professional level the relationship can be quite difficult.	**.456**	**-.597**
Working with older architects (late career stages; close to retirement) tends to be easier for BPS specialists, because they have more practical work experience.	**.471**	**.521**

Factor interpretation

Nine out of these ten variables highlighted positive features of the architect-BPS relationship. The only variable which signified negative sentiments in the collaborative relationship yielded a negative factor loading. By reverse-coding this variable, the negative sign was converted into a positive one. As all ten variables now indicate positive features of this professional relationship. the factor was labelled; **'BPS specialists perceive that they have positive relationships with architects they work with.'**

7.5.1.2 Do BPS specialists feel they have positive relationships with architects?

To ascertain whether BPS specialists feel their relationships with architects are indeed positive; a composite factor score was generated by averaging the scores of the variables which had loaded onto this factor. The mean of the composite factor score (table 7.15) falls at the central point on the Likert-scale; indicating neutrality. **This means that BPS specialists neither believe that their relationships with architects can wholly be described as 'positive' or 'negative.'** In the forthcoming sections; this factor is examined further to interpret the impact beliefs about stereotyping may have on BPS specialists' perceptions of their relationships with architects, and to determine the effect trust may also have on BPS specialists' perceptions of their relationships with architects.

Table 7.15. Do BPS specialists feel their relationships with architects are positive? BPS specialists' means for the composite variable addressing this issue.

	Mean	Standard deviation
FACTOR 1 COMPOSITE SCORE - BPS specialists have positive relationships with architects they work with.	3.001	.5604

7.5.1.3 Is there an association between BPS specialists' perceptions of their relationships with architects and BPS specialists' perceptions about architects' attitudes toward BPS?

It was hypothesised that negative attitudes towards BPS (discussed in section 7.4.1.1 earlier) could have an impact on relationships between architects and BPS specialists. A Pearson's correlation was undertaken to explore the relationship between attitudes towards BPS and relationships between architects and BPS specialists. A weak, ***positive*** correlation was found between the two variables (table 7.16). **Therefore it is confirmed that a relationship exists between the two variables, associating BPS specialists' perceptions that architects have positive attitudes toward BPS with perceived positive relationships with architects, although this is a weak correlation.** This means that BPS specialists, who perceive architects' attitudes toward BPS to be positive, are more likely to perceive their relationships with architects to be positive as well.

Table 7.16. Results of the Pearson's correlation exploring the relationship between BPS specialists' perceptions of their relationships with architects and BPS specialists' perceptions about architects' attitudes toward BPS.

SIG.	CORRELATION CO-EFFICIENT (r)	CORRELATION DIRECTION	CORRELATION STRENGTH
p = .01 Result is significant.	Correlation co-efficient (r) = .273 Number of observations (nBPS) = 148.	Positive.	Weak.

7.5.1.4 Does stereotyping have an effect on BPS specialists' perceptions about their relationships with architects?

In this section, a one-way ANOVA was undertaken to find whether there is an association between BPS specialists who feel that members of their profession stereotype about architects and BPS specialists' perceptions about their relationships with architects.

- **The dependent, numerical variable:** is the composite factor score computed for factor 1, which explores BPS specialists' perceptions about their relationships with architects.

- **The independent, categorical variable:** is the 'stereotyping' variable (BPS specialists only). This consists of three categories:

- - Category 1; consisting of BPS specialists who think that members of their profession work with architects based on stereotypical impressions.

- - Category 2; consisting of BPS specialists who think that members of their profession sometimes work with architects based on stereotypical impressions.

- - Category 3; consisting of BPS specialists who do not think that members of their profession work with architects based on stereotypical impressions.

A significant difference was found in the means of the three groups; F (2,123) = 4.583, p = .012. The means and standard deviations for each group are shown in table 7.17. Post-hoc comparisons using a Tukey HSD test further revealed that there was a statistically-significant difference between category 1, BPS specialists who think that members of their profession work with architects based on stereotypical impressions, and category 3; BPS specialists who do not think that members of their profession work with architects based on stereotypical impressions. However, no differences were found between category 2, who feel that BPS specialists sometimes work with architects based on stereotypical impressions, and categories 1 or 3. **We can therefore conclude that there is an association between BPS specialists who feel that members of their profession stereotype about architects and BPS specialists' perceptions about their relationships with architects.**

Table 7.17. Means and standard deviations of the three categories of the stereotyping variable.

CATEGORIES	Mean	Standard deviation
Category 1: BPS specialists who think that members of their profession work with architects based on stereotypical impressions.	3.176	.613
Category 2: BPS specialists who think that members of their profession sometimes work with architects based on stereotypical impressions.	2.964	.485
Category 3: BPS specialists who think that members of their profession never work with architects based on stereotypical impressions.	2.717	.517

7.5.1.5 Does trust have an effect on BPS specialists' perceptions of their relationships with architects?

A one-way ANOVA was also performed to determine whether trust affects BPS specialists' perceptions of their relationships with architects. In this case;

- **The dependent, numerical variable:** is the set of composite factor scores for factor 1, which explores BPS specialists' perceptions of their relationships with architects.

- **The independent, categorical variable:** was the variable entitled 'trustful dispositions between architects and BPS specialists.' The categorical variable consisted of three categories;

- Category 1; BPS specialists who agree that their relationships with architects are trustworthy.

- Category 2; who are neutral.

- Category 3; BPS specialists who disagree that their relationships with architects are trustworthy.

A highly significant difference was found in the means of the three groups; $F(2,123) = 4.076$, $p = .000$. The means and standard deviations of the three groups are shown in table 7.18. Post-Hoc comparisons using the Tukey HSD test revealed that these differences lay between the following categories;

- Category 1; BPS specialists who agree that their relationships with architects are trustworthy and category 2; who are neutral.

- Category 1; BPS specialists who agree that their relationships with architects are trustworthy, and category 3; BPS specialists who disagree that their relationships with architects are trustworthy.

No significant difference was found between category 2; BPS specialists who are neutral and category 3; BPS specialists who disagree that relationships with architects are trustworthy. **We can therefore conclude that levels of trust do have an impact on BPS specialists' perceptions of their professional relationships with architects.**

Table 7.18. Means and standard deviations of the three categories of the trust variable.

CATEGORIES	Mean	Standard deviation
Category 1: BPS specialists who agree that their relationships with architects are trustworthy.	2.719	.505
Category 2: BPS specialists who are neutral.	3.200	.453
Category 3: BPS specialists who disagree that their relationships with architects are trustworthy.	3.490	.672

7.5.2 COMMUNICATION AND TRUST

In chapter 5; an inherent relationship between communication and trust was underlined; as open interpersonal communication is assistive to nurturing interpersonal trust relationships. Reciprocally, those who trust each other are more likely to open up in communication; and share information. In section 5.3.4.2, communication was discussed with respect to the means and channels through which it occurs. Meaning interpretation and the impacts the communicated message has on the building design were also examined. These dimensions of communication were all examined in questionnaire 2. Summary statistics for all eight 'communication' variables were all shown in figure 7.9; as they were included in the factor analysis conducted in section 7.5.1.1.

To ascertain whether BPS specialists feel that communication with architects is effective; a composite variable was generated which combined the results of all 'communication' variables. The mean of this composite variable (table 7.19) was found to lie at the third point on the Likert-scale; denoting neutrality. **Therefore; this sample of BPS specialists does not feel that their communication with architects is effective. On average, their opinion about communication is neutral.**

Table 7.19. Do BPS specialists feel communication with architects is effective? BPS specialists' means for the composite variable addressing 'communication.'

	Mean	Standard deviation
COMPOSITE VARIABLE - BPS specialists feel their communication with architects is effective	3.184	.533

Statistical confirmation was also sought to prove that there is a link between trust and communication variables; a relationship which had been established qualitatively in chapter 5, section 5.4.3.2. A Pearson's correlation was conducted to explore this relationship; as perceived by BPS specialists. **A strong positive correlation was found between the two variables;** as shown in table 7.20; with trustworthy interpersonal relationships associated with perceptions of effective interpersonal communication. **The questionnaire data therefore confirm that trustworthy relationships between**

architects and BPS specialists are affected by open and efficient communication and vice versa.

Table 7.20. Results of the Pearson's correlation investigating the relationship between trust and communication.

SIG.	CORRELATION CO-EFFICIENT (r)	CORRELATION DIRECTION	CORRELATION STRENGTH
p = .000. Result is significant.	Correlation co-efficient (r) = .535 Number of observations (nBPS) = 148.	Positive.	Strong.

7.6 SUMMARY OF STATISTICAL RESULTS

Based on the statistical analyses performed in this chapter, the following statistical results were yielded about non-technical barriers explored in chapter 5; section 5.4 pertaining to *'architects' negative attitudes toward BPS,'* 'ste*reotyping,' 'perceptions about the purpose and potential of BPS,' 'trust between architects and BPS specialists'* and *'communication.'*

A) Architects' attitudes toward BPS (initially discussed in chapter 5 in section 5.4.1.1).

- Architects in England and Wales are likely to demonstrate negative attitudes toward BPS; whereas on average BPS specialists feel that architects' attitudes toward BPS are more positive (section 7.3.1.2).

- Architects in England and Wales demonstrate greater agreement that they should conduct BPS themselves than BPS specialists (section 7.3.1.2).

- Positive attitudes toward Part L of the building regulations are associated with positive attitudes toward BPS. However, this was only a weak relationship which suggests that there may be other factors contributing toward the formation of attitudes toward BPS (section 7.3.1.3).

- An association was also found between BPS specialists' perceptions of architects' attitudes toward BPS and BPS specialists' perceptions of their relationships with architects. Perceptions that architects' attitudes toward BPS were associated with perceptions that BPS specialists' relationships with architects are also positive. However, this was only a weak correlation, suggesting that there may be other factors influencing BPS specialists' perceptions about their relationships with architects; beyond attitudes (section 7.5.1.3).

B) Stereotyping (initially discussed in chapter 5 in section 5.4.1.2).

- Both architects and BPS specialists in England and Wales believe that members of their profession work with members of the other group based on stereotypical impressions (section 7.3.2).

- BPS specialists' beliefs about stereotyping were found to have an association with BPS specialists' perceptions about their relationships with architects. BPS specialists who believe that members of their profession never stereotype about architects are more likely to have positive perceptions about their professional relationships with architects (section 7.5.1.4).

C) Perceptions about the purpose and potential of BPS (initially discussed in chapter 5 in section 5.4.2.3).

- On average, both architects and BPS specialists in England and Wales similarly agree that BPS is often viewed in practice as a compliance exercise, rather than a potential design aid (section 7.3.1.3).

- On average, neither architects nor BPS specialists in England and Wales consider compliance modelling to encourage design-flair and creativity; both groups have predominantly neutral opinions (section 7.3.1.3).

D) Trust between architects and BPS specialists (initially discussed in chapter 5 in section 5.4.3.1).

- On average, both architects and BPS specialists in England and Wales share similar levels of trust toward each other; the results indicated positive trust but were skewed slightly toward the third point on the Likert-scale denoting neutrality (section 7.3.1.4).

- BPS specialists' levels of trust toward architects were found to have a strong impact on BPS specialists' perceptions of their professional relationships with architects; with increased levels of trust associated with perceptions of improved professional relationships (section 7.5.1.5).

- On average, both architects' and BPS specialists' levels of trust toward each other were not affected by their beliefs about stereotyping (section 7.3.2.3).

E) Communication (initially discussed in chapter 5 in section 5.4.3.2).

- On average, BPS specialists have neutral opinions about their communication with architects; they do not feel it is either effective or ineffective (section 7.5.2).

- A strong relationship was found between BPS specialists' levels of trust toward architects and their perceptions about communication with architects. BPS specialists' positive trust was associated with their perceptions that their communication with architects is effective and vice versa. This was based on a strong positive correlation between the two variables (section 7.5.2).

The following results pertaining to *'Attitudes toward Part L,'* and *'project clients discouraging early collaborations between architects and BPS specialists'* were also found. However, these results pertain to the samples of architects and BPS specialists who responded to the questionnaires only, as the analysis which took place to arrive at these results was not relational.

A) Attitudes toward Part L of the building regulations (initially investigated in chapter 5 in section 5.4.2.3).

- On average, both architects and BPS specialists in this sample were found to have neutral attitudes toward Part L of the building regulations (section 7.3.1.3).

B) Project clients discouraging early collaborations between architects and BPS specialists (initially investigated in chapter 5 in section 5.4.2.1)

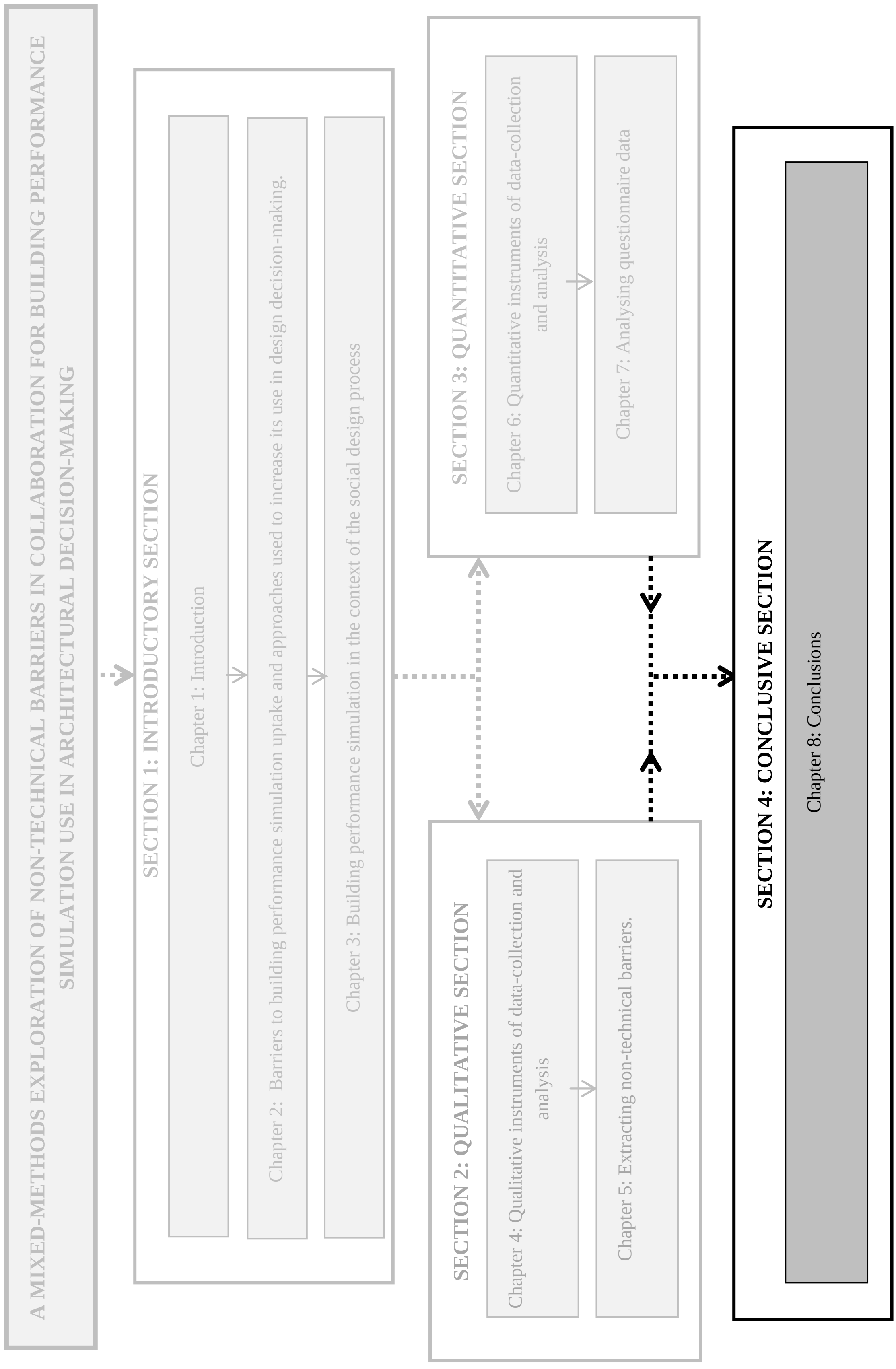
- Architects in this sample on average feel that project clients tend to discourage early collaborations with BPS specialists; reducing the potential for BPS to inform design decision-making (section 7.4).

It is important to note that the results presented in this chapter pertain to the data and analysis in the quantitative section of the research; based on the questionnaires only.

These conclusions **do not refer** to results of the qualitative analyses conducted in chapter 5; as the analyses did not occur cross-paradigmatically.

However, the results drawn from this quantitative stage of data-collection and analysis are triangulated and integrated with qualitative inferences arrived at in chapter 5 **to form pragmatically-drawn overarching research findings in chapter 8;** the concluding chapter of this thesis. By integrating the outcomes from both these empirical stages; the research findings reflect the mixed-methods approach undertaken in this thesis, and enable the overarching research question to be answered.

SECTION 4; CONCLUSIVE SECTION



8. CONCLUSIONS

"Once a proposition has been confirmed by two or more independent measurement processes, the uncertainty of its interpretation is greatly reduced. The most persuasive evidence comes through a triangulation of measurement processes." – Webb et al. 1966.

In this conclusive chapter, non-technical barriers to collaboration extracted and discussed in chapter 5 are triangulated with corresponding quantitative results from chapter 7; to form overarching research findings. **Triangulation occurs from a pragmatic standpoint;** i.e. with mutual regard to the outcomes of both social constructionist and positivist philosophical paradigms adopted at each stage in this research. It is also necessary to underline that the purpose of this triangulation is to generate complementarity. Therefore, divergent results from the two research stages are believed **to portray an alternate dimension of the non-technical barrier discussed; and to draw a complete picture of each finding;** rather than to portray a flaw in the research instruments employed.

The overarching research question of this thesis is also answered in this conclusive chapter. The research design and methodology used to fulfil the aim of the project and answer the research question are subsequently reflected on, and the limitations of the methods used are acknowledged. Additions to the existing body of knowledge made by this present contribution are highlighted. Finally, potential avenues to be followed for further research which continue to investigate non-technical dimensions of BPS use in architectural decision-making are suggested at the end of this chapter.

8.1 RESEARCH FINDINGS; INTEGRATING QUALITATIVE INFERENCES WITH QUANTITATIVE RESULTS

In this section, research findings are presented for each of the following non-technical barriers;

- Architects' attitudes toward BPS (section 8.1.1).
- Perceptions about the purpose and potential of BPS (section 8.1.1).
- Stereotyping (section 8.1.2).

- Trust dynamics between architects and BPS specialists (section 8.1.3).

In section 8.1.1, research findings concerned with perceptions about the purpose and potential of BPS are presented alongside findings related to architects' attitudes toward BPS. This is because these perceptions were found to contribute toward the formation of negative attitudes toward BPS; hence the two could not be presented in isolation. Barriers related to stereotyping and trust dynamics are discussed in sections 8.1.2 and 8.1.3 respectively.

8.1.1 ARCHITECTS' ATTITUDES TOWARD BPS AND PERCEPTIONS OF THE PURPOSE AND POTENTIAL OF BPS

Four research findings addressing architects' attitudes toward BPS and perceptions of BPS are formed in this section (table 8.1).

Table 8.1. Research findings about architects' attitudes toward BPS and architects' perceptions of the purpose and potential of BPS.

	QUALITATIVE INFERENCE IN CHAPTER 5	QUANTITATIVE RESULT IN CHAPTER 7
Research finding 1.	It was inferred that architects may have negative attitudes toward BPS (section 5.4.1.1).	Confirmed in section 7.3.1.2 that architects in England and Wales are likely to demonstrate negative attitudes toward BPS.
Research finding 2.	**Architects:** BPS was perceived amongst interviewed architects as a compliance exercise (section 5.4.2.3).	**Architects:** Confirmed in section 7.3.1.3 that on average, architects in England and Wales feel that BPS is often viewed in practice as a compliance exercise, rather than a potential design aid.
	BPS specialists: Interviewed BPS specialists do not share architects' perceptions of the main purpose of BPS to be for compliance (section 5.4.2.3). They were fully aware of the difference between BPS tools which are used for design purposes and tools which are used for compliance purposes.	**BPS specialists:** The quantitative results do not confirm the qualitative inferences from chapter 5. There was a non-significant difference between the results of architects and BPS specialists (section 7.4.1.3). The majority of BPS specialists in England and Wales agree that BPS is primarily used for compliance purposes in practice; but this agreement does not imply that BPS specialists are unaware of the difference between design tools and compliance tools.
Research finding 3.	It was suggested in sections 5.4.2.3 and 5.4.2.4 that negative attitudes toward Part L of the building regulations may contribute to formation of negative attitudes toward BPS amongst architects.	Confirmed in section 7.3.1.3; table 7.7; positive attitudes toward BPS are associated with positive attitudes toward Part L; although this is a weak association.
Research finding 4.	It is inferred that architects' negative attitudes toward BPS may have a negative impact on collaborative relationships between architects and BPS specialists (section 5.4.1.3).	Confirmed in section 7.5.1.3, table 7.16 that a relationship exists between BPS specialists' perceptions that architects have positive attitudes toward BPS and BPS specialists' perceptions of a positive collaborative relationship with architects.

Therefore, from table 8.1, research findings related to architects' attitudes toward BPS and perceptions about the purpose and potential of BPS are:

- Amongst the population of architects in England and Wales, attitudes toward BPS are likely to be negative; based on the results of both the interviews and questionnaires.

- On average, architects in England and Wales perceive the main purpose of BPS to be for compliance; rather than to guide design decision-making.
- Interviewed BPS specialists demonstrated an awareness of the difference between BPS ‘design’ tools and ‘compliance’ tools; yet questionnaire-respondents yielded a similar result to the architects; most BPS specialists predominantly view the purpose of BPS in practice as a compliance exercise. This result confirms that BPS tools are mostly used for compliance purposes rather than to guide design decision-making.
- Architects’ negative attitudes toward BPS are further associated with negative attitudes toward Part L; particularly as architects perceive the primary purpose of BPS to be for compliance checking rather than to aid in design decision-making.
- When BPS specialists perceive that architects have positive attitudes toward BPS; this is further associated with BPS specialists’ perceptions of positive collaborative relationships with architects. Therefore, BPS specialists’ perceptions of architects’ attitudes are likely to have an impact on their perceptions of collaborative relationships with architects.

8.1.2 STEREOTYPING AND ITS EFFECTS

Two research findings are formed in this section; addressing the non-technical barrier of stereotyping; and the effects beliefs about stereotypical impressions may have on the collaborative relationship between architects and BPS specialists (table 8.2).

Table 8.2. Research findings about stereotyping; and the effects stereotyping may have on collaborative relationships between architects and BPS specialists.

	QUALITATIVE INFERENCE IN CHAPTER 5	QUANTITATIVE RESULT IN CHAPTER 7
Research finding 5.	It was predicted that architects and BPS specialists may have stereotypical impressions about each other (section 5.4.1.2).	Confirmed in section 7.3.2 that both architects and BPS specialists in England and Wales believe that members of their profession work with members of the other group based on stereotypical impressions.
Research finding 6.	It was further predicted that stereotyping may have a negative impact on collaborative relationships between architects and BPS specialists (section 5.4.1.3).	Confirmed in section 7.5.1.4 that a relationship exists between BPS specialists' beliefs about stereotyping and BPS specialists' perceptions about their collaborative relationships with architects. BPS specialists who believe that members of their profession never stereotype about architects are more likely to have positive perceptions about their professional relationships with architects.

Therefore, the following can be concluded about stereotyping:

- The results suggest that architects in England and Wales work with BPS specialists based on stereotypical impressions and vice versa; based on both the qualitative and quantitative results.

- It is also possible that stereotyping may have a negative impact on the collaborative relationship between architects and BPS specialists as; based on the latters' result, those who believe that members of their profession stereotype about architects also tend to have negative perceptions about their professional relationships with architects.

8.1.3 TRUST DYNAMICS

Three research findings concerned with trust dynamics between architects and BPS specialists are reached in this section (table 8.3).

Table 8.3. Research findings about trust dynamics in architect – BPS specialist relationships.

	QUALITATIVE INFERENCE IN CHAPTER 5	QUANTITATIVE RESULT IN CHAPTER 7
Research finding 7.	It was inferred that trust dynamics between architects and BPS specialists may be poor; and that members of the two groups may not trust each other (section 5.4.3.1).	Not confirmed. The result in section 7.3.1.4 indicates that architects in England and Wales are likely to experience positive trust dynamics; although the results were slightly skewed toward neutrality.
Research finding 8.	Poor trust dynamics between architects and BPS specialists may have a negative impact on collaborative relationships between members of the two groups (section 5.4.3.1)	It was confirmed in section 7.5.1.5 that a relationship exists between trust dynamics and perceptions about collaborative relationships. BPS specialists who trust architects also tend to perceive their collaborative relationships with architects to be positive.
Research finding 9.	A relationship between trust dynamics and interpersonal communication was inferred; with improved communication associated with improved trust (section 5.4.3.2)	The relationship between positive trust and perceptions about effective communication is confirmed in section 7.5.2, table 7.20.

Based on table 8.3, we can therefore conclude the following about trust dynamics between architects and BPS specialists:

- In England and Wales, most architects and BPS specialists in England and Wales are likely to experience similar levels of trust toward each other which are predominantly positive; although veering towards neutrality.

- There is a strong association between BPS specialists' trust in architects and BPS specialists' perceptions about ensuing collaborative relationships with architects. This suggests that when trust dynamics between architects and BPS specialists are positive, collaborative relationships between members of the two groups are correspondingly more likely to be positive.

- Based on both the qualitative inferences and quantitative results, there is a strong relationship between trust dynamics and communication. BPS specialists who trust architects are more likely to feel that their communication with architects is effective than those who do not trust architects.

8.2 ANSWERING THE OVERARCHING RESEARCH QUESTION

The main research question of this thesis enquires;

> ***'Do non-technical barriers; which arise in collaboration between architects and BPS specialists, reduce the potential for BPS to inform architectural decision-making?'***

In this study, the discussion was encircled around the following non-technical barriers:

- Architects' negative attitudes toward BPS.
- Architects and BPS specialists' beliefs about stereotyping, and the stereotypical impressions members of each professional group have about the other.
- Perceptions about the purpose of BPS as primarily fulfilling a compliance requirement rather than being used as a potential design-aid to guide architectural design decision-making.
- Trust dynamics between architects and BPS specialists.
- Ineffective communication between architects and BPS specialists.
- Project clients discouraging early collaborations between architects and BPS specialists; thus reducing the potential for BPS to inform design decision-making[1].

In chapter 5 it was inferred that the main threat posed by the afore-listed barriers is that **they could cause relationships between collaborating architects and BPS specialists to become ineffective;** therefore reducing the potential for BPS to inform design decision-making. In the quantitative section of the study, it was found that BPS specialists in England and Wales are more likely to perceive their collaborative relationships with architects to become ineffective when they equally perceive architects to have negative attitudes toward BPS, when they believe that members of their own

[1] Research findings were arrived at with respect to all of the above-named barriers; with the exception of the final one concerned with the role of project clients. Although it was confirmed in chapter 7 that architects feel project clients discourage early collaborations between themselves and BPS specialists, this confirmation was limited to the sample of architects who participated in the study. Nevertheless, being unable to generalize this barrier does not negate neither its existence nor its possible threat in reducing the potential for BPS to inform design decision-making.

profession work with architects based on stereotypical impressions or when BPS specialists do not trust architects.

The potential damage signified by the afore-listed non-technical barriers is multiplied by their complex entanglement within one another. In chapter 5 (section 5.4), each non-technical barrier extracted was interconnected with the one preceding it and, as one barrier was revealed; the others were subsequently unravelled. Moreover, these non-technical barriers identified were found to be enrooted within a backlog of architectural ideologies affirmed through education and professional enculturation; as discussed in chapter 5 (sections 5.2 and 5.3). **Non-technical barriers to collaboration identified in this thesis therefore constitute an external façade to a series of historically-embedded complexities; making these barriers potentially more difficult to address, solve or remove.**

It can therefore be confirmed that there are non-technical barriers which do reduce the potential for BPS to inform design decision-making in the architectural design process. Some of these barriers were identified in this study; related to the context of England and Wales. However, this is not to suggest that the barriers identified in this study are the only non-technical barriers to collaboration between architects and BPS specialists. Rather, than striving to discover **all** the barriers, this research study constitutes a starting point to proving that non-technical barriers to collaboration do exist by unfolding a few of them, and highlighting their potential threat of reducing the potential for BPS to inform design decision-making.

8.3 REFLECTIONS ON THE RESEARCH DESIGN AND METHODOLOGY

This research proposed an alternate starting point to the existing in BPS literature; that alongside widely-recognised barriers related to BPS software; there may be additional non-technical barriers which further amplify the problem and reduce the potential for BPS to inform design decision-making. In correspondence with this starting point, this project further proposed a different way of empirically exploring the problem; by viewing architectural design as a social interaction between multi-disciplinary practitioners; and the use of BPS in architectural design as an amalgamation of different knowledge-domains. In accordance with this social view, methods from the social sciences were also used. The merits of both qualitative and quantitative traditions in social science research were mutually-acknowledged and fully-exploited in this project;

by designing a pragmatic two-stage methodology consisting of both qualitative and quantitative instruments of data-collection and analysis. By employing instruments from both traditions, the known shortcomings of both were cancelled out; and the findings were only formed in this research by taking the results of both qualitative and quantitative analysis into account.

Extracting non-technical barriers to collaboration and arriving at overarching research findings in section 8.1 of this chapter by integrating the results of both research stages indicates that the aim of this research project outlined in the introductory chapter has been fulfilled. Moreover, fulfilling the aim of the research and answering the overarching research question serve as testaments to the success of the two-stage research design purposively tailored to carry out this project, and the applicability of social science research methods to the BPS domain for future research.

8.3.1 LIMITATIONS OF THE WORK

Even though the experience of using social science research methods in this project was a successful one, limitations were inevitably experienced; particularly during the quantitative research stage. These were related to:

1. <u>Determining the exact populations of architects and BPS specialists in England and Wales;</u> from which representative samples of both groups could be derived. The RIBA Chartered Members Directory (RIBA 2011b) and the Register of Low Carbon Consultants (CIBSE 2012) were used; as these comprised the best available representation of the two groups' populations. For architects, the register provided by the Architects Registration Board (ARB 2012) would have been more accurate, yet did not contain full contact details for all architects listed and therefore could not be used. Similarly, the Register of Low Carbon Consultants (CIBSE 2012) was used because a listing of BPS specialists could not be obtained from IBPSA England (IBPSA-England 2012), and a regional affiliate such as 'IBPSA Wales' does not exist.

2. <u>Sampling errors and potential sampling bias:</u> A response rate of just over 50% was obtained for both samples of architects and BPS specialists. Although this represents a high response rate based on comparisons with the response rates reported in other questionnaire-based studies in this research area, the

possibility of bias is still included within the samples. Nevertheless, because no data was collected with regard to respondent demographics, such as gender, age or years of experience, there was no way of determining whether the two samples were biased or whether they were internally homogeneous and accurately represented their respective populations. It has therefore been noted that it is necessary to collect data concerned with sample demographics in future research using questionnaire-based studies.

3. Not collecting demographic data potentially reduced the breadth of exploration: The fact that information about the age-groups of questionnaire respondents was not collected particularly reduced the potential to triangulate qualitative inferences which were related to the question of architects' age in chapter 5. For example, section 5.2.2.2 entitled 'elderly architects resistance,' and the sub-section of section 5.3.2.1 entitled 'knowledge, interest and age' pointed towards age as a significant factor potentially affecting collaborative relationships between architects and BPS specialists[2]. However, this could not be tested quantitatively; and the factor of architects' age affecting collaborative relationships remained unconfirmed and did not include within the conclusive research findings. Nevertheless, the pertinence of architects' age as a decisive factor affecting collaborative relationships between architects and BPS specialists can be tested further in future research; as suggested in section 8.5.

4. Questionnaire-design: Statements included in questionnaires 1 and 2 were designed based upon quotes from architects and BP specialists obtained during the interviews, as shown in chapter 5 (section 5.5). This meant that some of the barriers which were tested in the architects' questionnaire were not tested in the BPS specialists' questionnaire because they had only been mentioned by interviewed architects; and vice versa. It was only recognised later in the research that, had the same statements and questions been designed in both questionnaires 1 and 2, this would have facilitated a more direct comparison between architects' and BPS specialists' responses about each of the barriers.

[2] It was inferred in these sections that younger architects may have greater knowledge and/or interest in BPS for their wider exposure to issues related to sustainability. This inference was also based on the notion that more recent architectural graduates were more likely to have had studies of building physics included within their curricula.

Questionnaire 2 aimed at BPS specialists consisted of a section questioning their perceptions of their collaborative relationships with architects. A corresponding section questioning architects' perceptions about their collaborative relationships with BPS specialists was not designed in questionnaire 1[3]. This meant that the effects of extracted non-technical barriers on collaborative relationships could only be tested in questionnaire 2, and therefore from BPS specialists' perspective only. On the other hand, if this data had been collected from the architects as well, this would have facilitated the arrival at conclusions about the effects of non-technical barriers on collaborative relationships from both the architects' and BPS specialists' perspectives. However, this limitation was only noted during the quantitative analysis stage; i.e. after all the data had been collected.

8.4 CONTRIBUTIONS TO THE EXISTING BODY OF KNOWLEDGE

Contributions to the existing body of knowledge made by this PhD research were made within the topic of investigation, methodology and research findings;

1. **Topic of investigation:** To the best of the author's knowledge, this is the first empirical piece of work in the BPS field to approach the topic from a non-technical perspective rather than a computer-based one. This work builds upon the proposition of Mahdavi (2011a) to explore elements of a human dimensionality in BPS research, and Bleil De Souza's (2008 and 2012) suggestions to conduct qualitative and social work in this area; by conducting an empirical investigation of non-technical barriers using social research methods.

2. **Methodology:** This research project is also considered innovative as it is the first time that multiple social research methods have been used in the BPS domain to explore further reasons beyond the technical, which may be reducing the potential for BPS to inform architectural design decision-making. Moreover, this is the first empirical work exploring this problem which used a combination of qualitative social science research instruments (semi-structured interviews and thematic content analysis) and quantitative instruments (self-completion questionnaires and statistical analysis). Use of both qualitative and quantitative

[3] Following the same reasoning explained in the preceding paragraph, the effectiveness of collaborative relationships was only discussed by BPS specialists interviewed, not architects.

instruments meant that the findings integrated the virtues of *"deep, rich observational data"* (Sieber 1973) associated with qualitative tradition and *"hard generalizable data"* (Sieber 1973) associated with quantitative research.

3. **Findings:** Based on innovation in the topic of investigation and methodological approach, this is the first empirical piece of work to identify some of the non-technical barriers which may be reducing the potential for BPS to inform design decision-making.

   It has further been acknowledged that the threat of each of the extracted barriers extracted and discussed lies in their prominent interconnection. As demonstrated both qualitatively and quantitatively; none of these barriers resides in isolation; each is conjoined to a preceding barrier and is simultaneously the reason for the formation of the next one. The non-technical barriers extracted in this research are essentially a facade to a more challenging backlog of ideological and historical conflicts.

8.5 FURTHER RESEARCH

Three potential avenues for further exploration are proposed as continuations to the research conducted in this thesis. In all these propositions; the findings presented in this thesis can be used as starting points; prelude to illuminate further work in each of the forthcoming potential research areas.

8.5.1 FURTHER STUDIES OF COLLABORATION

In both stages of this research, data was collected from architects and BPS specialists in separation and complete isolation from one another[4]; to allow participants to divulge their opinions freely without becoming affected by other participants in the study; whether of their 'own' or the 'other' group. Therefore, the aims of this thesis did not include an examination of architects and BPS specialists physically **working together.** With an awareness of the non-technical barriers extracted in this research, one possibility for further research would be **to conduct an ethnographic study of architects and BPS specialists in collaboration.** An ethnographic study of this nature

[4] In the first empirical stage, interviews were conducted on a one-to-one basis; as described in chapter 4 (section 4.2.6). In the second empirical stage, two questionnaires were distributed; one to architects and one to BPS specialists.

could potentially provide a participatory and first-hand approach to answer the following questions;

– How do these, and other non-technical barriers arise in practical project scenarios, if at all? How do architects, BPS specialists and any other members of the design team deal with these and other barriers if and when they do arise?

– Do non-technical barriers seem to impede BPS uptake and use in design decision-making more than technical barriers; pertaining to limitations in BPS software?

– How do these and other barriers affect the project design, procurement and delivery?

– From a methodological perspective, do participatory and ethnographic research methods allow more non-technical barriers to be identified than interviewing? How do the findings from an ethnographic study about BPS uptake to inform architectural decision-making compare to the use of interviews and questionnaires? Do the two methodologies divulge alternative dimensions of the problem; or do they reveal similar results?

8.5.2 FURTHER STUDIES ABOUT THE ROLE OF ARCHITECTURAL EDUCATION

Having identified Post-Modernist paradigms of architectural education in the UK as potentially influencing architects' ideologies; another promising route for further research would be **to explore how education affects architects' ideologies, understanding, favourability and uptake of BPS. A deeper investigation about the role of architectural education may facilitate answering some of the forthcoming questions;**

- At what points in architectural education is BPS introduced to architectural students, if at all? Is BPS marketed by these educational establishments as a potential design-informant, and if so how is this done? Moreover, are these initial introductions followed-through in design projects; and are students encouraged to use BPS to demonstrate the predicted performances of these buildings in design studio projects?

- How are architectural students taught to handle constraints in design projects? How are architectural students taught to deal with BPS in light of the discussion about constraints?

- Do fresh graduates of schools of architecture demonstrate a deeper understanding and awareness of the purpose and potential of BPS than middle-aged or elderly architects? Does this make younger architects more likely to include BPS within their design decision-making than middle-aged or elderly architects? Alternatively, how does age difference affect collaboration and communication with BPS specialists in a collaborative environment?

- Are ideologies stemming from paradigms of architectural education particular to UK architects? Or are these ideologies common amongst architects following different training systems in other geographical regions of the world; such as the European Continent or the Americas, for example? If these ideologies are different, are improved examples of BPS uptake in architectural decision-making demonstrated in European or American countries; and what lessons can be learnt and applied in England and Wales from these examples?

8.5.3 FURTHER STUDIES ABOUT LANGUAGE AND COMMUNICATION

Having identified the relationship between interpersonal communication and interpersonal trust dynamics between the two groups; another avenue for further research is to explore the premise of architects' and BPS specialists' languages in more detail. Through an analysis of the professional discourses of the two groups, the following questions could be answered;

- Do architects and BPS specialists essentially speak different professional languages in the building industry? And if so, do they realise that they speak different languages; or do they operate on the assumption that they essentially assign the same semantic meanings to words?

- In chapter 5, the words 'zone' and 'detail' were identified as ambiguous in the two professional domains. Are there more ambiguous words and terminologies whose meanings are not mutually-shared across both professional discourses? If so, what are they? Could a vocabulary of these ambiguous words potentially be compiled to facilitate translation and mutual-understandings of meanings between the two groups?

- How does each of these professional discourses mirror the underlying worldviews of each group? Can discourse analysis (another method from the social sciences) be used as a tool to uncover worldview divergences between the two groups; as a means of facilitating understandings between the two groups?

- Finally, if a mutually-understood professional discourse can be unified such that both architects and BPS specialists understand each other; will these breed improved trust dynamics between the two groups in collaboration?

8.6 CLOSING REMARKS

The matter of introducing BPS technologies into the architectural world is essentially a question of multi-disciplinary research and knowledge transfer initiatives. Multi-disciplinary work promises to bridge the gaps between two unique professional cultures which do not overlap. Because there is little overlap, this ‘bridging’ cannot occur based on uni-disciplinary approaches which try to impose their patterns, working procedures and philosophies onto the other culture.

Although the author’s own background is architectural; and although the scope of this research has been concerned with bridging between the architectural and BPS domains; the social sciences were recurred to as an outside and altogether third domain to pragmatically observe and better understand both professions and cultures. Furthermore, this research project serves as an illustrative example of how adopting multi-disciplinary approaches holds strong potential to provide lattice for both the architectural and BPS domains to come together. It also emphasises that employing multi-disciplinary approaches in future research promises to illuminate this field further; and consideration of different research philosophies, methodologies and apparatus is instrumental, enlightening and expansive to the BPS domain.

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APPENDICES

APPENDIX A: Documents submitted to the Welsh School of Architecture Research Ethics Committee in September 2010; to gain approval for the data-collection procedures conducted in the qualitative research stage.

DKA

WELSH SCHOOL OF ARCHITECTURE
ETHICS APPROVAL FORM FOR STUDENT PROJECTS

EC1009.045

WS

Tick one box:	☐ UNDERGRADUATE ☐ M.ARCH √ PHD
Title of project:	Optimising communication between architects and simulationists, for integration of thermal simulation software in the architectural design process.
Name of student(s):	Sara Alsaadani
Name of supervisor:	Don Alexander, Clarice Bleil De Souza
Contact e-mail address:	alsaadanisa@cardiff.ac.uk , Alexander@cardiff.ac.uk, bleildesouzac@cardiff.ac.uk
Date:	07/09/2010

Participants		YES	NO	N/A
Does the research involve participants from any of the following groups?	• Children (under 16 years of age)		√	
	• People with learning difficulties		√	
	• Patients (NHS approval is required)		√	
	• People in custody		√	
	• People engaged in illegal activities		√	
	• Vulnerable elderly people		√	
	• Any other vulnerable group not listed here		√	
• When working with children: I have read the Interim Guidance for Researchers Working with Children and Young People (http://www.cardiff.ac.uk/archi/ethics_committee.php)				√

Consent Procedure	YES	NO	N/A
• Will you describe the research process to participants in advance, so that they are informed about what to expect?	√		
• Will you tell participants that their participation is voluntary?	√		
• Will you tell participants that they may withdraw from the research at any time and for any reason?	√		
• Will you obtain valid consent from participants? (specify how consent will be obtained in Box A)[1]	√		
• Will you give participants the option of omitting questions they do not want to answer?	√		
• If the research is observational, will you ask participants for their consent to being observed?	√		
• If the research involves photography or other audio-visual recording, will you ask participants for their consent to being photographed / recorded and for its use/publication?	√		

Possible Harm to Participants	YES	NO	N/A
• Is there any realistic risk of any participants experiencing either physical or psychological distress or discomfort?		√	
• Is there any realistic risk of any participants experience a detriment to their interests as a result of participation?		√	

Data Protection		YES	NO	N/A
• Will any non-anonymous and/or personalised data be generated or stored?			√	
• If the research involves non-anonymous and/or personalised data, will you:	• gain written consent from the participants	√		
	• allow the participants the option of anonymity for all or part of the information they provide	√		

Health and Safety	YES
Does the research meet the requirements of the University's Health & Safety policies? (http://www.cardiff.ac.uk/osheu/complete_risk_assessment/index.html)	√

If any of the shaded boxes have been ticked, the supervisor must explain in Box A how the ethical issues are addressed.

The list of ethical issues on this form is not exhaustive; if the supervisor is aware of any other ethical issue

[1] If any non-anonymous and/or personalised data be generated or stored, *written consent* is required.

should make the SREC aware of it.

Box A **The Project** (provide all the information listed below in a separate attachment)

1. Title of Project
2. Purpose of the project and its academic rationale
3. Brief description of methods and measurements
4. Participants: recruitment methods, number, age, gender, exclusion/inclusion criteria
5. Consent and participation information arrangements - please attached consent forms if they are to be used
6. A clear and concise statement of the ethical considerations raised by the project and how is dealt with them
7. Estimated start date and duration of project

All information must be submitted along with this form to the School Research Ethics Committee for consideration

Supervisor's declaration (tick as appropriate)	
• I consider this research project to have **negligible ethical implications** and **the student can proceed with the research immediately** (*can only be used if none of the grey areas of the checklist have been ticked*).	✓
• I consider this project research to have **some ethical implications. Box A** clearly describes the ethical issues and how they are addressed. **The student has to await feedback whether the research has been approved by the SREC Chair or whether it will have to be considered by the Committee.** The student will receive feedback within 7-10 days.	
• I consider this project to have **significant ethical implications** and should be brought before the Ethics Committee. **Box A** clearly describes the ethical issues and how they are addressed. **The student MUST NOT proceed until the project has been approved by the Ethics Committee.**	

Signature Clarice Bleil de Souza **Name** CLARICE BLEIL DE SOUZA **Date** 7/Sep/2010

Advice from the School Research Ethics Committee

STATEMENT OF ETHICAL APPROVAL

This project had been considered using agreed Departmental procedures and is now approved

Signature **Name** Wouter Poortinga **Date** 07/09/10

Chair, School Research Ethics Committee

Box A – The Project

1. **Research Title:** Optimising communication between architects and simulationists, for integration of thermal simulation software in the architectural design process.

2. **Purpose of the Project and its Academic Rationale:**

   This project aims to understand the communication that occurs between architects and simulationists, and to understand in more detail why problems in communication between architects and simulationists occur. The project draws upon a hypothetical model, which is suggestive of three main 'levels' at which misunderstandings may occur (Appendix B.).

   Furthermore, the research aims to compare and contrast the similarities and differences between architects and simulationists, by investigating issues including their background education, practical experience, knowledge and awareness of each group's problem-solving methods, the languages that they use when discussing aspects of the building industry and their worldviews. By investigating these issues, the researcher may be able to comprehend which of the aforementioned issues has the most effect on communication, and results in miscommunications between architects and simulationists. More information about the project is provided in Appendix C.

3. **Brief Description of Methods and Measurements:**

   Data will be collected and analysed using semi-structured depth interviews (SSDI). Detailed information concerning this method, why it has been chosen for this project and how it will be applied is provided in Appendix C.

   Five Central Research Questions (CRQs) have been drawn up, as well as a series of Theory Questions (TQs) from which Interview Interventions/Interview Questions (IIs/IQs) have been developed. These IIs/IQs are the ones which will be posed directly to the interviewees.

   It is anticipated that there will be four interview sessions conducted with each interviewee. Each interview session aims to address one CRQ, and the responses for the fifth CRQ will be inferred subjectively from the responses given during the first three interview sessions.

   In the cases of most questions, each group of interviewees will be asked the same question, thus allowing comparison of responses. However, in the cases that certain questions are irrelevant to certain interviewees, alternatively framed questions have also been proposed. The proposed CRQs, TQs and IIs/IQs to be asked, and how they have been developed from the original Research Purpose (RP), are shown in Appendix D.

   It is important to note that, since the SSDI method is a type of conversational interaction between interviewer and interviewee, which is deliberately semi-structured, the IIs/IQs specified are **only** initial questions, deliberately designed in an open manner, and allowing for improvisation and inference during the interview.

4. **Participants: Recruitment Methods, Number, Age, Gender, etc.:**

   There will be three participant groups for this study:

   Group A: Architects who carry out thermal simulation tasks within the architectural practices they work for (i.e. in-house.)

Group B: Architectural designers who sub-contract thermal simulation tasks to simulationists.

Group C: Simulationists who carry out thermal simulation tasks for architectural designers and practices.

Within each group, it is anticipated that interviews will be conducted with three interviewees, hence the total number of participants will be nine participants altogether. Therefore, twelve interviews will be conducted in total.

Concerning the recruitment of interviewees, e-mails will initially be sent out to architectural practices and simulationists and/or sustainability consultants across the UK, giving a brief outline of the project. Those who reply showing interest will then be contacted by phone, giving more detailed information on the project.

Main inclusion criteria for Group A Participants:

1. To be practitioners working in architectural practices, and who work regularly in modelling and thermal simulation of buildings. They may or may not have a basic degree in architecture.

Main inclusion criteria for Group B Participants:

1. To be architects, architectural designers or architectural assistants working in architectural practices which demonstrate a clear interest in sustainability.

2. To have worked closely with simulationists in past projects, to have interacted closely with them, and to have used the results of simulation and thermal analysis in the past to inform their design decisions.

Main inclusion criteria for Group C Participants:

1. To be practitioners who do not have an architectural degree, yet who have a chosen career in simulation and thermal analysis of buildings.

2. To have worked closely with architects, architectural designers or architectural assistants in past projects, to have attended meetings, interacted and communicated with them, and who have provided consultancy services based on the results of simulation.

5. Consent and Participation Information Arrangements:

The proposed study does not pose a realistic risk of any participants experiencing either physical or psychological distress or discomfort. The interviews aim only to address issues related to the participants background education, professional practice, problem-solving methods and interaction and communication that occur between them. No sort of participant deception or manipulation is involved in the research project, and it is not intended that any personal or sensitive information is collected from the participants through the interviews. Consent forms will be sent out to all participants, explicitly informing participants that they and the practices they represent will remain anonymous, that the participation is voluntary and that participants may withdraw at any time they desire.

6. Statement of Ethical Considerations

This research project does not pose a risk on participants experiencing either physical or psychological distress or discomfort. The targets of the initial interview questions prepared are only to understand how background education, professional practice and problem-solving have an effect on communication between architects and simulationists. Furthermore, the project does not involve any kind of participant deception, manipulation, distraction or misleading information. No sensitive data will be collected that could trigger upset, anxieties or any other adverse emotional reactions. The information sheet provided (Appendix A) that will be posted to participants in advance clearly informs participants about issues of confidentiality, that participation is voluntary and that participants may withdraw from the study at any time.

7. Estimated Start Date and Duration of the Project

It is intended that the researcher will begin making arrangements for interviews with potential participants as soon as the research has been approved by the School Research Ethics Committee.

Consent Form - Confidential data

I understand that my participation in this project will involve participation in four interview sessions, all of which will be conversational interviews related to my educational background, my professional practice and how I work with other members of the building industry. I understand that each interview will take up between 45 minutes to 1 hour of my time.

I understand that participation in this study is entirely voluntary and that I can withdraw from the study at any time without giving a reason.

I understand that I am free to ask any questions at any time. I am free to withdraw or discuss my concerns with Don Alexander or Clarice Bleil De Souza.

I understand that the information provided by me will be held confidentially, such that only the Principal Investigator, Don Alexander and Clarice Bleil De Souza can trace this information back to me individually. I understand that my data will be anonymised as soon as it is collected, and that after this point no-one will be able to trace my information back to me.

I understand that I can ask for the information I provide to be deleted/destroyed at any time up until the data has been anonymised and I can have access to the information up until the data has been anonymised.

I, ____________________________________ consent to participate in the study conducted by Sara Alsaadani, Welsh School of Architecture, Cardiff University with the supervision of Don Alexander and Clarice Bleil De Souza.

Signed:

Date:

Dear Sir or Madam,

I am writing to invite you to participate in a PhD project currently being researched at the Welsh School of Architecture, Cardiff University, entitled *'Optimising communication between architects and simulationists, for integration of thermal simulation software in the architectural design process.'*

The overall aim of this project is to gain an understanding of communication between architects and simulationists; whether they fully understand each others' thinking and working methods, and are able to communicate efficiently and fully understand the information being exchanged between them. It is anticipated that the results of this research may contribute towards improvement of thermal simulation software interfaces and long -term uptake of thermal simulation software by architects and building designers, and improved integration of simulation and thermal analysis within the architectural design process adopted by practitioners.

I hope that you would be able to help by participating in a set of semi-structured, in-depth interviews. Four interview sessions have been planned, each dealing with a different topic related to your educational background, professional practice and how practitioners in your field communicate with **architects/simulationists.** The duration of each interview session should take between 45 minutes to one hour, depending on how the conversation develops during the interview. These conversations will be audio-recorded, for transcription and analysis later on during the course of this research.

Your participation in this project is entirely voluntary and you may withdraw from the study at any time. The information you provide will be treated confidentially and anonymity. Neither the name of the practice being represented, nor the names of individual employees will be used or quoted in the reporting or analysis in any way. **This research project** has been approved by the Research Ethics Committee of the Welsh School of Architecture in September 2010, under the reference of EC1009.045.

If you have any queries about the project or the interviews please do not hesitate to contact me. I am happy to respond to any questions you may like to ask.

Thank you very much in advance for your help and kind co-operation.

Sara Alsaadani
PhD Researcher,
Welsh School of Architecture
Cardiff University
Bute Building, King Edward VII Avenue
Cardiff
Wales
CF10 3NB
Tel: 07904700970
E-mail: alsaadanisa@cardiff.ac.uk

APPENDIX B: Sample of one of the architects' interviews.

FIRST INTERVIEW WITH ARCHITECT A6.

INTERVIEWER’S NAME: Sara Alsaadani

DATE: 2nd June 2011

INITIALS USED IN THE TRANSCRIPT:

A6: Architect 6

SA: Interviewer Sara Alsaadani

CONVENTIONS USED DURING TRANSCRIPTION:

[ ] Square brackets, with the action in italics in between are used to describe sounds on the audio-recording that are not actually included in the speech, other stage directions, including interruptions, etc.

... Three dots indicate pauses during the speech.

Quotations during the conversation have been highlighted in the transcript but putting them in between inverted commas and making them *italic.*

Words that have been emphasised during the speech have been highlighted in the transcript, by making them ***bold and italic.***

TRANSCRIPT NO.1:

SA: OK... so... um... yeah thank you very much again for... for coming to speak to me. Um... I wanted to start off by asking you a little bit... if you could tell me about yourself?

A6: Yeah, sure.

SA: What you do and everything.

A6: Sure... sure. So... um... I'm... um... an architect and... um... I studied... um... at xxx University, um... in... started in 19xx actually... um... and then I... when I... I did everything at xxx University... um... all three parts of the architecture so I got professionally qualified there and then I started working in architectural practice... um... well I started at Nick Grimshaw so... uh.... uh it was my first job and I worked for... um... a year at Grimshaw's on the xxx Building.

SA: Right.

A6: Uh... and then after that they... um... at the same time I was I was extending my... um... diploma into a masters... you could do that through xxx University. It meant you had to extend your thesis by quite a significant amount... um... and at my... um... subject matter was looking at energy efficiency actually and it... I had... I was trying to look at the different... at that sort of point I was quite interested in the ***subject*** and why you got such different types of architecture that all claimed to be energy-efficient, for example you could have high-tech stuff; the work of xxx and xxx and people like that... that was energy-efficient or you could have the real low-tech green 'sandals-and-woolly-jumper-kind-of-stuff;' I've been... I'd had a couple of tutors at Sheffield who were kind of quite famous for this autonomous kind of... um... house book they wrote; the green... the real deep green... so I was looking... that was what my masters was kind of focused on and I carried on doing that and then I moved from... um... xxx to... um... xxx architects where I worked on... um... xxx Underground... um... Tube station... xxx underground on the Jubilee Line... um... for... um... eighteen months and I... um... is this alright telling you kind of...?

SA: Yes! Yes... yes... please that's what I'm...I'd like to know that.

A6: Oh OK... good... good. So I worked there for... um... eighteen months on xxx station and one or two other projects, and then I left there and went to a place called xxx Architects, and I was there for a year... and I got fed up with it I wanted to work in a... a smaller practice, I decided I wanted to work in a smaller practice ‘cause I wanted to work on more smaller jobs and run those jobs; do you know what I mean? If you work in a larger practice or even in a medium-to-large practice you tend to be... you know a small component in a big machine and... uh... um although it can be quite interesting working on projects like xxx Underground station, at the same time it can be frustrating if you’re not getting out and about and working on site and all that type of thing... so I did that and I changed and I worked in the a...a small architects practice for about four years... um... but they don’t exist anymore, they were called xxx... um... they were in xxx and I worked on small... not... generally smaller scale residential... um... projects... um... a mixture of things... um... and... uh..., and although I really enjoyed it I enjoyed the site work and so on, I got fed up of working for posh rich people that lived in xxx... you know after a while I couldn’t care less whether we were specifying... or they wanted... you know large... travertine limestone or marble floor... in fact actually after a while I hated them so I... um... and I actually I was quite interested and always had been; still interested in the energy efficiency stuff, and still interested in the idea of... um... teaching actually.

SA: Oh OK.

A6: Teaching architecture... and at that time they were offering a course at the University of xxx in... um... in teaching architecture for architects that had kind of been working in practice for a while... in a sense perhaps had lost their contacts that they’d had at universities; mine had been at xxx, and wanted to get a degree... uh.... a.... um... a qualification so... a certificate in teaching architecture.

SA: Yeah.

A6: So I did that and that was a day a week for a year... um... and through that I got involved with a masters course that was taught through the University of xxx, but had been in xxx... um... it’s actually still running and it’s quite a big course; it’s called the Masters... um... MSc... uh... um... xxx course. It would probably be... um... similar to the xxx one but... uh... just much bigger in the sense that they accept any student.

SA: Oh OK.

A6: They're not too worried about what their qualifications or background are; it's almost like... um... it's almost like if you want to be on the course and you can pay then go on it so there's... in excess of two-hundred students you know, at any one time on that course.

SA: Yeah.

A6: And I... and I taught on it part-time for seven... seven years... um... and through that... um... there was quite a big connection between the course... um... and the xxx; you know it was students, tutors, politicians... students and tutors that were working...were on the course and on the course that were at xxx and I got interested in the idea of working at xxx. By that stage, that small practice had folded and I... and I was kind of working on my own, and doing the teaching and I went to xxx... and I got a job there and I've been there ever since; for x years basically working at xxx, and I was teaching on the xxx course... um... whilst working at xxx up until about two years ago. Now I work... um... just at xxx.

SA: Right.

A6: And... um... at xxx although I'm still an architect and I pay my RIBA subscription... um... just so I can come here and drink these posh smoothies...

SA: RIBA Banana smoothies *[laughs]*.

A6: *[Laughs]* Yeah actually anyone can do that... um... I... um... work in a variety of projects... um... mainly consultancy kind of work although we do... we have done... um... early stage design work as well; I worked a lot in education initially and we would do conceptual design work which was quite good because we had xxx experts in a variety of subject areas like daylighting, acoustics or wind or whatever so we could kind of pull those... those in and include them as part of the... um... the project. Anyway I did a range of things but about four years ago we bid to the government for some funding to design a low-energy design tool for architects, and that's where my connection with xxx University began really... because we formed a project involving xxx, xxx University... um... xxx Research; it was sort of affiliated at xxx University... uh... xxx who are a small scale environmental consultancy and xxx who are likewise a small scale environmental consultancy. And we started... um... on the project of developing this piece of software which we now call xxx, and we're just... um... four years on we're just at the point where we're looking to release the software; it's more or less complete, its about ninety-five percent there. The software... um... essentially is... um... aimed at architects and... um... designers; the idea is to use it or it can be used right at the beginning of the design process; right at the inception stage

<u>SA:</u> Yeah.

<u>A6:</u> So it's not a piece of software that competes... um... with things like xxx or xxx or other type... more engineering-based software but... um... that get... get you Part L compliance, it's really... um... meant to be an easy-to-use software... um... that will help designers make the right kind of early decisions like how to... where to place their buildings, how to orientate them, what the depth of plan should be, percentage of glazing, what the mix of renewables might be or other sources of energy provision and so on... to help them make those early stage decisions... but there's a processer... a computer processor that will help them do that they could design within it... it looks at early stage site analysis... um... broad-brush building design it gives you continuous energy and use figures and then... um... looking at mixing in different types of renewables as well into the... into the process... so that's... um... where we are and really where I am.

<u>SA:</u> Yeah.

<u>A6:</u> That brings you up to date with it all.

<u>SA:</u> Right, well... um... it's all pretty interesting. Um... about xxx, could you tell me how it's meant to be sort of 'easy to use;' what's... why's it... why's it different? Or how's it different to xxx or...?

<u>A6:</u> Yeah OK. Well I suppose the first thing is, it requires far less input... uh... far less information to be inputted into it than something like xxx, to give results so it... you... you only... if you select a particular building type, say if you were designing an office, then what the programme does is that it makes a whole load of assumptions on things like occupancy use... um... uh... U-values... um... lighting and so on... uh... that you can actually go on and ultimately change but at least it's makes those assumptions for you... um... and then once you've done that it's very easy to look at different types of buildings in terms of their shape and orientation and so on... it... it... in terms of the detail of glazing for example you're only specifying glazing percentages, if you like, or the ratio of glazing to solid... uh...

to... you say south facade is fifty percent glazing... you're not designing or looking at any... any more detail than that. So it requires less input and far less information than something like... um... xxx to get results, and it enables you to get results very very quickly... um... so... uh... what you can do is... um... quite easily and quite quickly compare different scenarios; different options for the designs for individual buildings or for small-scale masterplan or even large-scale masterplan. The other thing is that it looks at a number of different buildings as well whereas I think xxx tends to focus on one very... you know... internally and it needs a lot of information... uh... so that's... also... um... we try to... um... make it so it's quite user-friendly you know, with the architect in mind, so hopefully it looks quite good; it's quite reasonably looking, 'cause architects will probably it's quite important... um... and... uh I... um... so I think those are the key things really... you know... um... it really just requires far less information to go in there.

SA: Yeah. Have you... have you tried it? Have you got any architects to try the software?

A6: Yes.

SA: Um... what kind of feedback did they give you? I'd be interested in that...

A6: Yeah. We...sure...we've had a number of architects... we've had... uh about... um... a dozen architects that have been using it and looking at it over the last three to six months, and we've had a range of feedback. In the early days I think we almost let them look at it prematurely because... um... uh... it wasn't probably quite ready, but more recently we've been having better feedback. We've also had some students look at it and I've worked with the students from... um... University of xxx; there was a little masters course there, not the one that I referred to earlier but... um... another one that I have a colleague who runs... plus also I think it's been used with some of the students at xxx; I'm not sure to what degree. But yeah, the feedback that we've had has been pretty positive... I mean pretty positive from the industry that... the other thing is that we don't really think that there's many pieces of software like this in the marketplace at the moment although I think there's other things coming out. I think the closest to it is xxx which might well be...yeah... and xxx again... it's more complicated more difficult to use than... than xxx.

SA: Yeah.

A6: I'm sure about that... um... and xxx I think falls somewhere between xxx and IES, you know, somewhere in the middle. It's not a compliance tool but it's quite complicated. But that said it gives quite good information... um... yes so just to answer your question, we have had... we have had comments on the usability of it, the functionality... um... on the kind of level of accuracy, the results and so on. It's been pretty positive but we've also had... um... feedback where we've had to change things and address things... and address them, for example at the moment you can't import .dxfs or .dwgs into the software, and everybody's been asking for that; all architects have been asking for that. So that's something we're looking at the moment, trying to... um... include within the first release of the software, whereas before we weren't but now we are aiming to do that.

SA: OK and is... is this interface something that an architect can use to draw directly onto it? Is it...does it work in the same way as xxx maybe works or maybe xxx?

A6: Yeah absolutely it's very... very simple to draw on... um... I suppose in a way it's... it's like... it's not as good or refined as xxx, but it's very simple and very quick. You just draw shapes in 2D and then you have a 3D viewer... um... once you've drawn your shapes, which could be rooms or entire buildings, then you click on the... um... the walls of those shapes and specify... um... glazing quantities in terms of percentage. You can also put other shapes within the shapes and... um... select... um... buffer zones or atrium space or external spaces... um... and you draw on an existing buildings and call those obstructions. You can also add roads and rivers on the plans, which are sort of noise and... um... and then that enables you to assess it in terms of energy, daylighting and solar analysis. It looks at shadows as well. But you draw directly onto the... um... onto the software and you can bring in pictures... um... in jpeg format or whatever; site plans and draw over the top of those.

SA: OK so you can trace over them.

A6: Trace over them yeah, its very... that's right, you can trace over existing buildings or even... even of course... new schemes and whatever.

SA: Yeah... yeah.

A6: It's very quick, yeah.

<u>SA:</u> OK... um... and during the development of that... um... I suppose... what were the jobs of the other practitioners who were working with you on that development?

<u>A6:</u> The other members of the team?

<u>SA:</u> Of the team, yes.

<u>A6:</u> ...of the team so our... our key role; xxx has been to project manage... if you like I've been the project manager. But at the same time... um... look at the specification of it as well... um... the ideas behind it and architecturally how it would... would work so I'm an architect as well. But we've also been in charge of the financial side of things. xxx... um... very much started off... um... in a in a role... um... do you... did you know xxx.?

<u>SA:</u> Yes.

<u>A6:</u> Yeah, she worked on it

<u>SA:</u> I know her very well.

<u>A6:</u> Yeah she's... she's great. So xxx and xxx were very much in the early days actually producing specifications for how it would look, how it would work, how it work architecturally; the ideas behind it. Of late xxx actually got more involved in terms of actually software programming as well... to make it work or fix problems that we've had with it. Then... um... and... um... the x remaining... um... organisations have all been... um... responsible to some degree or other for the programming; the actual... producing the tool in terms of actually...the software programming.

<u>SA:</u> Yes.

<u>A6:</u> Yeah.

SA: And... and... did... did you have any sort of direct interaction with ...with these people who were doing the programming? Were they mainly computer scientists or were they sort of engineers or building physicists?

A6: Oh yeah so... um... because each practice; each of the three were... came from... um... although they had software engineers they were essentially environmental consultancy practices. That meant that they weren't ***just*** computer programmers and that's it; they generally had some knowledge or knowledge within their organisation of building science and energy efficiency and environmental... some more than others for example xxx... um... who had produced the xxx... which... um... a mini... mini... mini... version of that sits within our software... um... he... he... actually did the xxx course at... um... at... although he's a software computer programmer, he's also had... studied as a... you know.... to become a sort of environmental engineer. Uh xxx obviously is a building scientist...

SA: Yeah

A6: ...but also a software knows how to program. Oh xxx Research likewise... we... xxx Research had produced a piece of software called the xxx in the kind of 90s... and then in... in... the last ten years had made a computer version of it.

SA: Uh-huh.

A6: ...and that partly sits within our ...within xxx. So that's kind of... we kind of used that... um... as well as part of xxx, but kind of developed it and changed it and expanded it and so on.

SA: OK. Alright. Um... going... going back a little bit into the background again...

A6: Sure.

SA: Um... so you trained at xxx?

A6: Yeah.

SA: Um... can you tell me a little bit about... about your school? What... what it was like to be an architectural student over there?

A6: Sure. Um... yeah I did all five years there. So I did undergrad three years, then I had a year out and I did the diploma there. I mean... I've obviously liked it otherwise I probably wouldn't have gone back... um... it... we had... um... the way it was set up, was you would have...in a year system so you all worked on the same projects together... um... essentially... um... each year depending on which year you were in... you had a design project on the go it would be a... um... the design of a new theatre or art centre or a... or whatever you chose to... chose to design... set up houses or so on... so you always had your design project and then alongside that... um... more formal lectures; things like history of architecture... um... building science... uh... structural engineering... um... what else?... *[Asking himself]* ...More architectural philosophy... those are the key ones that I can think of and they ran in parallel to the... um... design project and then at the end of the year you had...as well as being marked on your design project, you also had a set of exams related to each of the subjects which you had to pass as well... and that's how... that's how it works. So it's a mixture... but I always felt, from my knowledge of how a lot of the London schools work, and other schools around the country, I've personally not that I've studied there but although I have taught at the University of xxx and I've also taught at xxx a bit, and I always felt that xxx had quite a nice balance of the kind of philosophical 'designy' side and the technical side as well... it's got a very... or ***has*** had a very good building science department as well which was good, you know...um... and I personally quite like that because... uh... uh... although on the one hand it allowed you to be... you know 'designy' and all the rest of it and... pretentious, at the same time it... it gave you a bit of a technical grounding and... and I always... amazes me actually I think there's a lot of schools of architecture think get away more and more and more with lack of teaching... the lack of technical stuff, and they do it in a way of making it seem like it's not a trendy thing to do; you know it's... it's... somehow we're intellectually superior if they just teach students... um... how to talk basically... um... the philosophical talk.

SA: I've picked up on that. I've picked on that... um... with some of the architects the architects that I've been talking to... um... because I generally get the impression that there's schools of architecture sort of very... um... design-based, but then they go into practice... I mean how... how many architectural students will actually... will actually become xxx and xxx of the world? They will be involved in all the technical detailing...and... aspects...

A6: Well he's... here's the thing is… there's two things that are going on I think. You get a big school like the xx or the xxx which probably are good at doing this kind of thing and then all the other London Schools copy them; they want to be trendy so... and... and then you get other schools of architecture in other parts of the country which copy them as well... so you won't... you go to the end of year show and you see some fantastic presentations but you won't see a building, quite often... you won't... it's almost like you're not allowed to, and the problem is that the... the student or the teachers that are teaching there are often haven't worked... some of them have worked in practice but a lot of them haven't so they've gone from straight from...you know... and they're competing they've gone straight from education into teaching and they're competing to out...'out-trendy' each other ...

<u>SA:</u> Yeah.

<u>A6:</u> Um... as if... as if what they're...they convince themselves as if they've got some deep intellectual thought behind what they're... what they're talking about and quite often it might be that they simply haven't... but that's my... my view. Um... what I dislike about it is therefore... if you... if you try and challenge it, or you think, *"well this isn't quite right,"* you get accused of somehow being narrow-minded, and that's not fair because there's a lot of great designers or a lot of people that are very artistic that also want to know the practical things as well.

<u>SA:</u> Yeah.

<u>A6:</u> Coming back to your point on about xxx where I've worked... um... the funny thing there is that what they do is that they recruit prac...students from these places or from the best students from around the country... and then the reality is that those students then go in and they're treated like... um... CAD monkeys... really you know; they work on a big project like I did on the xxx, and they're basically inputting information into Microstation or AutoCad or whatever so they're...it's a funny old thing cause you get taught this... this way of speaking... this way of going on at university and then the reality of it is something quite different. You know normally in my view you're scraping for... to get anything interesting even though you're working in this great practice on this great project...

<u>SA:</u> Yeah.

<u>A6:</u> You're always fighting to do something interesting like a door-schedule or a cladding package or whatever it is... you're quite often treated in this way and also you don't know much, and they certainly don't need people to suddenly come in and start talking high-level philosophy...not that it is high-level; it’s based on nothing a lot of it so it’s a funny old thing I think...

<u>SA:</u> Yeah it’s quite a mix.

<u>A6:</u> Yeah.

<u>SA:</u> Quite a paradox isn’t it?

<u>A6:</u> Personally I think so...I mean... but I’m just telling you... I tend to see things a little bit black and white.

<u>SA:</u> Yeah.

<u>A6:</u> When I taught at xxx I didn’t like it... I felt that the... the... um... the I didn’t like the other tutors there particularly; I felt they were all competing to show off in front of students, and you know rather than help them design buildings it would help them show off about what knowledge they had about the latest trendy international architect around the...that’s… that’s perhaps unfair I’m generalising but that’s what I came across... you know.

<u>SA:</u> Yeah.

<u>A6:</u> That’s why I prefer perhaps being involved in courses that are more like a masters or something like that, and leaning to building science and so on because... uh... there seems to be more... uh... there’s just more there for me to... to... to... to talk about and understand.

<u>SA:</u> It’s more tangible.

<u>A6:</u> It’s more tangible that’s right...you know...

<u>SA:</u> Yeah.

A6: That’s right. Substance behind it I think.

SA: Yeah. A lot more reality I think as well.

A6: That’s it... I... I’d like to... um... you know... I would like to teach again maybe at undergraduate level in some capacity but let’s see what happens in the future.

SA: OK. So where’s...sorry where did you teach again? Could you tell me about that?

A6: Yeah I taught initially at the... um... the University... well it was through the University of xxx.

SA: Yeah.

A6: The course is run at the xxx.

SA: Oh yeah I know that it’s in xxx.

A6: That’s right... that’s the one that I referred to... yes... so I was involved in that for x years. During that period I taught for about a year at the xxx University... um... in the architecture bit there... but I didn’t really enjoy it and I didn’t get on very well with it and I stopped it... it just carried on, and then actually pretty much after that I started working at xxx and kept on with the masters course at the University of xxx.

SA: Right OK. So... um... I suppose this must have been quite a multi-disciplinary course. It must have brought in students from many different backgrounds?

A6: The xxx one?

SA: Yeah.

A6: Yeah... there was probably less than...probably about x percent of them were architects, or architects backgrounds. The rest were from all over. Some had some background in the construction industry... a huge amount didn't and there was a huge age range... you know from early twenties to... up to seventy years old... you know... essentially the guy that ran it was a fantastic guy... um... if you were enthusiastic enough really you got on that course and that's why it had a high number of students on there... but there were good students and his philosophy was... you know... if they're enthusiastic and they work hard then... you know... we get them through kind of thing.

SA: Right OK. Could you tell me a little bit about the experience of teaching all these different students? What was...

A6: Sure.

SA: I mean I'm just assuming that it might be very different to teaching only architects but I'm kind of under the impression that... you know... architects have a way of thinking and a way of talking about things that must be... a vocabulary that is very different to you know other practitioners and...

A6: Yeah... yeah I mean it was very different to my experience of teaching undergrad... I mean partly because we weren't doing design projects... although we did do a little bit of design there... um... essentially the course was structured into... it's structured into a number of lectures... um... that happen well it runs once a month and it's a residential thing so it works five days a month, and during those five days they have a number of lectures... uh... and... um… which students attend on a whole ***range*** of subjects from technical things like say daylighting or acoustics, to the...to deep green philosophy. I tried to steer clear of all that but in actual fact... uh... had a... had a... um... quite an interesting time with a lot of the... it... it... because of the nature and the ethos of the location... um... it attracted a lot of people with... um... a leaning towards the more deep green kind of... um... 'sandals-woolly-jumper' approach than... but... uh... nonetheless, because it had a course leader who was a building scientist, it had a kind of sensible technical approach to it as well. Anyway I fitted in where I did and said what I felt and... in actual fact had quite a lot of... um... interesting debates with the hippies on the course... do you know what I mean? *[Laughs]*... Anyway, so we'd had a number of lectures, then what we had was that the students would have to do essays... each... each... which related to each... each... unit... um... they used to have a general... there'd be a couple of themes running through the unit so that students might be learning about a different type of construction technique... and what... and daylighting... or they might be learning about... um... renewable technologies and... um... acoustics or something like that... and then they'd write an essay about that subject matter. They also then had to make a presentation; a formal presentation, which would be based on their... um... generally based on the subject matter of the essay and then they got marked on those... um... and they got marked... each unit on those... and then they went on and did a thesis. So the teaching consisted of formal lectures, seminars... and seminars with the... um... different... um... tutor we all had our own tutor groups so it would be about... like... each time we went there there'd be say about a dozen students that we'd work with... and as you say they were from a range of backgrounds, a range of ages and a range of experience. I liked it because... I mean... it helped me being an architect... they kind of respected that to a certain degree. But I quite liked the fact that they were a range of capabilities because I quite like helping people...and so I felt that I could help people... that they didn't have the skills to write a particularly good essay then I could help them do that... you know what I mean? And also I quite liked the... um... the richness in views and experiences that they brought to the table. I mean some of them had... you know... some of them might have financial experience... you know experience of how the financial world worked... for example... so here we are babbling away about energy efficiency or whatever or environmentalism and they would look at it at a higher... in a... you know more interesting level and bring that to the sort of discussion table so... um... I quite liked it... um... you know... that said it was strange at times... you know, you got people there that just seemed to be... um... so kind of alternative and just angry with society and sort of leftover communists or something like that... you know... um... 'cause we all know that environmentalism has increased popularity since the wall came down in 1989, so there was a lot of that sort of thing on the course... a lot of anger from those kind of people... but I just sort of... um... argued with them... anyway but it... it... it was quite different... they... and because they were masters students as well as... of course they paid money... they were determined to they were very interested and very interest***ing*** so there was a good vibe and a good... don't know if that answers the question well enough but... um...

SA: Yeah... yeah.... um... something's just crossed my mind but... um... what was the ratio of males to females you had?

A6: On the course?

SA: Yeah.

A6: It was... um... it wasn't bad actually... um... in the sense that it... um... it... actually it varied. Sometimes it could be... you know... as much as forty percent... even heading towards fifty percent female, sometimes some intakes were more male-dominated and certainly the more... it's always the case the more engineering units or parts of the course... ‘cause you take combinations... tended to attract the men and the girls would be... or the females would be more attracted to the more sort of social ‘sciency,’... which I always found a shame because... you know... but females seem to choose to do that so... um... for whatever reason but... um... the course had quite a good balance but I think that’s partly because it had a fairly soft ‘lefty-greeney-feel’ so... um... for whatever reason, females felt that they could come and do it whereas the more building ‘sciency,’ it gets the more of them... which I think is a shame, because it’s nice to have intelligent females in a course and always keep the ratio about half and half... you know...

SA: Is that... is that a general sort of trend that there are... the males are generally more attracted to the building science than... it attracts less females? Because so far most of the people that I’ve talked to have been... have been male and it has occurred to me because I spoke to a social scientist and he said to me, *“have you looked at gender because that might be that might be... something interesting to sort of challenge?”*

A6: Well, I think it’s the same in life isn’t it? You know the more ‘sciency’ the subject is the more engineering... it just seems to attract more men sort of...

SA: Yeah.

A6: ...doesnt it? And in...and in the construction industry it’s the same... um... you know in... at... a... the xxx there will be students... the females tend to want to study at xxx or look at... you know... you know... different... whether what materials buildings are kind of made out of...the embodied energy... whereas the males will tend to lean towards building physics and how... how... the... um... what the internal environment’s like in terms of ...uh... acoustics or... or... daylighting... and this type of thing. You know it doesn’t have to be that way but it just tends to be that way. And I don’t... I can***not*** see any kind of reason for stopping females from applying and studying that kind of stuff... they just tend to choose...

SA: Yeah... I don’t think anything does...does stop... them it’s just the way they are.

A6: Yeah I mean in architecture you know... there’s a higher proportion of men and I think part of the reason for that... is I think females are quite bright... and actually after about the... the first degree... their first... part one they have... they say to themselves, *“do we really want to study for seven years to... to... to... a subject that* *doesn't even pay that well? And also we've got other things that might come on in our lives like having children or so on..."* So they often drop out at that point. People blame it on the fact that they go out on the construction site and men wolf-whistle at them and stuff and I just don't believe that. I think they're the ones that are making the decision... I think... really you know... any course is set up... would like to have a nice mix of course... I mean I'm not sure what it's like on your masters for example... I have met... in fact the only people I have met have been females so I don't know what the ratio of that is...

SA: I don't know I think I never actually sat on the masters I... I mean...I've been through different courses... I'm a PhD student...

A6: PhD apologies... yes...

SA: Yeah... yeah...

A6: Yes so... I... for some reason... yeah...

SA: It's alright... but there are quite a few PhD students... but then the nature of research is... is different isn't it? It's a different experience.

A6: Yeah and I think actually that's quite attractive to females as well... I think... the nature of research.

SA: Yeah.

A6: ...interests yeah... yeah...

SA: Yeah.

A6: ...but it wasn't bad it was quite good actually that course for... um... but I always wondered for example it did there was a technical...running alongside of it... a technical there was a more engineering- based one... it would just be all men you know...

SA: Yeah... um... what about teaching... um... building physics at the undergraduate level? You were saying that you were taught building science at xxx?

A6: We were, yeah. We were taught building science at xxx.

SA: Can you tell me... I don't know if you remember anything about that... what the nature of the study was... was like? Yeah... how that was implemented?

A6: I liked it... um... I always felt it should be better integrated into design... i.e. we had design projects... we had design... we had the architecture and then we went and had our lectures where we would learn about something like... um... how relative humidity worked or maybe about an air-conditioning or something like that... to quite a high level but the two... although there ***was*** a certain bit of integration...I always felt it could be better integrated into the actual design process, so it would be more... you would have a more practical understanding...

SA: How was it poorly integrated? Could you give me an example?

A6: Well you could... it... depending on how your design project went the... the... the building science tutors were available for tutorials and crits to kind of... to kind of have a look at what you were doing but... 'cause you would often be so busy, and just trying to get a design... you often didn't do that, sometimes buildings... one of the building science teams might be a tutor with... over a year... but... but... but that aside then essentially you went along with the lectures and that was that... and had an exam in building science... so I felt there it could have been a bit of integrated... better... I think it's better than... um... my guess is that it's integrated better than the other courses but then... xxx had a... had a... the last time I was there seemed to be heading towards more... towards the London... you know... system because the head of the year was from there and wanted to change everything...

SA: Mm.

A6: …and stop students from actually designing buildings and... you know... this sort of thing but... I don't know what's happened there now.

SA: Right OK... um... and you... you've taught at undergraduate level you were saying?

A6: Yeah... a little bit at xxx.

SA: How did you... you witness any of the building physics teaching at that university?

A6: No... no I didn't... no... I mean I spoke to them a little bit, when they come up and said... um... *"we realise you've got some knowledge in this area can you have a look at our design for it?"* and I did that a bit... but... but it wasn't really going on, what I saw... but then I wasn't teaching that long and... um... it was only with one particular person and so... I... I... don't really know the extent to which it was integrated... but it was... it was like most schools of architecture... tutors are busy getting the design together.

SA: Yeah. The whole focus is always... is always on the design isn't it? The majority of it?

A6: Yeah... which is inherently... it should be. I just feel that there's an opportunity to link it in with the building science side, so that becomes more of an integral part of it, part of the design... you know...

SA: Yeah... yeah.... um... ok... so I mean from what you've said I gather you've had a lot of experience both in practice and in teaching.

A6: Um... yeah I've had some yeah.

SA: Could you... could you tell me about the similarities and differences of... um... well of… um... architecture... of architectural design and... in practice? Because I'm under the impression that maybe the implications are different depending on the environment that you're in... say in practice you've got pressures that don't exist in... in education...

A6: Yeah... yeah... that's true... yeah well obviously the big one is the financial drive of things it the financial... um... component doesn't... never features... doesn't feature at all at a ...um... at an academic level... I mean there's an argument to say that maybe it should certainly just as an interest and there's certainly no reason why there couldn't be some interesting exercises on it... um... uh... you know... so at least the architect has ***some*** clue what's going on... on there when they go into practice... um... but of course... you know... so you’ve got budget constraints and financial things that just don’t exist at... at... at...at an academic level... um... and... and therefore... so an academic level you’ve got... in a sense some less...less constraints to work with... um... I don’t think it’s a bad thing; you don’t want students to be worrying about out the financial matters right at the beginning in any case, so that’s one of them. The second is when you’re... um... it... when you’re designing at a... as... a student of course you’ve got to produce a number of drawings, and all of that... but you’re quite often doing it on your own and producing your own scheme, whereas in practice... um... you’re part of a team there, and it’s just the ***sheer*** volume of production information that you require to produce a building is... is... is... incredible you know, depending on the size of the building... you’ve got all the construction drawings, detail drawings, all the specification... um...and it needs to be written... just masses and masses of production information that ***really,*** if you’re going to work in a sizeable practice on any sizeable job, you slot into that whole machine, and it can go on for... it takes years and years to design a big building you know, far longer than it takes to do feature films you know, and... uh... producing the... and so you’re really not necessarily... as a student set up for that. I’m not saying you’d want to be either, you know ‘cause... um... actually it could put you off. I think also... the truth is that could... um... when you study as a student of architecture you feel ***special*** at the university like you’re a student of architecture... and you... it’s often a great thing to study; you go on really interesting trips, and you look at other people studying other subjects and it looks more boring or whatever... and you feel quite special. When you come into the real world you don’t get paid as much as them; you... the truth is that it can be quite boring stuck at a computer doing drawing. Some people quite like it but I think that some people get a bit of a shock... um... uh... and so you know... those are some of the... you know the key differences between...

SA: Right yeah. OK and... um... so you’ve had experience working at xxx...

A6: Yeah.

SA: Can you can you tell me about that?

A6: Yeah I mean I... um... my experience of working at xxx was horrible... I mean I hated it... it was... the only thing I quite like is being able to say, *“I worked at xxx on the xxx project,”* and some of the people were quite... quite nice but... but actually... uh... essentially my experience there... and I knew other people that worked at xxx, ‘cause a lot of them move around these places...

SA: Yeah.

A6: ...they get addicted to that having a big name... they're working at a big name and can't get out of it... um... so essentially it was full of... um... people that really rated themselves, of course, you know going from the top down to all the new... all the new... that had just had been students, so everyone thought they were the best and... but essentially it didn't really matter that... again the size of the project... we worked on the xxx project; there were about fifty people working on that... maybe forty people working on that project and essentially it was... although it was a fantastic project, whatever we were producing the production information... you know... it was people had been working on it for ***years,*** and people had just been... I mean essentially what I was doing was helping one of the architects draw... uh... holes in the... um... the various walls and floor plates throughout the building and so on... where the services penetrated... um and there were people there working on stairs... stair designs but not the stairs that you see but the emergency stairs...and they would just be drawing these things for... for... um... for years you know, or people doing door scheduling or whatever... very... very tedious work, that employing people that had got top architectural education to do this tedious work, all scrabbling around to try and get the... get the best job that they could which was say the cladding package, not allowed to sort of say this, working quite hard long hours for people that weren't particularly nice to work for, and then what happened to me was as soon as the project ended and they had to shed a few staff they said, *"thank you very much and goodbye..."* which they did to me and a few other people. It was a... but that said it's always been a good thing to have on my CV; it... people say, *"Oh good you worked at xxx...bla bla bla..."* so it set me up in a sense, but the truth of the matter is, although I like working centre of London in a nice flashy practice and, you know, we had a laugh when we went out socially, um... I didn't like the... they're very arrogant people in there you know... um... not very friendly they couldn't care less and... um... and... and the way I've described it is the way it works you know...

SA: Yeah.

A6: Um... uh... I don't know whether... that's... that's the life though, isn't it? That's the... I've called it... we call it, 'doing the porridge,' you know? 'Doing the red lining' in a place like that or you go to xxx, or you go to even a big practice that no one cares about like... um... xxx or something.... doesn't sound as flash but you'll get the same treatment depending on the size of the project and the team.

SA: Hmm. You know it's... it's quite interesting that you say that because I've had similar accounts from people who have worked at xxx.

A6: Oh xxx...yeah xxx would be... probably like xxx but worse probably... I met people at xxx that had been at xxx, that had worked at xxx... it's the same... it's the same ethos, you know... they're just and... and the thing is really, depending on... the funny thing about it is... um... architecture attracts some people that are good at art probably, but also perhaps were quite good at maths and physics and then depending... then they can have a range of personalities; you get the people that like to... to... need the people interaction they need the people variety in what they do or whatever... everybody when they go to these places are all doing the same thing. They're stuck against the computer for nine hours a day, in a fairly silent sort of atmosphere, knotting this production information out. I've once read... um... uh a piece of information on... uh... what work... I've got a relative who suffers from Asperger Syndrome and... and... what work might be appropriate for them? 'Cause they're not very good socially, and 'architect' came up, and that made me think, *"no wonder I hate it"*... I mean... yeah I like working on my own sometimes and getting my head down, but I also need variety, I need to be out and about, I need to be communicating with people and so on and my ...um... I think some of my... um... qualities... perhaps people qualities and so on... that's why I like to lecture and so on... were a nightmare ***there*** 'cause I just... in the end mucked about... I had to express myself in some way.

SA: Yeah.

A6: And you're dealing... and you're fighting with the next arrogant... even more arrogant person alongside you... just grapple in order to be allowed to work on the cladding package you know, and everybody thinks... 'cause they're working at xxx or xxx and it's...it's somehow all OK, but they're not even paid that well particularly, you know... but that's my view.

SA: Yeah but it's a good thing to have on the CV.

A6: But then it's a good thing to have on the CV... you know I mean I'm always proud to say, *"I've managed to work there for a year,"* you know...

SA: Yeah it's always like that, *"Oh wow that's impressive! That's interesting!"*

A6: Yeah it always comes across as impressive, yeah... but in actual fact it got... in reality it often gets better... the smaller practice you work in... but then again you could work in a small architect’s practice and not enjoy that depending on the personalities.

SA: Well could you tell me a little bit about that? Why’s... um... why might it be better to work at a smaller practice?

A6: Oh just depending on your personality and what you want to get out of it... you... you... well for number one... so say if you work in a big practice; you might be working on a job that’s fifty million pounds or bigger or whatever... so with that obviously there’s a huge amount of... um... hugely important that you get senior people running that kind of job, and that on a job requires ***masses*** of production information as I’ve described. If you work in a smaller practice you might work on a whole range of... you know... values but... um... you could be working on a... on a... on a kind of flashy house extension for a hundred thousand pounds for example... now if you’ve had a year or a couple years experience you can run that job you know... um... probably with a bit of help from a senior architect or the partner or whatever... you can run that job... you can produce all the drawings, the designs yourself and you can be the person going on site and so on... that job’s going to last for a year, as opposed to five or six years... so you might be running that job and you might work on a couple of jobs as well, so you could have more variety, you’re going to be out and about more... um... and more control over what’s going on and not just producing production information and you can also see a... a job through from inception to completion, whereas with a bigger job you might get stuck in a phase of that project for one or two years and all you’re in is you know the construction information... um... production information phase, or you may have only been in the design phase you know?

SA: Yeah.

A6: And that’s why it’s quite difficult for students when they come out... into practice to finish their Part 3 because they have to normally produce a case study on a project that... that has gone from beginning to end, which is the contractual side of things, and then if they’re stuck on a big project they won’t often have had... be able to write about it because they won’t have had the experience of drawing up contracts, dealing with clients going to site dealing with... um... construction issues on site all of that.

<u>SA:</u> Yeah... yeah..

<u>A6:</u> And... and... and... that's the experience I had for... um... for sort of... three or four years, you know... I was running projects and... um... enjoying... um... you know smaller teams and you know... I... I would be suddenly a senior architect managing one or two people as opposed to being... you know the small cog as I described before.

<u>SA:</u> Mm. Like at xxx or at...

<u>A6:</u> Yeah exactly. But the downside of it... after a while... you know... if you're working on the... at least you're involved in a project... say if you're working on the xxx, it would be fantastic to think that, *"I'm involved in this project that's going to have some big impact on the... the urban landscape,"* whereas if you're working on a hundred thousand pound refurbishment for a posh person in Chelsea, you know, after a while you might think, *"but..."* you might like it... you might like that because you might get off at just interior designing looking at materials and all that, but for me it wasn't enough I wanted to do something that I feel like I'm having ***some*** kind of influence on in... in life on a larger scale if that makes any sense...

<u>SA:</u> Yes I do... I do... um... a lot of the architects I've spoken to have... um... have talked to me a lot about the excitement they get from... um... from designing is how they manage to change different people's experience in life and how they... um... how they almost alter their behaviour or allow them do to things they haven't been able to do before. But I guess it's just the scale of that isn't it? Because you're interested in that on a larger scale projects, rather than smaller maybe houses or...

<u>A6:</u> Yeah... yeah... yeah. I suppose so... I mean like... that's why somewhere like xxx when I was working on the new school designs; I was a design advisor for well... I still am registered with the RIBA so I'd sit and help the... um.... on the clients side helping... basically you're trying to get their original... the original concept of the school pushed through the procurement process...and working on a new school... um... you... it gives you a sense of doing something good because it's a school, where you're going to have... you know a thousand pupils each year going through it and...uh...and so on... so that was quite nice... but I wasn't the architect on it, so that meant that I had...I could be involved in it but then I would move onto something else, you know...

SA: Yeah OK... um... and you were mentioning something about... I thought was really interesting... I'd like to get back to it; the idea of different sort of energy efficiencies of different sorts of architecture, like you were saying... I think... um... the more high tech and then the more sort of ...

A6: Yeah... yeah...

SA: What you did your masters dissertation on...

A6: Yeah.

SA: Can you tell me a bit about that?

A6: Yeah I suppose... um... probably it still exists today, and I think it all comes down to... um... I think the... the... the whole sort of environmental debate and... um... energy efficiency debate whether at a construction level, or a political level... um… means people react to it in different types of ways, and I think it basically comes down to views on technology, you know come people would... would argue that just to deal with problems then you... if you improve technology, you can use technology to solve those... some people... um... this is obviously a very simplistic way and stripped down way of looking at it, but some people will argue that... um... it's technology that's caused the problem in the first place and we need to move away from it and that gets reflected in architecture as well. I think it's the reason why you get... what... what was it... confused and interested me was how buildings could look so inherently different and each claim to be environmental and energy-efficient in their own way so you got the kind of hairy... um...brick buildings that are covered in turf or whatever made out of timber, all treading lightly and not... not using... all... all their emphasis is on less... using less resources and... and so on and... yes treading lightly on the land, and then you could you have... um... buildings that are steel and glass... um... uh... and throw in technology at them... uh... and why... why it was that this existed and... um... you know it's to do with the different attitudes and different views on technology really... um... and I think that... that... that... is reflected at a higher political, socio-political level on different people as well, so I kind of try to look at that and I understand... through that... trying to understand the different extremes and viewpoints in the whole environmental debate if you like... and I'm sure it still goes on today really, you know through different people's reactions to what to do about... about... um... global warming or resource depletion... you know... you have some people that will ask us to conserve energy by wearing four jumpers and not heating their home, and some people will want to... um... improve technology to... to... to... deal with problems, you know...

<u>SA:</u> Which...which view do you sort of lean towards?

<u>A6:</u> Well I'm... I'm... I'm... uh... I suppose I... I... um... throughout... um... I suppose I tend to lean towards the technology side ***definitely***... um... but... but... clearly obviously... from an architectural point of view, if you make a building that's a greenhouse, you know, a glass box then, you know, you create certain problems in the first place, so you need technology to solve it. That said... um... those buildings can be fantastic iconic buildings and they can regenerate and, you know, whole areas so they can... so the fact that they might be a bit more energy... um... intensive they can still have knock-on effects environmentally ...um... uh in any case so I find it...I find the whole environmental... um... thing... uh... the single most confusing and contradictory... um... issue that there is... anyway... you know you get people reacting and... um... um... responding to it to so many different and confusing ways; you know just recently... um... one of the big problems is... is concern over... uh... food scarcity... um... and so... um... but for a while people were promoting the use of bio-fuels... or bio-fuel take... can take... valuable land for growing food on, and so all of a sudden there can be a shift because... um... a certain level of knowledge or passion is applied to the subject in a way that... um... perhaps produced a result that... um... uh... uh... how can I explain it? *[Asking himself]*... but... um... people can feel very strong... um... and opinionated and convinced that they're doing the right thing which can actually produce a negative kind of result, so that's one of the... I'll give you an example in architectural terms... um... you could say, *"well I want to... um... make a building... um... less resource-intensive ...um... uh... what so I'm going to build my building out of timber rather than evil concrete or whatever..."* um... and you end up producing a lightweight building that overheats... um.... you felt good about it... it looked on paper like you are somehow morally a good thing so you made it look like it was a tree and it had grass on the roof or whatever, but actually it overheated so you had to air-condition it... um... uh... all because you had this irrational... slightly irrational reaction against concrete which represents big business and big companies and this... this... this... this... um... behaviour... and architectural level mirrors or reflects a higher level political response for the whole environmental group I think, and the reality is that it's just better... um... in non-domestic buildings to make them out of concrete because you can control their climate; you can control... moderate the internal climate; you can cool buildings at night time... you can... you use thermal mass to do this...

<u>SA:</u> Yeah.

A6: You know this is... and I think this is reflected in... right the way through the environmental debate, plus on top of that we don’t know for sure whether global warming exists or is caused by... um... man-made behaviour; not one hundred percent we don’t know that...

SA: Mm.

A6: Um... that’s why I’m interested in energy-efficiency and... and... uh... as opposed to... that’s what I always say about myself, someone that’s interested in that side of things and energy-use than... uh... than... uh... say if you like the... the... the... sustainability I’m more comfortable with that.

SA: Well how... can you tell me how... or why you’re interested in sustainability? How did that develop... that interest?

A6: Well I think... um... uh... as I said before I’m more interested in using the term ‘energy-efficiency’ than ‘sustainability...’ um... ‘cause you hear sustainability thrown at everything...

SA: Yeah...

A6: It means anything...anything...yeah... and also, I figured it... it tends to attract this sort of soft and kind of angry... um... left-wing approach of things, so I’m not too keen on but... um... anyway no... uh... actually my... um... my... uh... the truth is my... uh... interest in the topic began actually when I was at xxx... and... um... we had these tutors, who were actually do tend towards the kind of low-tech... they wrote a book that was called ‘xxx it was all about going off grid and all that type of thing. But I found that interesting at the time. Since then I... I don’t agree with.... but they’re more famous than me I’m not.... not known in... but I don’t agree with their philosophy... I don’t like it... I don’t like this... you know we should do things that... um... don’t... they want to have to ‘cause people to have to change their lifestyle...

SA: Yeah...

A6: ...that's what they want. They want people to stop doing this and stop doing that because they're somehow a bit angry themselves... I don't like... and I don't think it would work anyway. They want people to grow their own veg in their back garden; well that's not how it works... people live in urban areas... people aren't going to start growing their veg and even if they do it'll make no... it'll make very little difference.

SA: Yeah.

A6: In actual fact all... it will probably do is make food prices more expensive... but anyway so... to go back... however they were my tutors and they gave a lecture on the whole subject matter and at the time it was a very simple message... it was that, 'we are going to run out of oil and gas in thirty years...' well that was twenty years ago and that hasn't happened... um... and... um... so we've got global warming which is... a... a problem... um and... uh... but nonetheless they showed the very simple model which was if you made buildings very energy-efficient and put... um... renewables out there we can... um... cut down... we can reduce the amount of energy that's used in buildings by about half... or fossil fuels that are associated with buildings by about half, but I thought it was very interesting and I just got interested in the subject... I think also at the time I was fed up with all the philosophical garbage that was going on and I wanted my own subject to become interested in architecture, and I could understand it and it meant something, and I just got more and more interested in the subject matter through that really.

SA: Right, but I mean... um... I don't know about changing lifestyle and things... um... I was talking to an engineer actually about some of the... uh... the Code Level 6 houses... he was telling me that he had visited a Code Level 6 house...

A6: Yeah.

SA: In Wales...

A6: Oh OK yeah.

SA: ...and... um... he... he... kind of... find it quite funny because he couldn't open the window... because being in a Code Level 6 house you couldn't open the windows.

And he was saying to me that even... even with that kind of house you need to alter your behaviour ...um... to be well ...not sustainable... but energy-efficient...

A6: Yeah.

SA: And... um... I don’t know if you agree with this idea but is... is energy-efficiency and sustainability all about social behaviour? Because you can design a building that’s very energy-efficient but if you use it the wrong way then you’re not...

A6: Yeah that’s true... um... yeah I mean obviously there’s a balance... there might be certain modifications... but no what I don’t like is... um... I think people are busy... they work at... you know people... generally... people go to work they come home... they don’t want to be... uh... troubled to have to do a whole load of complicated things or behaviour modifications to... to... in the name of sustainability you know I think... um... yeah of course there’s a certain amount of modification that... that could be made you know... in terms of turning lights off and so on but if you can’t open windows and that causes stuffy environment that you feel detached from the outside then I think perhaps it hasn’t... there’s been a little bit of a failure there in the design I would think... think... about sustainability and energy-efficiency shouldn’t counter good design as well and uh... um... yeah that’s sort of what I think.

SA: Well what’s good design?

A6: Well I mean being if all... uh... light...to be open... and...and able to open a window then in the house then the designing with... with that in mind you know... that’s something that is ...uncomfortable for ...uh... for living then I don’t think that’s... uh... then... that’s... you know... good design...

SA: Yeah so it’s designing a comfortable environment for people to use.

A6: Yeah... yeah... that’s right... yeah... yeah.

SA: Well I think... um... I’ll stop there because we’re just over an hour.

A6: Blimey! That's gone by fast!

SA: Yeah... yeah it goes by quite fast doesn't it?

A6: Yeah!

SA: Yeah... yeah... OK... well... um...

A6: Hopefully you got some... um... useful stuff there?

SA: I did yes... yes I did .I've got to transcribe it all to... to you know make sense of it.

A6: What do you do? Do you... do... can you press a button and that brings it out for you?

SA: Um... no... no I connect it to the computer and I actually sit and type it all out.

A6: It's probably quite good actually.

SA: It's a good... good experience because it allows me to process the data and sort of make more sense of it.

A6: Can you... can you... can you... get... uh.... presumably you get things like that now that they do type it for you or?

SA: I'll just stop this...

A6: Yeah sure.

APPENDIX C: Sample of one of the BPS specialists' interviews

FIRST INTERVIEW TRANSCRIPT WITH BPS SPECIALIST S3

INTERVIEWER'S NAME: Sara Alsaadani

DATE: 7th October 2011.

INITIALS USED IN THE TRANSCRIPT:

S3: BPS specialist 3

SA: Interviewer Sara Alsaadani

CONVENTIONS USED DURING TRANSCRIPTION:

[ ] Square brackets, with the action in italics in between are used to describe sounds on the audio-recording that are not actually included in the speech, other stage directions, including interruptions, etc.

... Three dots indicate pauses during the speech.

Quotations during the conversation have been highlighted in the transcript but putting them in between inverted commas and making them *italic.*

Words that have been emphasised during the speech have been highlighted in the transcript, by making them ***bold and italic.***

SA: OK… I hope it catches everything we say… um… yeah, so today was just meant to be sort of… um… a chatty kind of conversation… um… basically… um I've got a set of questions that I have prepared, but these interviews are meant to be semi-structured…

S3: OK…

SA: So… um… I might not ask any of them… I might only ask one or two… basically, it depends on the information that you give me and what you tell me about… about your work, your career. And I might improvise, and then ask you questions about that…

S3: OK, sure.

SA: …um… but I wanted to get started by asking you a little bit about your education and your background…

S3: OK. I… um… well from university on; I did a degree in xxx, which should have probably taken me down the route of surveying and everything else. But I took a graduate job in a builder's merchant which… I was a branch manager at the xxxt for seven years…

SA: OK.

S3: and from there I progressed into a technical sales role of for an xxx; and it was seven years with them so I had a… I developed an understanding of building fabric performance… and from there, there was a change in regulation in 2006 where I saw an opportunity for…um…becoming xxx, and that's where sort of my career changed.

SA: Right.

S3: So 2006… and currently now I am a director of a company with xxx… um… that specialises in… uh… not just building simulation but… uh… building modelling in all the shapes and forms… um… as far as the performance of a building goes, I have since taken a masters in architecture, but it's advanced energy and environmental studies, through the University of xxx… and professional memberships through CIBSE and the institute of non-destructive testing… um… I am a xxx.

SA: OK.

S3: …and I've just completed a finished my masters off… actually my thesis subject was on building simulation and its… the accuracy compared to live data. So I had a three test… sorry two test houses in the xxx, and where they had buildings residential buildings built around the 1980s to a very high insulation specification at the time. But unfortunately it has not been maintained. So there were a lot of leakages and the buildings were tested at the beginning of the heating season last year. One was improved two months later and then retested and at the same time. We did a co-heating test…

SA: OK.

S3: …and the energy requirements… there was nothing else… no lighting, no occupation, just two heated buildings… one improved with a significantly lower infiltration rate of the air leakage… and it was a straight measure of energy usage between the two buildings, pre-improvement and post-improvement.

SA: OK.

S3: …and there were some interesting results that come out. And that was my primary research. But the secondary part of it was to… to assess how accurate modelling software… and we used xxx and xxx… um… to model two buildings and to see how accurate the data that we were extracting from the reports was.

SA: OK… um… so you were telling me that in your practice… in your company, you do building simulation… all areas of it. Is that what you were saying?

S3: Yes… so the simulation modelling, I suppose, is all done in the same way.

SA: Yes… yeah.

S3: …or very often done the same way… but we have different outcomes for different clients, so I suppose slightly unconventional through… um… a practice that specialises in M&E… we don't have specialist skills necessarily in those areas and we'll be appointed for modelling for energy performance purposes, but also modelling for daylighting and for thermal comfort, and to assist the architect in their design for daylighting… um… solar gain and… uh… and those types of simulations.

SA: OK… um… and who are your usual clients?

S3: Normally for the simulation modelling, either small M&E practices that don't have, within their discipline or that area of expertise or… um… small- to- medium- sized architectural practices. They tend to be South Wales-based.

SA: Sorry?

S3: They tend to be South Wales-based.

SA: Oh, OK.

S3: So our… our level of work… um… or the size of buildings that we normally work with don't tend to be… um… necessarily large buildings or complicated developments. They normally tend to be… um… quite straight-forward.

SA: OK… alright is that usually residential then? Or…

S3: No… no… no. Commercial… I mean on a scale of the largest type of building that we'll possibly… um… be involved in for simulation modelling for… would be like a Travelodge…

SA: OK.

S3: …which we’ve done recently… down to… yeah residential, small domestic…

SA: OK alright. Um… so yeah you are saying your clients are architects. Can you tell me a little bit about your relationships with architects? How… how you work with them; what you find maybe interesting, or easy to work with? And what’s maybe more difficult?

S3: OK… um… generally we have a good relationship, but that’s more our company ethos and how we work… because we want to build relationships… so… and… um… on a personal level the relationship… um… basically is… is normally friendly and… and… um… certainly it’s… uh… it’s a case of… uh… certainly there’s a mutual respect, or a respect for… uh… uh… from what… how I get involved…

SA: Yeah.

S3: But I do find, once we’ve got through that that personal relationship, I find actually that dealing sometimes with architects is very difficult.

SA: Why’s that?

S3: Um… I think they’re… and I’m generalising very much now… um… but the lack of… um… understanding maybe even to a slight ignorance in… um… the importance of the building simulation, and what role the simulation can play in helping their design…

SA: Yeah.

S3: …and in nine times out of ten, the cases are… in fact even at a higher percentage than that, the simulation is required for… just to demonstrate regulation or legislative reasons… not to influence the design and its’ in the chain of events leading up to construction. Simulation comes after the building has been designed…

SA: OK .

S3: …which sometimes I find a bit… maybe backwards sometimes?

SA: Yeah. Why's that?

S3: Well obviously the simulation has to come after the building's designed, but I would often think that… why didn't… why didn't some engagement happen before that? Why hadn't some engagement happened before that to try and find out why the building was being modelled?

SA: Yeah.

S3: And what possible items… or what can be… um… influenced at the design stage to make some things happen? Because, again from experience, I tend to find that the modelling that we're doing isn't necessarily giving the results… regardless of whether it's simulation modelling for energy use, or daylighting… the results are never as good as what someone's expecting them or hoping them to be.

SA: Uh-huh.

S3: And it's very difficult to undo the design then.

SA: Yeah.

S3: And to… and to re-evaluate it… I just find it comes too late. And it's frustrating.

SA: Um… what sort of stage in the RIBA stages are you sort of brought in, then?

S3: Um… well anywhere from stage… stage… well from Stage C.

SA: OK.

S3: And believe it or not, right the way through to the final stages, which is K or L.

SA: Right, OK, so construction; post-construction.

S3: Yeah.

SA: OK, alright.

S3: And that, then is definitely just regulation-driven.

SA: Yeah.

S3: Just a case of, *"I need... I need to demonstrate that my building has performed according to a certain criteria."*

SA: Alright.

S3: …and then it's very difficult, because the building has already been built, yeah.

SA: Yeah… yeah. So do you think then, if you were brought in before Stage C, it would… it would… well have a better influence in terms of post-occupancy then?

S3: Most definitely; without a doubt.

SA: Yeah.

S3: Um… the modelling… and I appreciate it has a role to play and has a…it fits into the RIBA Stages… and it's never going to fall into exactly one, but and maybe the modelling can be taken more to influence… and to use as… as a feasibility study.

SA: Yeah.

S3: …as opposed to just being another report which is added onto any architectural reports or anything that is surveyed… site investigations… just things that are added into that… and I doubt that sometimes the architects absorbs any of the information, because it's just another report…

SA: Yeah.

S3: …that has been commissioned and undertaken, and I don't know if it's ever going to influence anything in the design.

SA: Yeah.

S3: I could be wrong though. Certainly with the practices we deal with that tends to be the case.

SA: Right OK that's very interesting. So you were saying that architects are generally quite ignorant about the importance of simulation. Can you tell me a little bit more about that? How do you find that? How does that surface?

S3: OK… and into context now then I tend to generally deal with smaller practices.

SA: Yeah.

S3: Um… and the larger practices… even the South Wales-based ones, or Cardiff-based large practices wouldn't necessarily tend to use us for our services. It tends to be the discipline is either taken up in-house anyway…

SA: Yeah.

S3: …or they'll go to a similar-sized… um… simulation practice… um… so to put it into some sort of context of who we don't deal with… the xxx will… we have in the past but they don't tend to be a client. So I'm trying to set the scene of the type of practices we normally deal with. I don't think they really have a full understanding… I don't think… of the… the… how the building design can influence its performance once it's been occupied… and maybe it's being… I… I… I think it could be a place of that architecture is seen as the creative… uh… the design side of it.

<u>SA:</u> Yes.

<u>S3:</u> …and the practices that these people tend to work in…. don't tend to have the links direct links with M&E… structural…all… all within the periphery of themselves.

<u>SA:</u> Yeah.

<u>S3:</u> It all tends to be sourced from… could be anywhere… and we tend to be one of those sources of information. And well… I don't know… I don't think… maybe it's because there's not that very close link where we'll work in the same building. But they'll… it seems difficult to maybe communicate the messages over the telephone or by email, as opposed to you and me talking now.

<u>SA:</u> Yeah.

<u>S3:</u> It's not as easy to… to communicate and… and… and I don't know… I don't have… although I did my masters in architecture, it was a science-based architecture as opposed to an arts-base… so I don't know the… through your… um … the route for an architectural degree their… their five years and… um… professional diplomas and everything else… I'm sure that all of the aspects that should influence building design, plus lighting, energy modelling and use would get discussed in detail. But I don't know… it does doesn't seem to carry through into every day practice.

<u>SA:</u> Yeah… yeah.

<u>S3:</u> I don't know… I get the feeling that maybe if I was an architect, I'd want to be more creative and not to be stifled by something as trivial…well it's not trivial…but I mean building design can be quite stifling.

<u>SA:</u> Yeah.

<u>S3:</u> Sorry, I mean building simulation can stifle building design.

<u>SA:</u> Why do you think that is? Is it because of its very numerical… as opposed to… I don't know… um… or because it's very regulations-based, maybe?

S3: Yeah regulations-based… lots of um lots of facts and figures and achieving certain standards certain daylight factors and the way… and I just don’t know maybe I think it just stifles design… um… because sometimes what we… what we find appealing visually, is not necessarily the most efficient… or the best way to… um… to build something.

SA: Yeah.

S3: Um… certainly looking at room depths and… um… and visually facades and… with a lot of glass being used, it sometimes comes as a problem for us to model buildings where there’s such a…um… a lot of glass… um… and through curtain walling and through… um… large glazing and… um… fenestration through bedrooms and things like that, where there’s a lot of solar gain and hasn’t been accounted for… and… um… I don’t know why there’s that perceived ignorance, but it’s just seems to be a case of afterthought, I don’t know.

SA: Yeah, it’s just there. OK.

S3: You know there’s one thing that… that… I was at a seminar with just M&E designers on the importance of simulation, and other themes through CIBSE… and… uh… and I suppose they had an opportunity to say some things in the feedback event that went back afterwards, without… um… the possibility of offending any architects. And the guy summed it up perfectly and I can’t remember his very words but *“the architects like to think that they are the ones that create the buildings, but they’re only there to sort of cover over our services.”* So he was taking it… and it was obviously very tongue-in-cheek, but he was just doing what I suppose many people see in the architects as well… the architects design the building… they don’t really care what it is that goes inside it, in terms of the building services.

SA: Yeah.

S3: So no thought is given to the size of plant room, or how the services are distributed around the building… whereas this guy was saying, *“well look, we design our services and the architects are just there to put a rainproof cover over it.”* And he was a bit… he was a bit tongue-in-cheek… he was just saying, *“that’s all you’re good; for these architects.”*

SA: Yeah.

S3: And it created a bit of a laugh, but I knew it got some resonance from people there; *"yes that's exactly…"* what he was saying … strikes me as true 'cause I think people don't think about the services that go into the building… and therefore if that's what they've thought of then it's very unlikely that the window sizes, and even down to the… the thermal bridging is very often never accounted for. I've never seen a thermal bridging calculation other than the one we've done ourselves.

SA: You've never seen a thermal bridging…

S3: …a thermal bridging calculation other than the one we've done ourselves.

SA: You mean architects never do them?

S3: No, never.

SA: What else don't the architects ever do? *[Laughs]*.

S3: Um… accurate u-value calculations?

SA: Sorry?

S3: Accurate u-value calculations? A lot of assumptions are made… um… and that's a reliance then on software, as opposed to trying to remember when they went through their studies, and the mathematics side of the calculation being considered… reliance so much on the inaccurate information from manufacturers… um… and then I don't know maybe that's nothing to do with building simulation, but it doesn't help if you're either not given the information to start with, or the information you're given isn't correct anyway.

SA: Mm.

S3: It’s just… it sort of puts another sort of complication in our… in… um… what we’re trying to create.

SA: Yes… yeah, I understand… um… I wanted to ask you a little bit about your software… or what software you use and… could you tell me a little bit about that?

S3: Yeah sure… now I don’t… um… the one that… the more comprehensive modelling software that we use is xxx. I don’t have that much personal experience of using it but from memory… um… I think we use… um… xxx which is…um… the base…for… um… for modelling purposes…

SA: Yeah.

S3: …and then we have pretty much all of the… um… bolt-on applications that go with it for… um… I’m not sure… I can never remember exactly the names of them but anything to do with sunlight or daylighting… um… and we’ll also use the mechanical-electrical ones for thermal comfort.

SA: OK.

S3: But I unfortunately don’t get involved in that enough nowadays for me to sort of expand on that any further, other than I know that’s the software that we use. I have in the past used xxx but didn’t find it as a user-friendly the interface onto the software as xxx. And for all our compliance work, up to a certain level, we’ll use… um… iSBEM as our interface onto SBEM.

SA: Yes.

S3: Um… I suppose in a stricter sense, it’s not really simulation modelling, that.

SA: Yes.

S3: It’s compliance modelling, yeah.

SA: Yeah… um… do you think architects realise that difference, or to them is it just all simulation?

S3: No, to them it's just all simulation.

SA: Yeah.

S3: I don't think an architect realises you don't even model a building in SBEM… um… so I never tell them about that because it's… um… the process would reduce our fee slightly. But… um… yeah… um… um… I don't know think they…they wouldn't have a clue…I don't think…

SA: Yeah .

S3: I don't think architects know the difference… no way.

SA: OK… alright… um… well you were saying that your role now is not really directly… I mean you don't really use software… well, what… could you tell me a little bit about your role now?

S3: The practice does but my role is more so well I've been lecturing now for the last month and a half. Prior to that, I was writing a xxx or sorry xxx in resource efficiency and my role from the practice has been… we've got eight staff so it has been a more management role as opposed to a hands-on technical role. But I still keep my registrations and I still keep an understanding… but I just don't get involved on the day-to-day… um… calculations or methodology behind it all.

SA: OK, alright and… um… can you tell me… um… what is it that you're lecturing? Is it anything to do with simulation?

S3: Sustainable construction… no, nothing to do with simulation… no… no.

SA: OK.

S3: Sustainable construction to higher education… um… students in construction skills… so they're vocational; bricklayers… um… carpenters, plumbers.

SA: OK, Alright… OK… um… Going back a little bit further, can you tell me a little bit more about your masters course? What… what was that like? What was it about?

S3: Interesting… very interesting. It covered a lot of the aspects of building physics, but aside from the building physics and construction side there was a lot of the… certainly a focus on the ethos of the… um… where the course was held up at the xxx.

SA: Oh yeah.

S3: The course was held there. The ethos was very much one of looking for alternative energies… alternative sources… and they've got a very alternative view to education as well.

SA: Yeah.

S3: Um… the course was… every single student on there was a mature student so I think the minimum age range would have been was mid-twenties all the way up to people in their sixties. So very… very sort of broad… um… background and skills, and not everyone was from a construction background. In fact at least fifty per cent had come from another industry… another… another background. And I didn't find it then… possibly not quite what I was looking for, and it was a much broader subject and not quite a specialist one… and… uh… I didn't get as many opportunities as I wanted to, to study modelling. That's why I tried to place my thesis… uh… sorry, yeah, my thesis on… on something that had to do with my day-to day job as well…

SA: Yeah.

S3: …which was the testing of buildings and… uh… modelling of buildings.

<u>SA:</u> OK… so what was it based about then?

<u>S3:</u> The course?

<u>SA:</u> Yeah.

<u>S3:</u> Our impact on the environment through construction and… um… how to build more sustainably and… um… a lot of how we should as… as… um… as people within the construction industry maybe adapt and change our ideas, and maybe to not follow convention all the way through…to try and look at things from a different aspect.

<u>SA:</u> Mm.

<u>S3:</u> In all honesty the course can be done full-time but um the modules run one week every month I don't think any student who did it full time actually stayed on there's no campus up there so I didn't really have an opportunity to discuss with other students…

<u>SA:</u> Mm.

<u>S3:</u> …other than the week that we were on a residential… and for myself it was very much a case of I did my week and that was it. On a Sunday I was looking forward very much to getting back to work… um… it was a tough heavy week with a lot of heavy hours and lots of information.

<u>SA:</u> Yeah… yeah. I'm wondering whether you got the chance to do any sort of design work at all in terms of the architectural design?

<u>S3:</u> When I was on the course?

<u>SA:</u> Yeah

<u>S3:</u> No, we weren't allowed to mix with the architectural students.

SA: Weren’t you?

S3: No um

SA: So were the architects doing… sort of different work?

S3: Yeah… they were doing their level 2 diplomas… either level 1 or level 2… or maybe there was a blend of the two in there. And maybe… it was a bit disappointing… um… they were on a slightly different course, but a number of seminars were mixed seminars which they had to attend, as we did as well. And we didn’t integrate much with their work… either the two… it was the two… the two courses were run very independently of each other.

SA: OK.

S3: Different lecturers, different buildings and there didn’t seem to be a need to be, but I think they could have been brought together a bit more.

SA: So you disagree with that then?

S3: Oh yeah, I… we did have the opportunity to go and see some of the architecture’s work and the people on the architectural side, as it was… I’m sorry I can never remember exactly how… you do your degree and then you do three diplomas after that is that right?

SA: I don’t know. I didn’t do my undergraduate degree here so it was different for me as well.

S3: Oh alright. I’m sure there’s a number of diplomas afterwards.

SA: Yeah.

S3: Through their professional studies then for a number of years.

<u>SA:</u> Do you mean the RIBA Part 1 and Part 2? And then they go into practice and then Part 3…

<u>S3:</u> Yes… yes… I can't remember which part they were on, but a lot of them were there. So we had a chance to go down and have a look at their work, which was fascinating… it was just full of design and full of creativity… and ***these*** students given the type course that they were a part of as well, had understood… not necessarily the simulation modelling but had understood the building's function, not just for its occupants, but actually in terms of its… as its… uh…ability to consume energy, and how services were being used especially in the building, they really understood it.

<u>SA:</u> Right… OK.

<u>S3:</u> But it was a shame we never really got to integrate with them fully, other than going to view their work at a… um… a show after the course ended…that was all we got to see.

<u>SA:</u> Yeah but no communication? No…?

<u>S3:</u> No… I think I did one practical on daylighting and solar gain, with a mix of… there was a mix of the MSc students and the architects.

<u>SA:</u> Right.

<u>S3:</u> And I found that quite… um… helpful and knowledgeable more so than any of the MSc students. But I don't know if that was just the group that I happened to be in… I was in… I don't want to face up on… on… on my own experience, but it did seem to me like they understood how to calculate, long-hand daylight factors and the importance of window sizes. And now reflecting on this I'm thinking like, *"hang on if they were the people who were taught how to do that, why then do they seem to be the people who are most resistant to it when it sort of when its set back into work?"*

<u>SA:</u> Yeah.

S3: I'm not sure.

SA: That's really interesting, actually. That's quite… um… yeah…

S3: Oh yeah, they were fast. They were quick. They knew exactly what they should be doing and how to do it. Whereas I think a lot of the MSc students, whether they spent an age or not, they were like *"can you tell me that again? Can you explain this again?"*

SA: Mm.

S3: …and it was nothing more than GCSE level maths really and people were having difficulties grasping it.

SA: Yeah.

S3: I'm not saying that it… not all people on the MSc would be going into building simulation… I would have been one of the only people that did it… but so maybe it's not a true reflection on the types of students, but certainly the architecture students knew what they were doing and how to do it. And they were quick, accurate and understood it… yeah.

SA: OK, alright. By long-hand calculation do you mean the actual… sort of manual calculation of the…?

S3: Yeah.

SA: Is that important, do you think, for architects to have an understanding of?

S3: Yeah.

SA: Yeah? Is it is it possible at all for someone to go onto the computer modelling or using… using software without having… um… without having tried the long-hand calculations?

S3: Yeah.

SA: Yeah? You think so?

S3: Yeah definitely. Three out of four of the guys working for us wouldn't know how to do a u-value calculation long-hand… wouldn't know how to do a condensation risk analysis long-hand… um… wouldn't know how to work out daylight factor long-hand… uh… sorry daylight factors they would, um… but certain aspects of… um… building physics they couldn't be able to do long-hand. I've forgotten now because I don't do it every day.

SA: Yes.

S3: But I'd know where I could pick up some old college notes, and I'd know… I'd know the principles behind it.

SA: Yeah.

S3: But I think it's fair to say that people who struggle through the condensation risk analysis…

SA: Yeah… so they'd have a background understanding of what goes on behind it, I'm assuming?

S3: Um… not everyone in our office, no.

SA: Are they all… are they all… do they all have similar backgrounds to yours?

S3: Yup.

SA: Yeah?

S3: Yup… construction degrees or architectural degrees, yes.

SA: Um… have they all done building physics at university or college or…?

S3: To a lesser or greater extent, yes.

SA: Yes…

S3: I don't actually… I don't… I can't imagine in any of their cases… um… they'd all have been educated to degree after… pretty much… um… yeah all of them are have been educated to a degree… um… two in architectural technology… um… and one in construction… uh… I can't remember exactly but something in construction.

SA: Yeah.

S3: And they'd have all covered on it in their studies, and not one of them remembered.

SA: Not one of them remembered?

S3: There was no need, I don't think. They've got the software to do them!

SA: Yeah.

S3: And recently the youngest member of the team, in his early twenties… so he's not long in finished in college…

SA: Right.

S3: …has gone back and done some postgraduate studies on modelling and… uh… u-value calculations, condensation risk and thermal bridging…

SA: Uh-huh.

S3: And when I asked him, when he came back, how he found it, I said… you know, *"did you find it easy?"* He said, *"yes, I found it easy…"* because of his very recent background in education and what he… he'd been doing recently in work. But he didn't find it easy… because he remembered it. He just found it easy because he was used to working with numbers and could understand the basics of construction.

SA: Right… it's funny that you should say youngest because the next question that was on my mind was… and I've been thinking about this throughout my research… what are… there… maybe younger architects in particular might have a better understanding of simulation and… slash… or sustainability as a whole… um… than… than older architects. Maybe because it's implemented in their education and in their training? Um… Have you dealt with, sort of, older architects and younger architects?

S3: Yeah… yeah.

SA: Do you have any opinion of that?

S3: Um… I'll generalise now.

SA: Yes, OK.

S3: But certainly the older architects are harder to deal with professionally however they're easier to deal with on a personal level

SA: OK, why's that?

S3: Um… they've seen it… been there… done it all before… and… uh… don't get so phased by inherent problems that happen.

SA: Yeah.

S3: They… they've had problems for many years, which they have more or less solved, or have come to the compromise to get the solution… and I found that maybe as we get older they mellow out a bit, or just think, *“hang on, we’ve had problems before. It’s nothing new! We’ll just get over them!”*

SA: Yeah.

S3: Whereas I’ll find some of the younger architects have more of an understanding of… I suppose what we can call a modern science behind a building… although maybe that’s not a very good word to use… you know building design isn’t exactly modern… but I just… you know the services and everything… there are many different newer ways of heating, cooling and lighting a building.

SA: Yeah.

S3: …and I think the younger an architect is, in their career, the more switched on they are to some of the other disciplines that are involved in the building design.

SA: OK.

S3: Yeah, definitely.

SA: And is that why you find older architects harder to deal with?

S3: Practically, yes… um… it’s very much a case of… sometimes getting information out of them can be difficult, and we get to the stage sometimes where, when we are looking for information about a building to model it properly, we literally have to give a checklist to someone…

SA: Uh-huh…

S3: It’s no good asking the question because the information is going to get back… it’s either passed off quite flippantly, and that then causes problems for us further down the line. A perfect example… and I can’t relate it to a scheme that we’ve worked on, but would be *“Oh can you please let us know the u-values of the building?”* And instead of either checking what they are, they will just rattle off what is known to be the regulatory code.

SA: Yeah.

S3: And we model with that, and then its… five… ten months down the line, someone will question, *"why did you use this figure?"* and we will say, *"it was the figure we were given…"* and well… *"it wasn't,"* and this is what I was saying about the accuracy earlier in this interview.

SA: Yeah… yeah…

S3: the information is never really always that accurate.

SA: Yeah.

S3: And the older guys just seemed a bit more… *"yeah, well just give them whatever they want to hear,"* instead of being quite thorough with it.

SA: Yeah.

S3: So we have a little checklist now which will go to a client. It doesn't have to be architectural… but it could also be… um… um… a contractor, or someone that could actually do a proper… um… someone that could actually do a robust check of the information that we are using is actually correct.

SA: Yes.

S3: And there are often discrepancies… many discrepancies…

SA: And… from the architects side basically?

S3: Yeah, but not just from the architects side… but generally from the architects side.

SA: Yeah.

S3: Um… I don’t know, maybe it’s a case of… maybe the information isn’t that important or the information isn’t going to make a difference to the overall calculation or… I couldn’t really put my finger on it as to why…

SA: Yeah.

S3: But there seems to be no urgency, and a lack of accuracy with it.

SA: OK.

S3: That said, the M&E clients we have can be just as bad.

SA: Can they?

S3: Oh yeah. And they don’t see the benefit or the point in modelling the building any more than the heating calculations that they’ll do to size equipment.

SA: Uh-huh… right, OK. That’s actually really interesting I didn’t expect to hear that to be honest.

S3: Yeah… yeah, big time.

SA: Yeah, because I would have expected… I mean I don’t know but I would have expected the M&E consultants, on some level, their work process or the nature of their work is probably similar to simulation or engineers than to an architect’s…that can be quite different.

S3: Yeah… yeah.

SA: So I wouldn’t have expected that, to be honest.

S3: Well certainly some of the larger M&E practices that we do work with… um… they use the same software or similar software to what we'll use, and in the same way that we'll use it…

SA: Mm…

S3: And… um… maybe sometimes their problems are the same problems that we have.

SA: Yeah.

S3: But then getting the information out of an architect, or from other disciplines is… is… they find it just as difficult… and maybe because they're not modelling the building that is being measured in any sort of regulatory capacity… because that's where we step in for it… it's a case of, *"well I'll just build with the information I'm given..."* and maybe a bit defeatist to not try to probe it further. But because we come under quite a lot of scrutiny and order, we have to establish some… a level of accuracy and make sure we've gone through a robust sort of process to arrive at that calculation.

SA: Yes.

S3: And if there's any… um… any sort of… uh… information that hasn't been sort of quantified properly, we want to make sure we've got it covered.

SA: Uh-huh.

S3: So to take the information verbally off someone is a big no-no for us.

SA: Yeah.

S3: We just need everything backed up. And because we're doing it on a daily basis, we soon see where potential problems will happen… and that, from the information that we'll get back from an architect, it tends to be around the building fabric. There tends to be a lack of accuracy there.

<u>SA:</u> Right… so… um…. a lot of the time then, is it a matter… is it a matter of documentation from the architects?

<u>S3:</u> Uh-huh.

<u>SA:</u> They’ve got to produce big reports to give to you as inputs then? Is that it?

<u>S3:</u> No… no. just some accuracy in it… um… we’ve modelled a building and spent I don’t know how many hours on a building that has one zone.

<u>SA:</u> OK.

<u>S3:</u> It’s an extension to a large warehouse… um… it’s going to be used for storage of pharmaceuticals and… pharmaceuticals in a… um… epidemic… um… basically if there’s a big flu outbreak… happens in the winter, this part of the building is not going to be used for general storage. It’s just there for… for outbreaks of any… any epidemic that might happen. Now the architect’s information came back to a building regulations minimum, and even though we questioned and we said, *“OK, look, are you sure the fabric information that you’ve given us is correct?” “Yes… yes, a hundred per cent, it’s correct now, yes…”* um… we spent hours and hours modelling. It was very difficult actually to simulate a building with only one room in it

<u>SA:</u> Yes.

<u>S3:</u> Because simulation modelling… you get more accuracy the more activities and… and… and… if one room on a simulation… when you’ve got many… many rooms has been modelled, and the understanding of the software… the calculation hasn’t worked as it should do, it gets levelled out, because other rooms do work and other zones do work. But when you’ve got one zone, only… or one part of the building that needs modelling, and you know that the software hasn’t modelled it as it should have, but you’ve got nothing to balance it out with elsewhere in the model… so you just do sort of a… um… a more level average.

<u>SA:</u> Yeah.

<u>S3:</u> And you are very heavily reliant on the correct information.

<u>SA:</u> Yes.

<u>S3:</u> And we were told, *"no,"* after questioning them once… *"yes, it's definitely done to u-value minimums… um,,, for Part L 2010… OK…"* um… it's back to the M&E… the problem we've got is either the heating and lighting; the two aren't working together.

<u>SA:</u> Uh-huh.

<u>S3:</u> So the heating has to improve, or the lighting has to improve, or possibly what's best is that they both have to improve.

<u>SA:</u> Yeah.

<u>S3:</u> …um… because they're both in the building fabric… that's what was… um… designed to; Part L minimum, and the building was halfway through construction phase and there were hours and hours of work between ourselves and the M&E designers… and I know the lighting guy was just pulling his hair out because he just couldn't improve his design anymore than what he had done. And they were looking to spend tens of thousands of pounds more on their design, while they changed some of the lamps around them and design it differently, only to find that then a couple of days later, *"Oh yeah, actually the u-values weren't actually what you were given… we've found out since that the wall u-values have gone to 0.35 to 0.18…"* and it was a misunderstanding between the architect and the contractor, where there wasn't that firm a specification.

<u>SA:</u> Yeah.

<u>S3:</u> I don't know whether it was design and build or a more traditional um uh construction route but either way what the architect believed was correct was nowhere near there was no accuracy whatsoever and when we did get the right information it was almost as if, *"oh yeah, you were right, the u-values were lower than what we probably told you."* No apology; no, **"did it cause any grief?"** Or, *"was there any problem with that?"*

SA: They didn’t realise how much trouble they’d caused?

S3: Yeah it was like, *“you were right, we were wrong… here are those correct ones…”* and it was very much like… cause we didn’t get paid any more for all the extra work that we were doing.

SA: Yeah… yeah. So it’s a lot of… lots of time and money then.

S3: Yeah, and all it took was a phone call…

SA: Yeah… yeah.

S3: …or for someone to actually check the accuracy of it.

SA: Yeah… yeah.

S3: And I don’t know… it could have been a contractual issue… I’m not sure. But either way it just seemed a bit… um… a bit disappointing. Now that’s a relatively simple design a large extension several thousand square metres floor area, but relatively simple in design. So when it’s a complicated design, you can just imagine the type of information that we’re sometimes not getting.

SA: I’m sure… I’m sure… yes… yeah.

S3: Yeah and… and I don’t think many architects realise the importance of getting accurate information…

SA: Mm.

S3: …or why… why you even need to provide it at all. As I said, I’ve never seen a thermal bridging calculation.

SA: Yeah… yeah.

S3: Never seen one. I've asked… asked a… do you mind if I touch by something a second?

SA: No… no… go ahead.

S3: We have a client… I can't mention the name, and I know you said this is all confidential.

SA: No I won't… I don't need any names.

S3: No it's OK. It's a very large fast-food chain in the UK. We do all their building simulation work for.

SA: OK

S3: …um… now they historically sailed through building regulations… um… for one reason or another. But it was to do with some inadequacies with our simulation for… to provide their energy performance certification.

SA: OK.

S3: Which…. um… I know in a strict sense isn't proper simulation, or what you call proper simulation. But still in summary we do a lot of… for this particular client. Now they changed their designs slightly… uh… six months ago, on the back of… there'd been a change in regulations for Part L.

SA: Yes.

S3: The architects… we have close links with the M&E contractors who also do some of the design work. We have very close with… and working well as a team. Now we also have close links with the client. And we suggested having a meeting to discuss the amendment changes in Part L and what impacts it's going to have on their designs… because these things… wherever you pick them up and put them down; they're identical everywhere.

SA: Yeah.

S3: They have three different models and that’s all they use.

SA: OK.

S3: And there was certainly a reluctance from all three, client architect and M&E to discuss the incoming Part L changes.

SA: Yeah.

S3: When they happened, and they found that their design wasn’t working… so they obviously wanted to do something fast with it. And then we had a sort of sit down meeting, which was perfect because I thought, *“that’s what we should do for all design.”* But it was very much a case of, *“we can only do this and we can only do this…”* and it became sort of lock heads with it. I… I kind of sat in the middle of it and the architect was saying, *“that’s all we can do. We can’t improve the building anymore that way…”* the M&E; *“we can’t improve the building anymore that way…”* and I don’t think either side really was willing to take on any responsibility.

SA: Yes.

S3: And when I went back to the architect, I said, *“look, you told me we’re using your… as good as a thermally-performing envelope as you can… can you provide me with a u-value calculation? Or a thermal bridging calculation?”* And they couldn’t do either.

SA: Uh-huh.

S3: And… um… well I was just really… really disappointed with that.

SA: Yeah.

S3: And we’re talking for a large… I mean thirty new stores a year.

SA: Wow

S3: They're big consumers of energy, and up until six months ago, they just… there was no real concern about the energy consumption because they were involved with a turnover of a million pound a day, on a real decent weekend… not a million pound a day, a million pound a week. But they were shedding 6000 pounds of hours worth of food, and… uh… it was a case of… uh… *"kind of irrelevant in a way…"*

SA: Yeah.

S3: *"...how the building performed?"*

SA: Yeah, they didn't really care?

S3: And linking it back to simulation, well they… they had never had a building simulated ever… and it's only now that we've done some additional calculations for them outside of just achieving legislation.

SA: Yeah.

S3: And *"have you thought about this? Have you thought about that? The impacts that certain things are having?"* Um… that they've actually started to listen and… um… their answer to… not necessarily the answer, now but the answer to getting through legislation was just a cost-driven one.

SA: Yeah.

S3: *"What's the cheapest way we can go through this?"*

SA: Uh-huh.

S3: And… uh… looking for a solution from a renewable source was very much a case of, *"right, which ones gives the quickest return?"* Not a case of, which is most appropriate for the building?

SA: Yeah.

S3: So when I suggested that when we model the building to find out if one's more appropriate than the other, or to find out which is better in terms of payback, in terms of CO_2 reduction… uh… in terms of energy supply in terms of energy demand… *"no... no... no... we just want to get the cheapest way possible please,"* just modelling for legislative… the regulation reasons.

SA: Yeah.

S3: And just leave it at that, nothing else.

SA: OK.

S3: And… uh… yeah… there you go.

SA: Yeah, so that's the attitude.

S3: Well, one driven by money unfortunately.

SA: Sorry?

S3: One driven by money.

SA: Which… I mean it's understandable, I suppose. It's like… kind of how the world goes round sometimes… um… do you find that architects have, well a sound knowledge of building regulations? Do they…

S3: Um… generally speaking, yes they do.

SA: OK.

S3: I just think that they maybe lack the exact requirements.

SA: Mm.

S3: I mean what do you have? Maybe fifteen parts of the regulations at the moment.

SA: Yeah.

S3: And as a practice we only deal with one of them, being Part L. And I'd imagine there is… um… as knowledgeable as we have to be, and possibly what we are as specialists in our field, and I wouldn't expect an architect to be at that level of competence in all of the fifteen or sixteen parts of the regulations.

SA: Yes.

S3: So, yeah, generally-speaking, I find most architects have a good understanding… um… there's… whenever there's a regulation change in Part L, and I'm sure this happens for all regulations, there are awareness seminars… and there are sort of partnership practices that we work with. All of them at the regulation change will undergo some sort of formal training with ourselves…

SA: Yeah.

S3: …to give them an understanding of either what's going to happen, or what has just happened.

SA: Yes.

S3: And how they can adapt their work practice to… to suit with it. And really without fail it's… it's always well well-attended, and people come away with thinking, *"we've been well-informed and got a better understanding…"* and yeah I think they generally go down well. And it would be fair to say that most people are fairly keyed up on it.

SA: OK.

S3: Yeah.

SA: Alright, OK. Just… I think this might be my last question… um… going back to software… um… why is it that you use xxx, rather than other software?

S3: Well, because the user-interface is easier.

SA: OK… is it visual?

S3: Yes, but in fairness, the one that we used to use was visual beforehand.

SA: Yeah.

S3: And I think it's improved. The other software that we used to use was xxx and that was visual. I used xxx in college as well… um… which gave me access for a nominal student amount.

SA: Uh-huh.

S3: So that influenced why I used it for that period of time in college.

SA: Yeah… uh-huh.

S3: …and after that, it's just a case of getting used to it. I was… you know it didn't seem that much of a change but it seemed to give us a more opportunities. I found other software quite restrictive. You wouldn't use… yet… necessarily… if you are only going to do one type of the simulation, then another… there was no… you can cross from one to the other quite easily.

SA: Yeah.

S3: Whereas I'm comfortable with xxx. We build a base… a… a… you know a visual model, and then we can apply whatever sort of calculation we want to simulate it.

SA: Yes.

S3: And that's the reason why we deal with that.

SA: OK… alright. There's just something else that came on my mind… um… uh… I haven't used xxx myself, so I don't know what this would look like. But I'm assuming that the outputs of simulation results would be quite numerical, wouldn't they?

S3: Yup

SA: Um… how do you manage to communicate that to architects?

S3: Um… right this is probably a failing on our side then.

SA: Sorry?

S3: A failing on our side, because we don't.

SA: You don't communicate?

S3: Not properly.

SA: OK.

S3: I mean we give them a report based on the outputs themselves… um… and to justify our fee, our report is padded out, just as it is with a nice introduction, executive summary and everything else. But I don't think maybe we communicate the results and the impact of the results. And certainly we don't go into the detail of cause and consequence either… it's all solution.

<u>SA:</u> OK… so you don't give them suggestions as to what to change? Or what might be improved?

<u>S3:</u> Um… limited… a limited part of the report.

<u>SA:</u> OK.

<u>S3:</u> Um… yeah I don't think that we would necessarily go into that much detail with it… that we can pull our hands together and say, *"well look we've given all the evidence you need"* or *"all the information you need to influence future design, or possibly the existing design…"*

<u>SA:</u> Yeah.

<u>S3:</u> And yeah… that's a failing on our side actually.

<u>SA:</u> OK… alright… yeah… OK. I think I've actually been through most of these questions, and you've given me a lot of really interesting information… thank you. I think we're coming up to an hour, anyway so I'll stop the recording now. Thank you very much.

APPENDIX D – Samples of open coding and categorisation of the interview data, as part of the qualitative thematic content analysis conducted in the research (chapter 4).

to produce a lovely space – he doesn't recognise that allowing the 'right temperatures' is his [the architect's] job!.

Two things here: manufac

4. COLLABORATION AND COMMUNICATION:

CONCEPT – whose job is it?

- "You get to a point in life when you're thinking, *"I thought I'd cracked it all you know,"* and then you start getting BREEAM and all these other bits and architecture starts to become a paper exercise"!

① Implies that, by a certain point in time, his age/experience, he had 'cracked it all'. [CONCEPT OF AGE!]

The roles of architects + engineers in creating sustainable buildings.

② Conveys a certain degree of anger/disdain at all the 'sustainability stuff' → reduces it to a "paper exercise."

Attitude – 'it's not my job! don't ask me to do it!'

- "I fully understand that and it's great to have that done [have comfortable environments created], at the minimum of effort service-wise. But to me I've got a service engineer to do that. I will employ; or we will employ as a practice a good service engineer that will do that for us. As long as he can provide the environment that will allow the right temperatures and everything for me to produce a lovely space; then he's done his job. And if he's a good engineer and can do it well I'm really pleased. If he's a bad engineer; then you struggle afterwards."

I don't think he appreciates the value in it!

"I will employ or we will employ" → [rather than I/we will work with," for example.]

~~be bureaucra~~ Paper exercise > ~~bureaucra~~ → tedious, rules + regulations, formality

- "It's [producing sustainable buildings that create comfortable environments] all doable. But I think too much emphasis at the moment is put onto the architects to try to create that. I think it needs to be spread evenly amongst everyone. The service engineer should be doing their bit. And the manufacturers need to be doing their bit, and be a bit more honest about it as well, because it doesn't take long before you're kind of drilling into what they're producing and you go, *"oh actually it's not that sustainable to be honest."* We had a chap in here a couple of weeks ago talking about sustainability of concrete. Yeah! OK it's ***a bit sustainable,*** and there are ways that you can make it look a bit more sustainable. But actually he was fairly honest because he said it's a product that will last a long time. You can always strip off the cladding and keep the concrete. You don't have to demolish buildings."

[CONCEPT – architects attitudes towards the engineering/ simulation/sustainability practice.] ~~OR~~ he is misinformed and does not understa[nd] how central his role is, and what it is all about!

→ CONCEPT – Trust issues!

architects don't always seem to

He doesn't see/ believe that the task of "producing sustainable buildings" is the task of the architect! he feels that too much emphasis at the moment is put on the architect to create that!

- "I just think a lot is put onto the architect about that [to create sustainable buildings], and a lot is done with paperwork and I just feel sometimes that it detracts kind from what real architecture is about."

DETRACT → diminish/lessen/reduce/weaken/ undermine! → this is BELOW the work of architects!

Trust who they are working with/ collaborating with!.

- "I've got a service engineer who's done a report, and this is a leisure centre that I'm doing at the moment. It's got loads of really clever interesting stuff. Ask me if I understand it; ***I don't!*** I do not understand it. What I said to the service engineer is, *"am I going to have people coming into my leisure centre, getting changed and standing there shivering before they go into the swimming pool? Or before they go into the hall? And then when they get into the gym are they going to start working out for like two minutes and then sweating like a pig?"* And he said, *"no."* He said, *"We've covered all of that."* And so there is a reliance upon the service engineer, to understand what you are providing. So, a leisure centre; it's fairly well-documented. An office building is fairly well-documented but there are other things that can be done. It doesn't ***have*** to be all about this *[points at the big fat chunky document]."*

→ He doesn't have a clue!!

Conveys an air/ attitude of cynicism + skepticism about all the sustainability stuff + documentation + paperwork exercise, as he calls it.

I don't think he tries/he doesn't really make the effort to really understand any of it either!.

Q – if the architect doesn't understand it, how can they work together?!...

WITH the architect > that he works against him? or in a different direction? Or to fulfil his own agenda?

architect's role as the orchestrator – the detailed day-to-day co-ordination of design!

[redacted] – COLLABORATION AND COMMUNICATION QUOTES

conditional – does he not always do his job?

How will he work "with" you if you don't understand what he does? The challenge is that the architect doesn't feel that the service engineer works

- "If the service engineer does his job then we can add something extra into that, which might make them turn the temperature down. He knows what the requirement is and he knows what the minimum requirement is, and he can tell me how much insulation he needs to provide that without using too much power, and so I will go to this manufacturer and I will ask him to tell me how I can do that, and I will put all of that together and I will create a room."

- "So I expect a service engineer to do all this [sort out internal temperatures and internal comfort]. I expect him to work *with* me. But there's got to be a trust there. I've got to have an expectation that he will do his best."

seems to imply that he finds that service engineers don't always do their best. → what is 'his best'?!

maybe he doesn't TRUST the engineer because he can't get his head round exactly what it is that the engineer does?

- "It [passive design] was never part of my study when I was architecture school, so this is all kind of new to me. I'm not saying I find it difficult, I'm just saying I find it a frustration. But I get a decent engineer which I've got on this job, who will work with me, as you know, *"have you thought about doing this? Because it will have this effect." "Yeah ok we could do that. How would I do it?" "And then you could do that."* But it is a teamwork. Architecture is a teamwork at ***this*** level. And then you turn to manufacturers and you try to work with them."

finds it difficult

The basis was not established.

compare this with other architects [I think all the other did passive design at university]

Frustration > synonyms – prevention/ hindrance/ blocking/obstruction/ irritation/ disturbance/annoyance/ nuisance/ exasperation/ aggravation.

← EMOTION/ATTITUDE. what is a 'decent' engineer?

- PROFESSIONAL TACTICS! I get on very well with them [services engineers]. I treat everyone as professionals and I am incredibly honest with them. I'll call a spade a spade; if I don't understand something I'll tell them. And that's a benefit of age. I can just say, *"I'm too old for this...explain it,"* and they will. I don't actually don't care if people think I'm stupid. It's better to let them think I'm stupid than have them explain it, than to walk away thinking that I understand it and I don't."

→ implies that some architects will walk away pretending to understand > egos!

Using 'age' as an excuse!

- "I'm very honest about it and so therefore engineers kind of ***like*** me, because they can spend the time explaining stuff to me and they'll walk away going *"that was good I had to explain to the architects,"* and that's fine by me; I've got nothing to prove in life. but sometimes pride gets in the way I've noticed around here, that they don't like to ask."

> so it makes the engineers feel good, because architects tend to convey that air of authority? so when they explain something to the architects, it feels 'good'

Asking questions → reduces that air of authority? Architects like to show that they know everything?

PROFESSIONAL TACTICS!

- "I'll ask the most stupid questions; sometimes even when I know the answer, just to kind of get that out the way [to establish a relationship where a feeling/impression of superiority on the part of the engineers is established.] So I have great relationships with engineers and generally they will explain things to me and we'll negotiate and haggle our way through to get what I want, which is the architecture, and what they want which is the efficient use of fuels. And that to achieve what I want again which is the environment within the building and outside the building. So it's just about being honest with them."

TRUST ISSUES!

Implies that he may think that services engineers do not usually like architects because architects are not usually "incredibly honest with them."

[redacted] COLLABORATION AND COMMUNICATION QUOTES

contradiction? ?

"These guys spend as long studying this stuff as I did studying architecture; architecture in the form of construction and art, whereas they are doing the engineering, So I just rely on these guys to guide me and put me in the right space, so that we between us we come up with something great. I don't see it as a 'them and us.' I see it, at this level, at this office level; I see it as a team."

I think the participant contradicts himself; what he says directly and what he says indirectly → "I will employ" someone to do his job" etc. & then "I don't see it as a 'them and us... I see it as a team."

Political games & trust issues - implicit games that have to be (implicitly) dealt with → "it was just a case of hitting them in the right way."

- "I'm generally there to fire-fight for the youngsters when they get bogged down with contractors. Typically we had a young girl who was doing a fantastic job; a hospital. But the contractor was blaming her for delays, and the client was losing faith in her. And she was doing a grand job; absolutely nothing wrong with what she was doing. But it was a political game that contractors play. So I went along for a couple of meetings and analysed where the delays were, and in fact they were nothing to do with us; and it was just a case of highlighting them; hitting them in the right way, as opposed to trying to defend something. So *"we don't need this yet, we don't need this yet; why are you asking for this?"* So I kind of do that."

→ Hawthorne Effect.

→ stereotypes - lack of trust built upon stereotypical impressions!

- "I think there's a perception to send too young an architect; they feel that they may not be as qualified as they ought to be. So I sometimes just go along to reinforce our position. Most of the time I feel that they're doing the job properly but they may not have the experience to understand the contractual game that gets played around a meeting table."

It's not just about the experience of building design + construction - it's about experience of communication + dealing with ~~other actors in the constr~~ multiple actors in the construction game.

- "Gone are the days of being a specialist. Now you ***have*** to know a lot and so that's why I'm finding myself most useful within the practice."

This should be in 'the discipline'

- "A while back I remember watching a documentary where they got a group of graphic designers, and they were going to get them to design a new zoo logo or something like that. And what they did was they picked them up and they drove them along a certain route. Along that route they had put posters up and things like that to influence them. And so they put them all in a room and they told them *"design this;"* and they came up with the design, at the other end of the room was a sealed envelope a big sealed envelope and when they opened it, it was the same; almost identical design. And that was because they had gone down this route and they'd seen symbols that prompted them that day and so it was fresh in their mind."

This should be in the discipline'

- "Unless it's fresh in your mind I don't think that you will keep looking at… it will affect your architecture too, so by going to the art exhibitions and things like that, it refreshes your mind. It kind of brings it to the fore, and doing the life drawing; it makes you think about the way you present drawings and things like that, so it's reciprocated. And I get a buzz from that and I get a buzz from their [younger architects'] input, even though sometimes I feel it's naive but naivety is not a bad thing in architecture. It's a good place to start."

All about pragmatic matters!

*Business aspects + efficiency of operations!

[redacted] – COLLABORATION AND COMMUNICATION QUOTES

so he is able to understand the 'political games?'

- "I always taped my meetings. I did so openly, so it made people a bit more honest. I'm quite good at contract law so I kind of pride myself in contract law. So when it comes to a meeting where a contractor is running a little bit behind on a project the client's sitting here and the architect's sitting here, and if it's a young architect the contractor's going, *"well I need this, I need this, I need this, I need this, I need this, I need this."* Well he knows that can't be done by the architect in time! He knows what resources the architect's got because the architect will be saying, *"well I'll get Fred to do that,"* or they'll never say, *"I'll get Fred..."* so they'll eventually work out that he's been doing it on their own, or she is doing it on her own, or that they have one or two guys working with them. So they can load that up and you have to understand the contract and you have to say, *"well look, show me on your program where it says you need that information. Now it doesn't. OK, what's urgent? Let's have a section of these minutes."* So it's knowing what you can get away with and what you can't get away with. No one's going to produce everything straight away, and they're always going to be queries and they're going to be variations, so it's understanding the contract. It's understanding people's posturing in a meeting and recognising when they're building up to a claim or something like that. So that's the politics. It's not heavy but it takes a while before you realise that [from] certain phrases that go out; *"he's looking for a claim here."* implicit politics → tight!

→ trust issues!

→ Lack of clear intent!

non-verbal communication

pre-empt: forestall, anticipate, obstruct, block, prevent, avert, det

NB: who out of the older architects talks about this kind of thing? (politics, etc.)

- "You've got to pre-empt that. You've got to say, *"well hang on, does that mean you're going to be delayed? Yes so how do we prevent that?"* And that sort of thing. Because more often than not the contractor will be in a delay situation but reporting that he's not delayed, and then looking for an excuse to hang that delay on, so you have to be a little bit pro-active and that's the politics. So that really only comes through experience, unfortunately. You have to be in meetings over and over again and start to recognise patterns."

provocations!

→ experiential knowledge.

implies that All consultants need to show/put together an image of a united front/unity/agreement/harmony to the client → again for ADDED TRUST?

- "You can tell someone about it [in the manner of teaching 'someone' to learn the pattern.] You can go, *"that's what they were trying to do,"* and that will be their, *"OK I've got that one. That's learnt for the future."* But that's the politics. That's the other thing, is that meetings are different. If you can have a meeting with the contractor and say, *"right, where are we, really? Be honest, be straight, sort it out between you and the contractor and with the other consultants,"* so that when the clients are there, the last thing you want to be doing is arguing between the consultants about whose fault it is. You don't need to report whose fault it is, you just need to get it resolved and move on and the client doesn't want to know. He doesn't want to know. He doesn't want to hear us bickering. So it's managing who attends meetings and things like that. If I don't get a choice; the meeting will always involve the client; I will turn up an hour earlier and sit down with the contractor and say, *"where are we?"* You know *"well why is it like that? Can we resolve it? Does the client... Well is it going to affect the end date? No, right then does the client need to know? Shall we deal with this now?"* Because the client's got a lot to worry about, he's getting a building that he then has to fit out and make work, so he's got other challenges. He's got other stuff that we're not aware of. This was a hospital the one; the one that I spoke about earlier, so he's not just got that; he's got all of the examining boards that have got to come and look at it, he's got to worry about. The last thing he wants is us arguing about where a damp-

be Honest! be straight!

→ suggests that this kind of thing is repeated frequently

key words → arguing - bickering!

Use of the word 'bickering' implies a child-like attitude/immature

→ unanticipated events > experience shows that perturbations of this type are not abnormal + that it is probable that they will happen.

Design vs. design-and-build

proof course goes on some brickwork. Just… *"it's dealt with…"* So that's the politics; it's not heavy politics. Simple politics." – subtle intonations?

- "We had a structural engineer and a service engineer who happened to be the same company. They're kind of two wings to that company, all working together for the design for Client A. Client A accepted the design and then it became a design-and-build. So Client B became the client and we were now reporting to them, so we were then their architect, so we stopped dealing with Client A. So we only deal with Client B and the same with the structural engineer but not the services engineer. Client B have their own services engineers called Imtech Meica and they said, *"right we don't want you anymore; we're going to use Imtech Meica,"* so there was a little bit of bitterness there. And because the structural engineers are part of the same company of the services engineers that lost that bit of the job, there's a little bit of bitterness and so we have to kind of make sure that we've got all of that sorted out before we sit down in front of the client. And so that's when it all gets a little bit bitter. And then you go to Imtech Meica, *"have you got such and such?" "Well, no we haven't been given it from the previous drawing… design…"* and it's where do those boundaries end? And you end up with these silly little arguments over nothing that can take half a day to resolve. You pick up the phone and go, *"look you're being stupid. Can we not just do this?" "Well yeah I suppose we can."* So sometimes it takes you a while before you realise that there's a challenge there; there's a problem there. It normally starts off as an ordinary email and another one and another one another one. You suddenly realise you're getting more emails, which I hate. But pick up the phone and go, *"what's the problem?" "Well there isn't a problem." "Well let's stop messing about.""*

bitterness x resentment/ acrimony/ unpleasantness/ sullenness/ hostility ↓ in the professional relationship.

presenting a unified agreement kind of front to the client.

additional burden of problems in addition to the expected ones!

- "You do get challenges with services engineers. We have a very similar one on the Royal Automobile Club. The M & E Engineer will not do any additional work without charging for it, and what we would consider 'design development' he considers 'additional work,' and the client's reluctant to spend more money. It's just that he's spent millions of pounds getting it done. Why should we spend thousands more? So you need to sort of say, *"Come on… just… OK, go to the manufacturer and get him to work with that…"* So we do get that sort of thing. But it's all doable. It tends to be what you tend to bring to the table. If you come with a good attitude generally it's going to be fine. But if you come with a bad attitude, it's the most horrible meetings in the world."

Non-routine problems!

non-routine [contingencies!]

different understanding/ interpretations of the design process + what each stage entails. Either: a) difficulty because the engineers don't understand the iterative nature of the design process [their work is a lot more linear!] OR: b) more political games to get more money out of it!

- "Because we work on big contracts, the majority of the contractors are older people. Because the contractor's going *"I'm not putting someone without experience on the job this size; we can lose too much money,"* which makes sense in the building industry, because experience counts as much as any qualification. But ***in architecture*** the principles of building haven't changed much. You've got to keep the weather out, you've got to keep the air circulating, you've got to keep the light going. It doesn't change perceptively; dramatically. However, there are the principles and then there are the modern products that you have to keep up to speed with, and there's traditional stuff which kind of is always there but it's not always covered as well as it should be. So it doesn't take long if you've got a youngish architect, who is working on a big job; a multi-million pound job, all the

continue

lack of trust → AGE!

so it is a lack of understanding of what the architectural discipline entails that leads to a lack of trust!

CONCEPT: ~~other~~ [INCORRECT PERCEPTIONS]

Consultants' lack of understanding of the architectural discipline contractors are looking at them and [saying/thinking] ***"this youngster's trying to tell them how to do their job."*** Their back goes up a little bit. It's… ***"don't start telling me how to do my job!"*** Well he's not trying to tell you how to do your job; he's telling you how he's designed the building and, *"would like you to construct it in this way… if you wouldn't mind?"* But that's not how it comes across. That's all it's about. I don't think they perceive them not having the knowledge. I think it's just that on the big jobs they don't expect young architects to be doing it, and there's no reason why they can't, because you're not expecting them to build the brick wall; you're not expecting that. You've just got to know how it all goes together."

incorrect perceptions leading to a lack of trust!

- "We as a practice at the moment tend to employ Part 1 students; people who have done the Part 1 of the architectural degree: I disagree with that. I think we lack technicians, and there are the Institute of Chartered Technicians… or Chartered Institute of Architectural Technologists I think it's called. These guys learn the technical side. They're not architects; they're not going to be architects, but they love construction and all of that. Well it used to be you'd have an architect and a couple of technologists or technicians. They used to be called technicians or technologists, and they would do the door schedules; they'd do your junction details and things like that. So it would free you up to keep you on the big picture. We don't do that so much here, and I think it's a failing, because I spend too much of my time trying to explain to people who are just out of their Part 1 what a damp-proof course is and where it goes and things like that. That's great for them, but it's not great for the practice because it's wasting *my* time, whereas if we employed technologists they would know all of that. But the more they study, they spend more time doing that, in fact, they would probably be able to know more than on *me*, where I am going wrong with my cladding and things like that."

Students just out of their Part 1 do not have the knowledge! [practical knowledge]

Divergence in the architect's speech. The 'energy' person is seen as just another consultant!

- "They [technologists/technicians] do energy; in fact they're probably better than us. It depends on how far on their education route they go. It's the BTech, HTech, and then they can do a Masters; things like that through the Chartered Institute of Architects; C-I-A-T I think it's called. So they can do all of those. The one that I used in my last practice, she was doing her Masters predominantly on concrete structures. And what she didn't know about concrete; she's brilliant. So it was great, if we had concrete buildings *"you just go use Jacqueline,"* and you worked with her and you'd come away learning stuff. It's brilliant. But then she took the job seriously. She was a technologist and therefore wanted to know all of the technology that involved construction."

using age as an excuse

- "That nowadays sort of is a blurred edge where that [technology in construction] ends. It certainly involves heat loss and heating systems and it certainly involves renewable sources. Your carbon footprint and things like that, which I'm probably getting a bit old to try to get all of that on board into my little head these days."

concept: reason(s) for lack of uptake of simulations in the architectural design process.

- "Because we get models done by our service engineer; heat loss models and things like that. It's just a black art to me. It's like being in the front row of the scrum, in which are constantly subject to continual change.

CONCEPT: Poor understanding/ lack of understanding/ lack of appreciation of the uses/ advantages of simulations by architects.

Doesn't understand any of it / what's important to him is the 'end result'.

rugby. You know stuff's going on but you don't know what's happening. But you get the end result!"

- "I've got service engineers that will do that [sustainability/energy-efficiency in buildings] for me. So I don't have to try and pretend to be clever. But it's just too late for that to affect my architecture. Whereas if I was younger, it would affect it if I was younger. The whole 'energy thing' would be affecting my architecture 'cause it's such an important thing."

attitude / true/false attitude(s)

Age as an excuse / Does he link understanding + using simulation with being 'clever'? Or is this just a figure of speech?

- "There are youngsters who hopefully I will get that buzz off of. And if I was to look at a building; a new built, then maybe I would sit down and say to the guys, *"look we've got to make this innovative; energy-efficient."* Not that I wouldn't be getting that from a services engineer because that's their bread and butter." That's their job.

*Consultant's practice size has an effect on collaboration between architects and simulationists?

Large practices (consultants) are:
- pre-emptive
- proactive
- they don't wait for my building to be designed.
- they want to be part of that [design] process

- "Akon are the current ones I'm using a lot at the moment. They are very good and… and not only that **but pre-emptive.** They actually kind of say, *"we need to have something along these lines because…" "alright, OK; how will that affect what I'm doing?" "Well we've looked at this, we've looked at that, and we think that if this is really what you're looking at for the building then this will work…"* So they are very good. They are the bigger practices."

- "I don't know what the smaller practices are like. They'll probably be more so because they're smaller practices, so they've got to be sort of more innovative. But I think of the bigger practices I'm certainly getting the feeling that they are proactive rather than reactive. They don't ***wait*** for my building to be designed. They want to be a part of that process more than they used to because it's such a big element."

i.e. whether simulation becomes part of the design process relies on whether the simulationists WANT to be part of the process. And when they WANT to be part of the process, then it is likely that the architects appreciate their presence and value them more hence; "so they are very good." [predicament from the architect's opinion/judgement/attitude/outlook.

Q- **

compare/ put this on the scale [RIBA stages]

- "Well talking about consultants; when do you start approaching a consultant to work on a project? Again I'm talking in terms of energy. Almost straight away. Yeah. Almost straight away, yeah. Which it never used to be. It used to be [that] I would design my building and then go to the services engineer and say *"right, service that." **Now*** it seems to be almost straight away. At this practice this time round, I've not been at a job where they have not been around right at the very beginning."

Presents 2 scenarios. Before + after. What is it that has sparked this change?

the architects have more work to do to be able to work effectively with the consultan

"Q-Right. And how's that changed things, or how has that improved things? I'm supposing it has improved things?" A- I mean, what I'm having to provide is different already. Now there's more to get in, because there's more processes being done. But it does mean that we can kind of work together to put them in different areas and make more exciting spaces out of spaces that would have been a little bit more bland. So yeah I think it's a ***great*** improvement."

- "I was talking to an engineer and he's a young lad [who is] looking to set up on his own but with an architect, because he wants to offer the whole package; the structure and the architecture. And I was saying to him, *"if you're going down that route you might as well put the services in as well, if you're going to do the whole thing,"* because services have a ***far*** greater impact now on the building than structures. Structures are relatively simple in terms of its effect on the environment, if you design in steel or in concrete, you know, whereas the services are just so fundamental."

→ attitude > expresses and describes that 'the services are just s fundamental."

- Q-"I'm wondering if you have sort of an understanding of how the energy consultants work? How these 'simulationists' work?" A-Yes I do; in so much as I know what they are looking to do. I understand the whole principle of cooling in the building in summer, and keeping it warm in the winter, and trying to minimise the impact of either of those on the amount of energy that we're creating; or we could be using. I also understand that there are various processes that we could use to both heat and cool the building that are passive."

- "A good service engineer, which we are lucky to have I think, will start discussing that [reducing the impact of the building on the environment and energy-efficiency] quite early towards; in the building [design]. It will affect the architecture."

→ expresses a difficult in understanding all the 'sustainab ility-stuff.'

- "I'm struggling to take all of this [sustainability, energy-efficiency, passive design] on board. And I think that's why it's a young man's [job] saying they're doing it at university talking about the environmental impact and the heating. And where the heat loss is going and where the energy's coming from. I wouldn't say I know it well; I don't know it particularly well. We certainly get a model done of everything; of every job that we do, and I do tend to query it. I don't just kind of go, *"OK that's it..."* Because sometimes they will just default the stuff, and I actually think it's nice to try and improve on what they're trying to do; on what they've done."

a 'young man's job' → the factor of age

Q-are younger architects more likely to adopt simulation in the design process than older ones?

→ trying to portray a more positive/ active/ pro-active attitude

→ practice's policy / belief system

- "So bring my knowledge into it and say, *"actually, well look, this floor slab; we can increase... because we're doing this, this and this... and how about we did this?" "Yeah, OK."* And so that all helps. I'm really conscious of the fact that we need to model these things well so that they're efficient as possible, but there is a tendency with your ***clients*** to say, *"Well I only want what I need to achieve..."* I think we have a duty to try and improve on that I think. Working with a service engineer I think can be a little bit sneakier, and you don't have to mention that you're doing better. As long as you're doing what you're saying needs to be done. I think we have a duty to future generations to try and do what's got to be done."

concept → clien affecting the adoption + use simulation in th design process.

attitude!

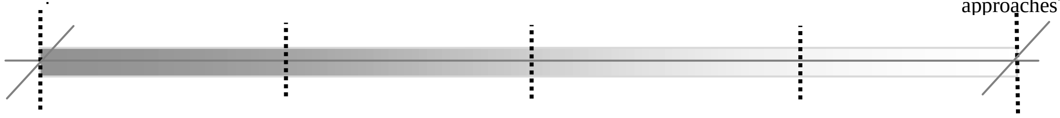
- "I do take it [sustainability in building design] responsibly, but I do accept my limitations and I do listen a lot to my service engineer because of that."

CATEGORIES FROM OPEN CODES

CATEGORY 1: CONSTRAINTS

POSSIBLE RANGE OF PROBLEM-SOLVING APPROACHES IN BUILDING DESIGN; RANGING FROM MOST CREATIVE TO LEAST CREATIVE.

? Numerical approaches?

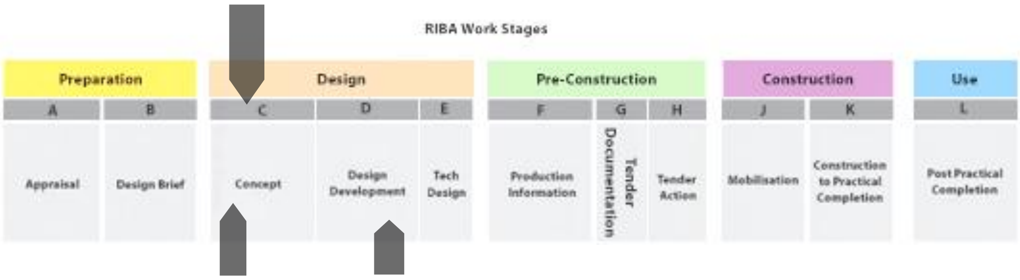


Most creative Least creative

CATEGORY 2: WHEN IN THE RIBA STAGES SHOULD SIMULATIONS BE DONE?

NR:

Literature – that simulations are most beneficial at conceptual design stage **(REF. NEEDED.)**

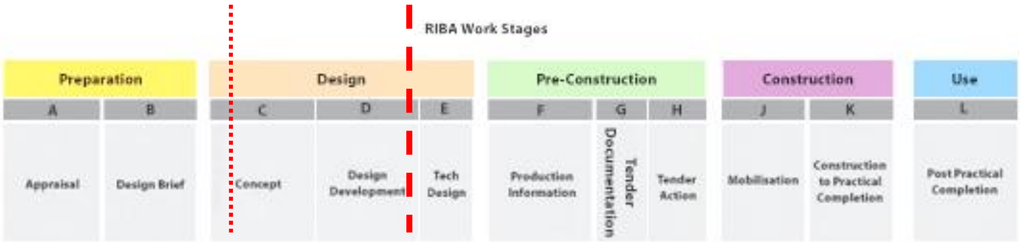


NR - *"there's no reason why that [simulations at early design stage] can't be done, other than the client's reluctance."*

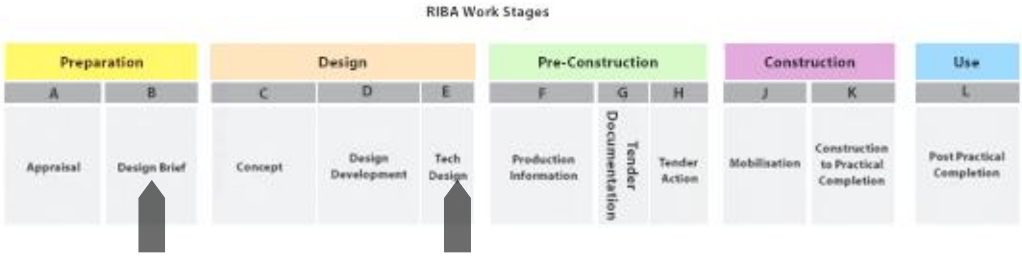
Client – *"it's rare that we get the opportunity to work with a simulationist before we make a planning application."*

Proposed/actual

When it should be done acc. to literature



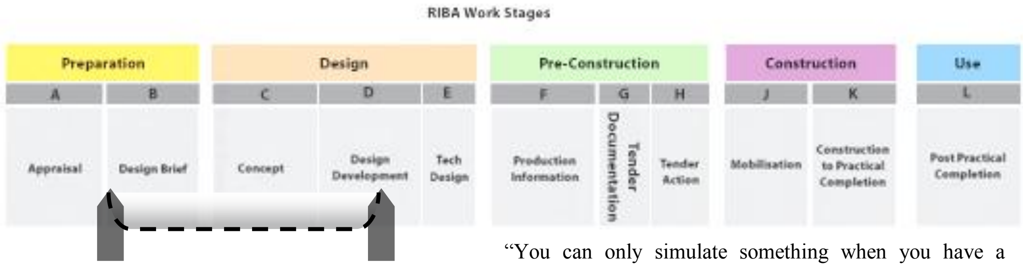
When it should be done acc. to NR When it is actually done.



PMB- [Currently] a consultant is brought in *"almost straight away."*

PMB- Prior to that, the architect would finish the design of the building, *"and then go to the services engineer and say, 'right, service that.'"*

<u>MB:</u>



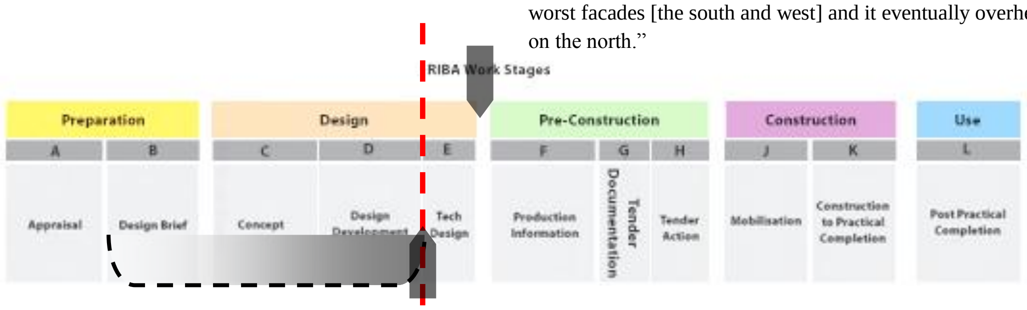
<u>MB–</u> "I think it depends on the project but to a degree quite early on."

"You try and bring on other consultants; perhaps on a free basis, free advice before the client employs them."

"You can only simulate something when you have a design to simulate. So it depends on time-scales. Perhaps there are certain time-scales to do the design, simulate it, adjust it, change the design…I think time-scale."

<u>SP:</u>

<u>SP–</u> "We asked for the consultant to work to stage E and really do a properly detailed design, and the client didn't want to spend the money. So when they did the modelling they only did the two worst facades [the south and west] and it eventually overheated on the north."



<u>SP–</u> "Because the services industry has changed, services consultants are often engaged maybe up to stage D where they do enough as design development"

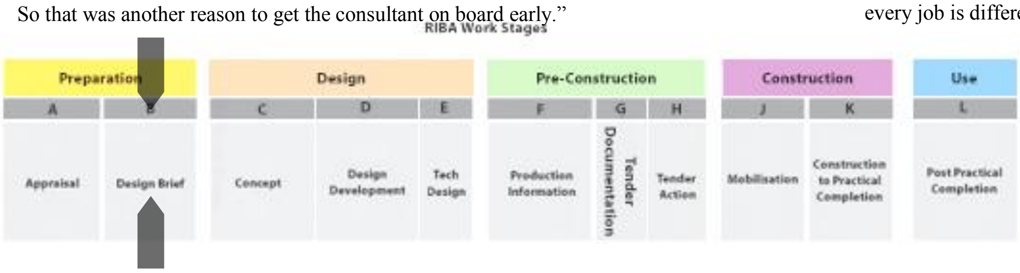
<u>NB – IT'S NOT ONLY ABOUT THE STARTING POINT OF THE STAGES; IT'S ALSO ABOUT WHEN TO STOP!</u>

<u>DEPENDS ON THE BUILDING PROJECT: e.g. this participant talks about designing a 'all-glass building;'</u>

<u>2 reasons to get the consultant on board early:</u>

<u>SP–</u> "One of the drivers is that planning often asks for various sustainability measures, or values to be met and they wanted forty per cent over Part L, BREEAM Excellent rating and a sixty per cent score in the water section of the BREEAM section. So it's a planning document. So that was another reason to get the consultant on board early."

<u>SP–</u> "The problem is that every job is different."



<u>SP–</u> "They [M&E consultants] were hired quite early on actually because we're doing a very big glass box…so we had to argue that, with all that glass, overheating would be a concern, with solar gain."

<u>SP–</u> "Because we got them on board early has meant we've been able to get the two innovation credits for BREEAM that you can get if you appoint someone early."

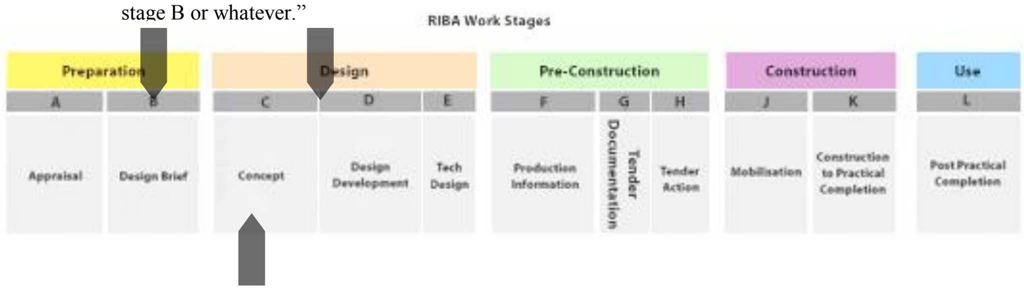
<u>SP–</u> "We try to get in early on the appointments 'cause we would ideally always want the services consultant to pick up as much modelling as they can.. The way things are written and appointments; they'll allow for modelling and there will just be one or two options. And what we tend to do as architects is design and redesign and redesign…you've got to pick a point in time where your ideas are suitably established, and aren't likely to change too much."

IT ALSO DEPENDS ON THE MODELLER/SIMULATIONIST:

SP– "You also need a really pragmatic consultant that understands not to race ahead and model a whole building, and to start to establish the principles of it; how much glass can you have? The amount of shading that you need? The type of plant that you're going to put in? Heating and cooling strategies; those sorts of things."

CS:

CS– Currently services/M&E consultants are brought in at "stages C to D or whatever. You need them on earlier; stage B or whatever."



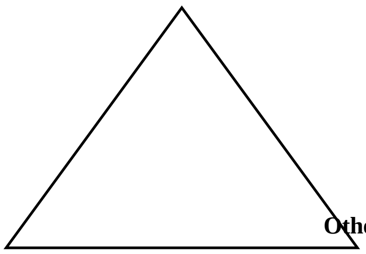
CS– "I guess [we are talking RIBA stage B] yeah, 'cause depending on how you look at it, A is normally about preparing the brief, but B and C are really where you start the very first …initially doing the site analysis work…the very first bits of sketching that you do…so it kind of gives you an indication early on."

CS– relates more to the kind of **concept, inception stages** of the process, so it looks at things like where you position your building, orientation, depth of plan, ratio of glazing, all those kind of things that architects do intuitively."

"It's to give them something to use right at the beginning of the process."

CATEGORY 4: COLLABORATORS WHO 'MAKE THE BUILDING WORK'

The architectural team



The client/client representative

Other consultants:

Project manager, Quantity surveyor, Structural engineer, Services engineer, Sustainability consultant, fire consultant, interior designer

CATEGORY 5: WHAT PROFESSIONALS SAY ABOUT 'CREATIVITY' IN THEIR WORK

QUOTE	COMMENTS
***"Creativity** comes from a response of everybody else around the table."*	Group-effort. Inter/multi-disciplinary effort.
Architects are enabled to be creative through *"challenging constraints...they will challenge ten constraints on a project; nine of them will remain and need to be exactly how they need to be, but there may be one that actually isn't that important after all, and suddenly it opens up a whole new opportunity and that's what your design hangs on..."*	
"I'm probably more in the sort of technical side than the ***creativity*** *side."*	Therefore, the 'technical side' does not involve/include creativity?
"I don't necessarily analyse everything I do in finite detail. From a creative point of view, I view it as more intuitive than following a formula."	Creativity is linked to intuition rather than following a formula.
"If you've ever been to a…you know you must have spaces that you've gone to that make you feel 'oh this is wonderful;' that's all about good design and creativity…builders like to do square boxes and 90 degree angles and things 'cause that's the most simple thing that they understand."	Good design is linked to creativity Creativity is less linked to conventionality?
"We're more of a creative profession; art-base than…than science-base."	Creativity is linked to art!
"If you haven't got any design ability or artistic ability then you haven't got creativity to express that kind of thing, really. You'll end up probably just reverting to technical solutions to design problems as opposed to creative, artistic; wider issues on design."	Design ability/artistic ability = creativity/creative expression. Technical solutions – the opposite of creativity.
"Clients come to architects with the design ideas. They don't come to technically…'give me a technically-workable building.' They want your ability to think outside the box and come up with creative ideas; that's going to give him something that has value."	*Creativity leads to novelty in design ideas – has an elevated status rather than just a 'technically-workable building.'*
[Technical observations] would somehow hinder it [my creativity] a bit."	*Technical ability – form constraints – reduce creativity.*
"Just have an A- average or better doesn't necessarily mean you're going to be any better as an architect, 'cause creativity is often driven by other things, isn't it?"	

CATEGORY 6: DIFFERENCES BETWEEN ARCHITECTS AND ENGINEERS

CONCEPT	ARCHITECTS	ENGINEERS
Problem-solving	"There is something more than that [a problem to solve] that is inherent in particularly building projects."	"Some engineers will only approach things as a problem to solve, which is fine and that's a legitimate way to approach a construction project."
Nature of the process	"you [an architect] could do it an infinite [amount of time]; loads of times."	"other consultants…it's [a] much more linear [process]; they're much more so on "we'll do this and then"…they assess it once and that's it.
Professional Environment	"Architecture is a much more self-contained environment. If we want something changing we'll do it [ourselves] and we'll do it now as opposed to when someone in some department elsewhere is available to do it."	N/A
Speed	"As architects we're very quick. We're very much more efficient about changing drawings and designs than our consultant colleagues."	N/A
Working Process Structure	N/A	"They're much more structured in the way that they produce information."
Active/reactive	"It's [architecture is] a very much more reactive model than the other consultants."	N/A
Definitive answers	"Whereas at times we don't necessarily know. We haven't necessarily decided what the façade is, or what the roof is, or anything like that.	"I think engineers are generally after a much more definitive answer as to what the building is. 'What is this? What is that? What is the performance of that?"
Levels of certainty	"Because we don't know!" Well today we say "it's this." Tomorrow it may be different.	[To them] "it's about inputting information into the program, [so] they just need these figures and materials and everything which…you can generally probably give them what they want. So they must be very frustrated in terms of 'well why can't you tell us what it is?" …whereas they can't take that sort of uncertainty.
Certainty vs. change	"We change the design a lot."	"They've assessed the design on 'today.' "What do you mean it's changed tomorrow?" They don't like change.

CONCEPT	ARCHITECTS	ENGINEERS
Flexibility		"I don't think they have a very flexible way of working with architects."
Observation of the building	"We think upon it as a 3D form."	"What they need is a very cold and technical thing…they just think of it as data to a degree."
Complexity	"They don't appreciate the complexity of the building."	
?	n/a	"They're much more…just factual."
IMPLICATI O-NS	"We probably think more about all the implications of things rather than…" "Whereas we think in terms of the implications of what we're doing; of what they're doing on the final building and how it's used, and the implications on the tenant, the landlord and when he's using it."	"…we want information so we can work out whether it can work or how it will work," or "we need the data just to complete the calculation.
		"they have their linear process, they have much more factual needs than we do."
Questioning	"We have to interrogate them and ask them a lot of things; to question what they're doing; what they're actually trying to end up; how they're going to interface the building."	"Sometimes they haven't thought through how it's going to work in the building. The system works or they have an idea of how the systems work, but I don't think they generally think it all the way through."
Delivery		"They only seem to design the schematics and the systems; they don't necessarily think about how it's going to be delivered yet."

CATEGORY 7: WHAT PROFESSIONALS SAY ABOUT ARCHITECTS' [ARROGANCE] - EXPLICITLY

OPINION
*"People think that architects are **arrogant...**because they're constantly challenging and asking questions...which is why clients hate architects"* and *"people think that architects are arrogant."*
*"Architects are slightly **different to everybody else."** – implies/gives an air of elitism!*
*"The modeller is just **a slave** doing some stupid work – I'm talking as an architect... I feel that my work is just **required,** but not **necessary** to them." SOMETHING MORE HERE!*
*"Sometimes **pride gets in the way** I've noticed around here* [among architects]; *they don't like to ask."*
*"It allowed you to be...you know 'designy' and all the rest of it and...**pretentious."** "A lot of schools of architecture think they can get away with...the lack of technical stuff, and they do it in a way of making it seem like a trendy thing to do...somehow we're more **intellectually superior** if they just teach students how to talk basically...**the philosophical talk."** "They convince themselves as if they've got some **deep intellectual thought** behind what they're talking about...and if you try to challenge it you get accused of being somehow **narrow-minded."***
"It's about perfection I suppose...some [architects] *are very **perfectionist-driven."** "I think a lot of them have **egos**...and I guess that's* [come from] *wanting to be a leader...leading a team of design and being* [viewed as**] *the most important person*** *by the client **in the room.** And historically architecture has been that way. **It was about the architect making all the decisions."***
*"I mean, **architects are considered to be arrogant,** etcetera etcetera, but they do tend to have a better overview, probably 'cause they have to."*
*"I think to a certain degree it's true. **Architects are arrogant.** That's not necessarily such a bad thing."*
*"In the world of design, trying to come up with a great idea or whatever…**there needs to be a certain level of arrogance anyway to push through a great idea."***
*"There's the perception that **architects need to be arrogant to push through an idea,** and sometimes they don't need to be. **They need to be creative and not so much as arrogant. But there's also a certain point that they need to be strong in keeping a hold of their idea**s especially when the process starts, because then there's a whole load of opportunities; all sorts of barriers for things to be watered down; right through the cost of things and practicalities and services and all of that."*
*"Also there's something to do with the way architects are trained they think they're trained to think that they're great creative people and architecture school; seven years or five years of it. It's all about design and philosophical thinking and talking in a certain way and **I think there tends to be a lot of arrogant."***
*"Architects don't get paid very well. So I think they make up for it by thinking that it's lucky that they live in this great design world. **After a while they become slightly bitter about not getting paid very well. And that makes them compensate by being more arrogant."***
"I've worked as you know at Grimshaws, and there were lots of arrogant people. And quite often the higher the [architect/profession] or the more famous the practice was, the more [arrogant they were].
"Obviously 'arrogant' is a difficult word to use** but to a certain extent perhaps it is a little bit necessary, and it goes with…architecture's not just about practical construction is it? It's about design as well. **And in the world of design, if you go into fashion design or anything it [arrogance] will be there and it leads towards there as well."

	OPINION
LITERATURE – L. BARROW 2004.	*"Formal architecture has traditionally been **an elite activity isolated to the rich and the ruling; today's modern architect is a product of this evolutionary heritage."*** *"Architects are often educated and trained in **a culture of individualism** and subjective aestheticism which often **obscures** broader inclusive issues of mass society."*
LITERATURE – HOORN J. F. Et al. 2010	*"Architects rather **stay in control** and are not interested in automated or intelligent support."* *"Perhaps they wish to **remain in the driver's seat** and do not fancy the idea that a system manipulates and processes architectural knowledge independently."* *"We suspect that architects are a **bit frightened by the idea that smart automated tooling would take over their roles.** Architects want to sit in the driver's seat and have a **tight control over all processes."***

CATEGORY 8: ARCHITECTS' ATTITUDES [AUTHORITATIVE/SUPERIOR AIR] – IMPLICIT

"I will employ; or we will employ as a practice a good service engineer that will allow the right temperatures and everything for me to produce a lovely space; then he's done his job," conveying an authoritative, superior air rather than one of co-operation, teamwork and mutual aid.   In particular, the phrase *"then he's done his job"* suggests to me that he considers his job to be particularly solution/stage-specific, rather than being a role that evolves and continues/contributes cyclically with the iterative nature of the design process.
I don't think they [engineers/energy consultants'] *have a very flexible way of working with architects. And I think they probably need to change 'cause we're not going to!"*- Implies an air of superiority and confidence.

CATEGORY 9: LACK OF APPRECIATION OF THE BENEFITS OF SIMULATION

OPINION
He does not find it *"fun;" "I seem to be losing the fun side of architecture."*
He repeatedly describes it in reductionist terms *as **"a paper exercise"*** or ***"the paperwork exercise,"*** implying a sense of bureaucracy which is characteristically tedious and rigid.
He feels that *"too much emphasis at the moment is put onto the architects to create"* sustainable buildings that create comfortable environments through *"BREEAM and all these other bits"* that make *"architecture… to become a paper exercise,"* and that he *"feel[s] sometimes that it detracts from what real architecture is about."*   Use of the word 'detracts' [synonymous with diminish, lessen, reduce, weaken, undermine] suggests that he somehow feels that this kind of work is below the work of architects.
He explains that while he fully understands the importance of sustainability, he feels that *"it doesn't have to be all about this;"* pointing to a large document created by an engineer servicing a leisure centre.

CATEGORY 10: DO ARCHITECTS FEEL THEY UNDERSTAND WHAT SIMULATIONISTS DO/WHAT SIMULATIONS ARE FOR?

Y/N	WHY
N	He shows a report documenting the servicing of a leisure centre project he is currently involved in. He expresses that, *"it's got loads of really clever interesting stuff."* However, if he is asked whether he understands it; ***"I don't!*** *I do not understand it."* And therefore he finds that there *"is a reliance upon the service engineer, to understand what you are providing."* In another instance, he explains that *"heat loss models and things like that; it's a black art to me. It's like being in the front row of the scrum, in rugby. You know stuff's going on but you don't know what's happening."*
Y	The participant illustrates his understanding of what he thinks the roles of engineers/simulationists encompass – that it is primarily *"to quantify;" "generally, you need an engineer to demonstrate all of that* [energy, Part L and sustainability] *and quantify it."* On the other hand, architects deal with many facets of building projects; not just building design, e.g. admin work, financial aspects, etc. which also demand "quantifying." – QUESTION: WHAT IS IT ABOUT SIMULATIONS THAT THEY CANNOT HANDLE?
-	*"You need to know and understand how the technological aspects of your building are going to come together before you start applying for planning."*
Y	*"Help designers make the right kind of early decisions like where to place their buildings, how to orientate them, what the depth of plan should be, percentage of glazing, what the mix of renewables might be or other sources of energy provision and so on."* *"Certainly the more detailed work* [is the work of engineers]; it involves a huge amount of input, or a far greater input than IES and so on." *"Service engineers…they understand the whole language."*

<u>CATEGORY 11: TRUST AND HONESTY ISSUES; POLITICAL GAMES AND NEGATIVE ATTITUDES IN THE WORKPLACE</u>

QUOTE	EXPLANATION/IMPLICATION
“The manufacturers need to be doing their bit, and be <u>**a bit more honest**</u> about it.”	Implies that he [the architect] does not always trust the descriptions and specifications that manufacturers label their products; descriptions that their products are sustainable.
<u>**“If**</u> the services engineer does his job.”	Use of the word ‘if’ shows that it is conditional, and implies that the services engineer does not always do “his job.” – the problem here however may be that the architect does not fully understand what the engineer’s ‘job’ is; what it entails.
“So rather than being able to <u>***trust***</u> everyone, you have to be able to sit down and have to do this kind of great exercise of <u>**proving**</u> that your building is sustainable.”	
“I expect him [the services engineer] to work with me. <u>**But there’s got to be a trust there.**</u> I’ve got to have <u>**an expectation**</u> that he will do his best.”	It is fairly normal/expected that there should be an element of trust between architect and services engineer, and the fact that the architect needs to emphasise that he has to have *“an expectation that he will do his best”* suggests to me that he does not always trust the services engineer; that in his opinion, services engineers to do not always do ‘their best.’
“So it’s just about <u>**being honest**</u> with them.”	n/a
“But the contractor was blaming her [the architect] for delays, and the client was <u>**losing faith in her.”**</u>	How the contractor-architect affects the client-architect relationship, resulting in the client ‘losing faith.’
“It was <u>**a political game**</u> that contractors play.”	Contractor-architect; ‘game’ implying that it has rules; implicit and subtle; it’s just a matter of **“hitting them in the right way.”**
“I always taped my meetings. I did so openly, so it made people <u>**a bit more honest.”**</u>	n/a
“So that’s the <u>**politics.**</u> It’s not heavy but it takes a while before you realise…”	n/a
“You’ve got to <u>**pre-empt**</u> that.”	Synonyms of ‘pre-empt’ > forestall, anticipate, obstruct, prevent, detect, etc. He uses further provocations to elicit what he wants to make clear in meetings; “well hang on, does that mean you’re going to be delayed? Yes, so how do we prevent that?”
“If you can have a meeting…and say, ‘right, where are we <u>**really? Be honest, be straight,**</u> sort it out between you and the contractor and with the other consultants.”	n/a

QUOTE	EXPLANATION/IMPLICATION
“When the clients are there, the last thing you want to be doing is **arguing between the consultants about whose fault it is.”**	n/a
“He [the client] doesn’t want to hear us **bickering.”**	‘Bickering’ implies a child-like attitude, of immaturity. This is further supported by, *“whose fault it is.”*
“So that’s the **politics;** it’s **not heavy politics.** **Simple politics.”**	Implies subtleties – practitioners need to be able to read between the lines.
“Client B had their own services engineers and they said, ‘right, we don’t want you anymore…’ so there was **a little bit of bitterness** there.”	Synonyms > resentment, acrimony, unpleasantness, hostility.
“There’s **a little bit of bitterness** and so we have to kind of make sure that we’ve got it all sorted before we sit down in front of the client.”	n/a
“The contractors are looking at them and [saying/thinking] **this youngster’s trying to tell them how to do their job. Their back goes up a little bit.”**	Lack of trust due to stereotypes, prejudices and misconceptions about the age of the architect > contractors’ assumptions that a young architect will be less knowledgeable and trustworthy.
“It tends to be what you bring to the table. If you come with a **good attitude** generally it’s going to be fine. But if you come with **a bad attitude, it’s the most horrible meetings in the world.”**	n/a
“Because we work on big contracts, the majority of contractors are older people. Because the contractor’s going **‘I’m not putting someone without experience on a job this size;** we can lose too much money.”	Lack of trust due to stereotypes, prejudices and misconceptions about the age of the architect > contractors’ assumptions that a young architect will be less knowledgeable and trustworthy.
“Working with a service engineer I think I can be **a little bit sneakier,** and you don’t have to mention that you’re doing better. As long as you’re doing what you’re saying needs to be done.”	n/a
The design team has “to put a sort of **unified front** on how to present something to a client.” The client “needs some sort of comfort to know that energy and Part L has been considered and sustainability.”	n/a

CATEGORY 12 : STEREOTYPES/STEREOTYPICAL IMPRESSIONS/BELIEFS

STEREOTYPE DESCRIBED	CORRECT[ED] UNDERSTANDING
Contractors do not trust younger architects, because they hold the belief that, *"in the building industry, experience counts as much as any qualification."* Contractors may hold incorrect perceptions of what younger architects are capable of.	Whereas, *"in architecture, the principles of building haven't changed much. You've got to keep the weather out, you've got to keep the air circulating and you've got to keep the light going. It doesn't change perceptively; dramatically."*
Non-architectural members of the building/construction industry may incorrectly hold the perception that what the architect is meant to do is to *"build a brick wall…"*	Whereas the architect "[only] got to know [is] how it all goes together.
"Historically architects have a very high failure rate because of their commitment to their job, and architecture's viewed as their… another wife or mistress or whatever…"	n/A
"You only have to look at the stereotypical architect…and I've got a black shirt on myself but I mean I've barely… I'm fairly conservative…but you know you just have to go in the shop over there [RIBA bookshop] and…she just came out looking pretty cool. Do you know what I mean? If you went into the CIBSE, for example, you'd get a different type of people."	N/A

CATEGORY 13: SHOULD ARCHITECTS BE DOING SIMULATIONS THEMSELVES?

Y/N	WHY	QUOTE
N	Lack of skills/ability	Because they don't have *"the right skills"* and *"the ability to do it."* Because architects *"loathe the risk associated with everything you do and without the right ability you would be putting yourself at risk by trying to attempt to do it without being able to do it properly."*
	Not the architects' logo.	It is not the architects' *"logo,"* and *"everyone wants a sort of logo"* these days.
Y-conditional	Improved speed and efficiency in the design process.	*"I think if we had the technical ability to do it, we should be doing it because we could then explore different options quickly…if you had the right skills you could set up various designs and do it very quickly.* *We're…as architects we're very quick…we're very much more efficient about changing drawings and designs than our other consultant colleagues. They're much more structured about the way they produce information."*
Y	Not the architects' logo.	*"That start[s] to challenge the art of what an architect is and what the architect does…I don't know how you would go about doing that, but I think eventually it would be something that architects will need to understand."*
N	Different ways of handling constraints.	*"Architects are trained to have a creative thinking that challenges constraints and pushes aside constraints."* SO: *"If you took an architect and asked them to be trained as a simulationist, then they would pick up the simulation tool and start challenging it; you know 'why has it got to be like that,' … and 'let's try and do that…' which may lead to some wonderfully creative simulations but possibly not the right solution."*
N	Not enough time	*"The time we have to detail projects seems to be slipping aside; the time we have to detail projects seems to be reduced because of the demand for time; you're spending more time doing the paperwork exercise…rather than being able to trust everyone you have to be able to sit down and have to do this kind of great exercise of proving that your building is sustainable."*
N	Qualifications	*"No I don't think we're qualified to do it…if we were to do it we would just be getting it wrong."*
	Architects do not understand how the software works	*"There's cheats within the software, because you can basically just elevate the performance of all the bits of kit…if you run the software and start to fiddle the figures as it were…you can get that to work."*
		"It would be dangerous in our hands."
Y-conditional	If it is early stage – to help them make more informed decisions.	*"[Climatelite] – software – it's to allow them to do some sort of simulation right at the beginning. If they themselves could do so."*
N-conditional	If it is later [detailed] stage – because it involves more input.	*"It's not really saying 'oh architects should be doing simulation themselves;' and certainly the more detailed kind of work…it involves a huge amount of input, or a far greater input than IES and so on."*

Y/N	WHY	QUOTE
N	Busy - time	*“Partly because they’re very busy, so they’ve got a huge amount of things to look at anyway, in terms of the concept, the detailed drawing, the structural drawing and managing the whole design process.”*
N	Training/qualifications	*“They’re [architects] not trained as building scientists, whereas service engineers are. So they understand the whole language. So I think architects, if they were to do simulations themselves, would almost need to probably re-train.”*
N	Would take away the work of services engineers.	*“If they did them themselves, probably you’d take away the work of services engineers.”*

CATEGORY 14: WHAT THE ARCHITECTS SAY ABOUT BUILDING REGS, CODES COMPLIANCE, ETC.

QUOTE
“There are very few briefs where you come across…written down… *“we need to achieve a benchmark of sustainability BREEAM excellent”* or whatever it might be. It’s quite rare to see that written down in a brief somewhere. And it’s a question we have to ask, you know, *“is there a sustainability credential or benchmark you’re looking to achieve in this building?”*
“You get to a point in life where you’re thinking “I thought I’d cracked it all…” and then you start getting BREEAM and all these other bits and architecture starts to become a paperwork exercise…now I spend meetings and meetings and meetings sitting down working BREEAM and sustainability, and trying to resolve a product to see whether it comes from a sustainable source.”
“A lot of the…BREEAM and everything that’s pushing towards earlier engagement of consultants anyway, so that it’s forcing developers down the road of sort of having to engage more of the consultants early on, so that the decisions that are made are the right decisions.”
“We have to have a broad knowledge of a lot of things which…I think you probably have to have a good understanding of a lot of the other consultants’ requirements; loads of information, loads of knowledge on the other statuary requirements, from planning to building regs to highway, to all sorts of…”
“Part L has become pretty tough …the new version out…it’s a real challenge for us to make things work.”
“I’m one of the BREEAM accredited professionals in the company, so I’ve done the course through the BRE and I’m here to help with BREEAM assessments…out sustainability working group as well within the company; there are probably twenty or twenty-five of us that have got an interest in sustainability, so we meet once a month and just talk about it…you’re very reliant actually on the client, unfortunately, in a lot of ways.”
“I’m not sure building regs are as good as they are written. They could be quite constraining in terms of … you’re very reliant on the client being able to work within the site they have available, and when they have the budget to do what they need to do.”
“I think the new Part L leads itself very much to mixed use developments. There’s a certain scale where you can support energy demands in a sustainable way.”
“It’s [Part L] very difficult. I mean it would be interesting to see how it turns out in the future, but it’s only getting more and more difficult.

QUOTE
“The government initiates more of the infrastructure to be renewable. It’s the only place I can see it working, actually.”
“We’re building such a large building, and have really strict targets on planning to meet better improvements over Part L and BREEAM actually. It needed an excellent rating. We had to discuss the option of ‘do they just give all the money over to a new wind farm? And the chance then is when do they get built? How is it managed? Who gives planning permission?’ It’s a minefield actually.”
“Doing the BREAAM course, and the reason for [being an] accredited professional, the reason the BRE set it up, apart from they get themselves a bit more money through our annual subscription, is that the intention to get people like me on board early; sort of stage A…stage B and help to influence the architecture.”
“’Cause what has happened in the past is that the sustainability becomes a tack-on element, and you know, “let’s throw some PV on the roof and a biomass boiler into the scheme…” and in fact now that just won’t work. Part L won’t allow biomass to be thrown in without having your target building biomass. So all these easy cheats and wins don’t exist like they used to.”
“If you need 40% improvements over Part L, if you run the software and start to fiddle the figures as it were, you can get that to work. Under the new Part L you’ve actually got to identify all the bits of plant that are going to be used. It’s not just putting a figure in the box as it were. What Watermans were saying about the tendering was they think every job they tender now they will actually ask for the full thermal model, or full Part L model to be handed over during tendering. ‘Cause they’ve been caught out under the old Part L…you’ve made assumptions about the u-values of the façade or the shading or whatever, and actually that’s not the case. We’ve found that the bits that weren’t well-modelled were the bits that overheated, or the bits of the plant that wouldn’t fit or…because that bit of kit that they’ll say is that efficient needs to be bigger than the bit that was drawn.”
“I think that will be really interesting to see where the fully-glazed; relatively sophisticated building in terms of its facades; how it sits in the new Part L environment, and bearing in mind that Part L is going to keep changing and getting more [onerous]. There’s not much hope for it really.”
“I’m 80% negative about Part L but I’m sure every architect has the same opinion of it, because it’s constraining our flair and freedom, isn’t it? I get tired of it! I get tired of everything!”
“There’s always a reason that we’ve got to do something a certain way and it’s normally building regulations unfortunately. They’re there for a reason, so I shouldn’t be too negative. But the beautiful bits of architecture that you see in magazines aren’t always compliant.”
“Because we got them [M&E consultants] on board early has meant that we’ve been able to get those two innovation credits you can get for BREEAM if you can appoint someone early. And although we did it slightly before the new credits came in they’ve given them to us anyway.”
“All the planners want; it’s the scheme of the scale, and the planners want is the sustainability statement. They want to know that things are as they should be. I think the mayor’s office are hotter on overheating in residential and aspects like that than others. I mean Part L’s picking more of it up now. But it used to be…limit air leakage; have very air-tight buildings with high U-values etc., which are still relevant.”
“In this current project, the client seems to talk a good talk until they actually have to start forking up money for it. And if it wasn’t for the planners’ policies being quite strict, in fact overly-difficult…’cause I haven’t kept up with the way regulations have moved on…they’re still quoting this target but actually is getting hard to meet now because everything has got more onerous.”
“We looked at things like biomass, ground source heat pumps or whatever. But that has only been put in mostly because the planners require it, or required something. And they’re very hot and very bright on sort of green credentials.”
“It’s quite interesting in the new BREEAM 2011, ‘cause I’ve had a look through it and the management section quotes a lot more from post-occupancy evaluations so you get credits now in the management section for an independent consultant going into an occupied space at least 12 months later, and assessing all sorts of things. It’s not just about energy or about comfort. It’s about accessibility; it’s about all things…how building users deal with that space. And you get credits for that now which I think it’s quite good ‘cause you get feedback from reported…you don’t have to do anything with it. Just the fact that you’ve gone and actually assessed…”
“I’m not sure that the hotel team always do [model all their designs] because we’ve got a model set up; as in a base hotel that works for a particular operator. In theory that will work until the regs change, and then you’d have to re-assess the theory that would work.”

CATEGORY 15: WHAT THE ARCHITECTS SAY ABOUT THE ROLE OF THE CLIENT IN INFLUENCING WHAT DECISIONS ARE MADE AND HOW THEY ARE MADE

QUOTE	COMMENT
"**A client** will ask, "well why is it done that way?" or "why have you chosen that material?" So there needs to be a reason and you have to have an answer."	
"If I want to future-proof my building, then I need to think sustainably, and there's a certain amount of education that needs to happen with **clients."**	Clients need to be made more aware of sustainability – raising awareness of clients on how building design affects the environment and that is directly related to their decisions.
"Some clients will have a corporate policy about sustainability and will say their company will need to make a statement about that. And it's not always very rigorous; it's often quite fluffy…"	Client affect decision-making about how 'sustainable' the building will be.
"We normally start off with a passive or naturally-ventilated solution with a minimal sort of mechanical input **because the client might not want to have the cost** of putting that sort of thing into the building and the maintenance of it, and the space that it takes up."	Client affecting decision-making and choices between alternative design-solutions – for cost minimisation.
"Normally **the client is keen to establish the size, the scope and the massing and the materials of their building,** put it in for planning and then **work out how to build it afterwards."**	Clients view simulation as 'working out how to build it,' whereas architects are aware that simulation needs to be done BEFORE – i.e. there is an argument/disagreement between architects and clients about when is the best stage to incorporate simulations; linked to different reasons:
"We are discovering, and have known for a long time but are trying **to persuade clients** that that is not a really appropriate approach to building; and that you need to know and understand how the technological aspect of your building are going to come together **before** you apply for planning."	Clients need to be PERSUADED – Clients need an EDUCATION"
"**There's no reason why it [energy simulations] can't be done other than the client's reluctance** to have a **cast of thousands around the table** when they don't even know, for themselves, **whether they've got a viable project under their hands."**	Clients are RELUCTANT – COMMERCIAL EXERCISE – they want to know that they've got a viable project under their hands.
"I'd love to sit down with somebody with a loose building model on a screen, or even a physical model on the table and have a discussion…**but it is very rare that that option is available to me as an architect because of the client."**	Clients limiting the options of architects and simulationists working together at earlier points throughout the project.
"The client could see it **purely as a commercial exercise…"**	View/observation/standpoint of what a building project entails – "a commercial exercise."
"There are some clients that we have out there who are **starting to ask us** to work in that way [BIM – collaborative 3D modelling] **because they're fed up of things clashing in 3D,** because no one drew a section at quite the cut through the building that picked up that particular clash of building with corridor ceiling or whatever it might be."	Clients even affecting decisions on HOW architects work and WHAT SOFTWARE IS USED"

QUOTE	COMMENT
"The pressure ultimately comes from a client who's gone to the bank and says "I need to borrow twenty/thirty/forty/fifty million pounds for this investment." Because the client has a deadline to hit and there's a lot of money at stake and that's where the pressure starts. So every other decision really kind of filters down from that financial deadline. And that's ultimately what it's all driven by."	Financial pressures – financial deadlines
"The M&E Engineer will not do any additional work without charging for it, and what we would consider 'design development' he considers 'additional work,' and the client's reluctant to spend more money. It's just he's spent millions getting it done. Why should we spend more?"	Client falling prey to architects and engineers misunderstandings/disagreements?
"I will show that [a squiggle drawing] to a client so that it doesn't look like a CAD drawing, and I will be the first person to make a mark on it to show I'm not precious about the drawing, because what tends to happen with CAD drawings is that…it looks finished, and the client won't comment. So you've got to be the first to dispel that by turning it into a sketch."	Architect affects what the client thinks/how the client makes his/her decision by what they present to the client and how they present a drawing to him/her.
"We're all appointed by clients and we're all very much brought in at different times and it's not yet seen as a holistic approach as to how buildings should be designed with the most benefit."	Viewing the client as the one who is employing/the one doing the appointments.
"Clients don't really seem to give you enough time to enough time to do it [simulations]…they're not willing to invest that time in allowing you to create something perhaps with other consultants."	Clients affecting how much time is dedicated to each task/design stage.
"Clients come to the architects with design ideas. They don't come to 'give me a technically-workable building.' They want your creativity."	
"If we're asked to do a sketch-scheme the client doesn't want to employ half a dozen consultants to work with it so there isn't that opportunity to have that level of advice or interface with other consultants."	
"You could probably view those as your employer rather than your client."	
"There are probably twenty or twenty-five of us who are interested in sustainability, so we meet once a month and just talk about it. You're very reliant on the client, unfortunately, in a lot of ways."	
"You're reliant very much on the client being able to work within the site they have available, and when they have the budget to do what they need to do."	
"The thing that lets us down is their scope of services and what they've been appointed to do by the client or the project manager."	
"We asked for the consultant to work until Stage E and really do it properly; a really detailed design, and the client didn't want to spend the money. So when they did the thermal modelling, they only modelled what they considered to be the two worst facades…and it eventually overheated on the north."	
"So change is inevitable, and what satisfies one doesn't work for another. And of course the client…don't forget the client…the client being the guy that's paying the bill and trying to maximise the value, will have a different take on it again."	
"They modelled two of the main elevations of the building. I wanted to model the whole building but the client didn't want to spend the money, unfortunately."	
"In this current project, the client seems to talk a good talk until they actually have to start forking up money for it."	
"Certain clients, not necessarily ones that we always deal with, will have a much higher sustainability agenda, and they'll want…even if it will cost them money; they'll want to put in as much [sustainability elements/vocabularies] as they can."	
"The client drives so much of it really."	

QUOTE
“I think in some respects, this current job; because we’ve had such a tough time through planning, we’ve had to argue to the client…”
“If the client didn’t have to, they wouldn’t have spent that money. But the planners forced them to do it. So those things are a great story at the end of the day.”
“It does depend on the client.”
“We need to look at it. So you’ve got to pick a point in time which doesn’t waste people’s time and money, because ultimately the client will end up paying more if we keep changing things.”
“Because the client didn’t want to spend a lot of extra money on a triple-glazed façade with very active blind systems and what not, you end up with a fairly traditional double-glazed curtain-walling system…you have to limit your glass area quite a bit.”
“The modelling didn’t cover the full building as we wanted it to, and the client only wanted to spend money on two elevations, the two that weren’t modelled were the ones that were overheating. The other two were absolutely fine.”
“The modelling didn’t cover the full building as we wanted it to, and the client only wanted to spend money on two elevations, the two that weren’t modelled were the ones that were overheating. The other two were absolutely fine.”
“It’s a vicious cycle, isn’t it? You only get a client who wants to design an exciting building if you’ve designed an exciting building. So it’s chicken and egg. Clients only come to you if you’ve done an interesting piece of architecture. The best clients will come to you because you’ve done the best bits of architecture. But often you can only have the best bit of architecture if you’ve got the best client in the first place.”
“It does depend on the client. It just depends on where people’s priorities lie.”
“I think that’s quite important because then you can show the client the impact of the decisions you’re making.”
“And the client has to pay suddenly for two consultants right at the beginning rather than one that’s managing it and so on.”
“The clients have the money but for example if you commissioned a painting, they wouldn’t necessarily tell the painter what paints they should be using or when…you would expect them to want to see the final thing and they may be kept abreast of what they’re doing but not necessarily [prescribing how it should be done].”
“If you’re very well informed as a client then you may say ‘I’ve got a preference for this this and this,’ but generally you would then get on with it. And it’s similar with the process of getting a building built.”
“They’re perhaps up to the design team to perhaps command slightly higher fees and they think that by incorporating simulation early on meant that they would have to then justify…perhaps explain to the client why that was…but in many cases it will be lead primarily by the designers themselves. They don’t know what goes on in an architect’s office. Some might but lots and lots wont.”
“I think the clients perhaps need to be made more aware of simulation; it’s up to the design team really.” I don’t see more clients getting together because they’re all so different anyway.”

APPENDIX E

QUESTIONNAIRE 1; ARCHITECTS

INTRODUCTORY INFORMATION

Welcome!

This questionnaire is being carried out as part of a socio-cultural exploration of building performance simulation users. The research aims at identifying socio-cultural barriers preventing integration of building performance simulation in architectural projects. Building performance simulation (or BPS) is explored in this research in a conceptual and generic sense. The acronym 'BPS' is used throughout this questionnaire, to explore both dynamic simulations conducted to achieve heightened building performance (i.e. in terms of solar, thermal, lighting, airflow, etc.) and for compliance (e.g. SBEM assessments, etc.).

This questionnaire comprises the second phase of the research project. The first consisted of a series of in-depth interviews conducted with architects to understand their **perceptions, subjectivities, opinions** and **attitudes** towards BPS and how it should be integrated in the architectural design process. All opinions presented in this questionnaire have been expressed by architects during previous rounds of data-collection. It has been designed with the aim of understanding whether these perceptions, opinions and attitudes are shared amongst the wider architectural community. Therefore, the questionnaire is directed at architects who are familiar with BPS; either by conducting it within their architectural practices or by collaborating with BPS specialists[1].

There are no wrong or right answers to the questions. We are interested in **your personal views** and **your level of agreement** to the opinions presented in the questionnaire. The questionnaire should take about 20-30 minutes to complete. Your participation is entirely voluntary. Should you wish to withdraw your responses at any time, you may simply click the 'exit this survey' box at the top right-hand side window. Alternatively, if you decide not to submit your answers at the end of the questionnaire for any reason, your responses will not be recorded. All your responses will be treated in complete confidence. The answers you provide will only be used to produce aggregate statistical data.

Thank you for your help.

If you would like to proceed with the questionnaire, please confirm that you have read the above information and agree to participate in the questionnaire.

☐ I acknowledge that I have read and understood the above information. I agree to participate in the questionnaire, and I know that I am free to withdraw at any time should I wish to do so.

☐ Exit questionnaire.

[1] The term 'BPS specialist(s)' is used throughout this questionnaire to describe design-team members who are routinely involved in calculating building performance using specialist building performance simulation software. These often tend to be services engineers, mechanical engineers, sustainability consultants, etc.

SECTION 1 – BACKGROUND

In the context of your architectural work, is BPS conducted to test your building designs with respect to performance, at any point throughout the design process/ pre-construction stages?

Yes ☐ No ☐

Which of the following approaches is most commonly used in your architectural practice to incorporate BPS?

☐ AN IN-HOUSE APROACH; BPS is conducted either by yourself or by another member of your architectural practice.

☐ A COLLABORATIVE APPROACH; BPS specialists from outside your architectural practice are appointed at some stage during the design process to conduct BPS.

☐ A COMBINATION OF THE ABOVE APPROACHES.

☐ Other (please specify here).

SECTION 2 –WHO SHOULD BE CONDUCTING BUILDING PERFORMANCE SIMULATIONS?

To what extent do you agree or disagree with each of the following statements, about WHO should be conducting BPS?

	Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
BPS is of most benefit to the architectural design process **IF ARCHITECTS CONDUCT IT THEMSELVES**	☐	☐	☐	☐	☐
BPS is of most benefit to the architectural design process **IF BPS SPECIALISTS ARE APPOINTED AT SOME STAGE IN THE DESIGN PROCESS, AND COLLABORATE WITH THE ARCHITECTS.**	☐	☐	☐	☐	☐
BPS is of most benefit to the architectural design process if **ARCHITECTS** conduct it **DURING EARLY STAGES;** and **BPS SPECIALISTS** follow it up with detailed calculations **AT LATER STAGES.**	☐	☐	☐	☐	☐
Which professional conducts **BPS DEPENDS ENTIRELY ON THE COMPLEXITY OF THE PROJECT.**	☐	☐	☐	☐	☐

To what extent do you agree or disagree with each of the following statements, questioning WHETHER ARCHITECTS SHOULD OR SHOULD NOT be conducting BPS themselves?

	Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree
Architects should conduct BPS themselves, because it improves **SPEED and EFFICIENCY** of the architectural design process.	☐	☐	☐	☐	☐
Architects should conduct BPS themselves, because it better informs **EARLY STAGE ARCHITECTURAL DECISION-MAKING.**	☐	☐	☐	☐	☐
Architects are easily able to understand how BPS software works.	☐	☐	☐	☐	☐
Architectural education and training **SUITABLY PREPARES BUILDING DESIGNERS** to conduct BPS calculations themselves.	☐	☐	☐	☐	☐
Architectural education gives building designers the **BACKGROUND KNOWLEDGE OF BUILDING** required for them to do BPS.	☐	☐	☐	☐	☐
Architects should not conduct BPS themselves because it is not their **PROFESSIONAL 'LOGO.'**	☐	☐	☐	☐	☐
Architects should not have to conduct BPS themselves because **THEY DO NOT HAVE ENOUGH TIME** for it.	☐	☐	☐	☐	☐
If architects were to conduct BPS themselves, **IT WOULD TAKE AWAY THE WORK OF BPS SPECIALISTS.**	☐	☐	☐	☐	☐

SECTION 3 – RIBA WORK STAGES

Stages of the architectural design process at which building performance simulations should be conducted.

PREPARATION		DESIGN			PRE-CONSTRUCTION			CONSTRUCTION		USE
A	B	C	D	E	F	G	H	J	K	L
☐ Appraisal	☐ Design Brief	☐ Concept	☐ Design Development	☐ Tech. Design	☐ Production Information	☐ Tender Documentation	☐ Tender Action	☐ Mobilisation	☐ Construction to Practical Completion	☐ Post Practical Completion

In your practice, at which RIBA Work Stage (A-L) is BPS initially incorporated and used in building projects?

In your opinion, at which RIBA Work Stage (A-L) does initial incorporation of BPS promise most benefit?

To gain the most benefit of BPS, BPS specialists should be kept on board a project UNTIL which RIBA Work Stage (A-L)?

SECTION 4: THE CLIENT AS A BARRIER

To what extent do you agree or disagree with each of the following statements, about HOW THE CIENT AFFECTS BPS INTEGRATION in the architectural design process?

	Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree
Most of the time clients will have **HIGH SUSTAINABILITY AGENDAS,** and will generally encourage architects to integrate BPS as early as possible; to inform their decision-making.	☐	☐	☐	☐	☐
Clients usually see a building project as **A COMMERCIAL EXERCISE** and are generally looking to drive the **MAXIMUM FINANCIAL VALUE OUT OF THE PROJECT DESIGN.** They therefore encourage early BPS integration to save on long-term building life-cycle costs.	☐	☐	☐	☐	☐
Involving a BPS specialist earlier in the design process means that **THE CLIENT WOULD HAVE TO PAY MORE MONEY** towards managing more consultants.	☐	☐	☐	☐	☐
BPS is **NOT ON THE CLIENTS' USUAL LIST OF PRIORITIES.**	☐	☐	☐	☐	☐
Clients are unaware of BPS and **THE IMPORTANCE OF INTEGRATING IT IN THE ARCHITECTURAL DESIGN PROCESS.**	☐	☐	☐	☐	☐
It **is DIFFICULT TO GENERALISE** about clients.	☐	☐	☐	☐	☐

SECTION 5: ATTITUDES TOWARDS BUILDING PERFORMANCE SIMULATION AND PART L OF THE BUILDING REGULATIONS

To what extent do you agree or disagree with each of the following statements, about **ARCHITECTS' ATTITUDES TOWARD ADOPTION AND USE OF BPS,** and its integration in the design process?

	Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
Architects generally tend to have **POSITIVE ATTITUDES** towards adoption and use of BPS in building design projects.	☐	☐	☐	☐	☐
The potential benefits of BPS, and how it contributes towards decision-making, IS **FULLY PERCEIVED AND VALUED BY ARCHITECTS.**	☐	☐	☐	☐	☐
The numerical nature of BPS is **TOO REGULATORY AND CONTROLLING**.	☐	☐	☐	☐	☐
BPS encourages **DESIGN-FLAIR AND CREATIVITY.**	☐	☐	☐	☐	☐
BPS is often done for the **SOLE PURPOSE OF COMPLIANCE WITH BUILDING REGULATIONS, STANDARDS AND CODES.**	☐	☐	☐	☐	☐
The 'language' of BPS is **DIFFICULT TO UNDERSTAND.**	☐	☐	☐	☐	☐
BPS does not come under **THE UMBRELLA OF 'REAL' ARCHITECTURE.**	☐	☐	☐	☐	☐
Preparation for BPS inputs and interpreting BPS outputs **ARE VERY BUREAUCRATIC TASKS.**	☐	☐	☐	☐	☐

To what extent do you agree or disagree with each of the following statements, about **PART L OF THE BUILDING REGULATIONS (CONSERVATION OF FUEL AND POWER)?**

	Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree
Part L of the building regulations plays **A KEY AND POSITIVE ROLE** in helping to create a comfortable built environment for users.	☐	☐	☐	☐	☐
Part L encourages **DESIGN-FLAIR AND CREATIVITY.**	☐	☐	☐	☐	☐
Part L is **VERY TOUGH** and targets are **TOO HIGH** to achieve in order to attain compliance.	☐	☐	☐	☐	☐
Part L is **CHANGED TOO FREQUENTLY,** and it is difficult to keep up with the changes.	☐	☐	☐	☐	☐
Compliance with Part L is generally **AN HONEST MEASURE** of effective building performance.	☐	☐	☐	☐	☐

SECTION 6: TRUST BETWEEN ARCHITECTS AND BPS SPECIALISTS

To what extent do you agree or disagree with each of the following statements, about TRUST* BETWEEN ARCHITECTS AND BPS SPECIALISTS?

*Trust is defined as *"a psychological state comprising the intention to accept vulnerability based upon positive expectations of the intention or behaviour of the other"* (Rousseau et al., 1998).

	Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree
Generally, there is a **TRUSTFUL DISPOSITION** between collaborating architects and BPS specialists.	☐	☐	☐	☐	☐
Architects always believe that BPS specialists **EXERT THEIR FULL POTENTIAL** in the collaborative effort, and do what is fully required of them.	☐	☐	☐	☐	☐
Architects and/or BPS specialists often engage in **OPPORTUNISTIC BEHAVIOUR.** *(Opportunistic behaviour is that which involves consciously taking advantage of circumstances for self-interest, with little or no regard for principles).*	☐	☐	☐	☐	☐
Architects and BPS specialists working together always fully believe in the **COMPETENCE OF EACH OTHER;** and their respective **KNOWLEDGE, SKILLS AND ABILITY** to do their respective tasks.	☐	☐	☐	☐	☐
Architects and BPS specialists sometimes do not trust each other, as a result of **PREJUDICES, BIASES AND MISPERCEPTIONS** of the others' work.	☐	☐	☐	☐	☐

SECTION 7: STEREOTYPING

From you experience, would you say that STEREOTYPICAL IMPRESSIONS* of architects' and BPS specialists' practices, working methods and ideologies exist between members of the two disciplines?

Yes ☐ No ☐ Sometimes ☐

*A stereotype is defined as, *"a fixed, over-generalised belief about a particular group or class of people"* (Caldwell, 1996).

What stereotypical impressions do architects generally tend to have of BPS specialists?

Please specify these here.

END OF QUESTIONNAIRE

THANK YOU!

You have completed the questionnaire.

Thank you very much for taking the time to complete this questionnaire. Please now click on 'done' to submit your answers.

QUESTIONNAIRE 2; BPS SPECIALISTS

INTRODUCTORY INFORMATION

Welcome!

This questionnaire is being carried out as part of a socio-cultural exploration of building performance simulation users. The research aims at identifying socio-cultural barriers preventing integration of building performance simulation in architectural projects. Building performance simulation (or BPS) is explored in this research in a conceptual and generic sense. The acronym 'BPS' is used throughout this questionnaire, to explore both dynamic simulations conducted to achieve heightened building performance (i.e. in terms of solar, thermal, lighting, airflow, etc.) and for compliance (e.g. SBEM assessments, etc.).

This questionnaire comprises the second phase of the research project. The first consisted of a series of in-depth interviews conducted with BPS specialists to understand how they work with architects, and their **perceptions, subjectivities, opinions** and **attitudes** towards BPS integration in the architectural design process. All opinions presented in this questionnaire have been expressed by BPS specialists during previous rounds of data-collection. The questionnaire has been designed with the aim of understanding whether these perceptions, opinions and attitudes are shared amongst the wider community of BPS specialists. Therefore, it is directed at specialist users in BPS, who routinely collaborate and communicate with architectural designers; to test the performance of their building designs at some stage throughout the architectural design process.

There are no wrong or right answers to the questions. We are interested in **your personal views** and **your level of agreement** to the opinions presented in the questionnaire. The questionnaire should take about 20-30 minutes to complete. Your participation is entirely voluntary. Should you wish to withdraw your responses at any time, you may simply click the 'exit this survey' box at the top right-hand side window. Alternatively, if you decide not to submit your answers at the end of the questionnaire for any reason, your responses will not be recorded. All your responses will be treated in complete confidence. The answers you provide will only be used to produce aggregate statistical data.

Thank you for your help.

If you would like to proceed with the questionnaire, please confirm that you have read the above information and agree to participate in the questionnaire.

☐ I acknowledge that I have read and understood the above information. I agree to participate in the questionnaire, and I know that I am free to withdraw at any time should I wish to do so.

☐ Exit questionnaire.

SECTION 1: BACKGROUND, WORK APPROACHES FOLLOWED AND SOFTWARE USED

In the context of your work, do you carry out building performance simulations to test the performance of designed buildings; pre-construction?

Yes ☐ No ☐

Which of the following best describes your educational background (undergraduate degree)?

☐ Architecture

☐ Architectural engineering

☐ Architectural technology

☐ Building services engineering

☐ Renewable energy and sustainable technologies / Renewable energy systems engineering / Renewable energy and resource management

☐ Mechanical engineering / Mechanical and electrical engineering

☐ Heating, ventilation and air-conditioning (HVAC) / Heating, ventilation, air-conditioning and refrigeration (HVACR).

☐ Physics

☐ Other (please specify here)

Did your degree deal exclusively with buildings?

☐ Yes, exclusively

☐ It predominantly dealt with buildings, but included other disciplines as well

☐ No, not at all.

Did you follow up this background degree with a postgraduate diploma or degree?

☐ Yes

☐ No

Please specify here what field of study your postgraduate diploma / degree was in.

What professional title or description do you use to identify yourself between members of the building industry?

☐ Thermal modeller

☐ Mechanical engineer / Mechanical designer

☐ HVAC engineer / HVAC designer

☐ Energy consultant

☐ Energy assessor

☐ Sustainability consultant

☐ Building physicist

☐ Low carbon consultant

☐ Other (please specify here)

Generally, which of the following best encompasses the range of services that you or your practice provides to architects? (You may choose more than one).

☐ Dynamic simulation modelling for design purposes; to assist with building design decisions with regards to energy and performance throughout the RIBA Work Stages

☐ Modelling for compliance purposes; to ensure that the designed building satisfies regulatory requirements (Part L) and benchmark standards.

☐ A combination of both: modelling for design and compliance purposes; although the majority tends to be design work.

☐ A combination of both: modelling for design and compliance; although the majority tends to be compliance work.

☐ Other energy performance assessments (e.g. EPCs, DEC assessments, etc.)

☐ Services modelling

☐ Other types of work not mentioned above (please specify here).

Which of the following approaches best describes the way you work with architects?

☐ AN IN-HOUSE APPROACH: You are a BPS specialist working as part of an architectural practice.

☐ AN IN-HOUSE APPROACH: You are a BPS specialist working as part of a multi-disciplinary practice.

☐ A COLLABORATIVE APPROACH: You are a BPS specialist working as a member of a consultancy that specialises in mechanical design, HVAC design or sustainability consultations. Architectural practices consult with you to evaluate building performance at some stage throughout their design process.

☐ Other (please specify here).

What software do you mainly use to carry out your BPS calculations and/or energy assessments? (You may choose more than one).

☐ EnergyPlus + a plug-in interface such as OpenStudio

☐ DesignBuilder

☐ IES Virtual Environment

☐ TAS Thermal Analysis Simulation Software

☐ Autodesk Ecotect

☐ Autodesk Green Building Studio

☐ SBEM + iSBEM user interface

☐ ESP-r

☐ BIM Modelling software such as Autodesk Revit

☐ TRNSYS Transient System Simulation Tool

☐ Bentley Hevacomp Dynamic Simulation

☐ Other (please specify here)

SECTION 2: WHO SHOULD BE CONDUCTING BUILDING PERFORMANCE SIMULATIONS?

To what extent do you agree or disagree with each of the following statements, about WHO should be conducting BPS?

	Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree
BPS is of most benefit to the architectural design process **IF ARCHITECTS CONDUCT IT THEMSELVES**	☐	☐	☐	☐	☐
BPS is of most benefit to the architectural design process **IF BPS SPECIALISTS ARE APPOINTED AT SOME STAGE IN THE DESIGN PROCESS, AND COLLABORATE WITH ARCHITECTS**	☐	☐	☐	☐	☐
BPS is of most benefit to the architectural design process if **ARCHITECTS** conduct it **DURING EARLY STAGES;** and **BPS SPECIALISTS** follow it up with detailed calculations **AT LATER STAGES.**	☐	☐	☐	☐	☐
Which professional conducts **BPS DEPENDS ENTIRELY ON THE COMPLEXITY OF THE PROJECT.**	☐	☐	☐	☐	☐

To what extent do you agree or disagree with each of the following statements; questioning the IMPLICATIONS OF ARCHITECTS CONDUCTING BPS?

	Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree
If architects were to conduct BPS themselves, they would be able to realise **THE IMPACT OF DESIGN DECISIONS ON BUILDING PERFORMANCE,** with respect to energy.	☐	☐	☐	☐	☐
If architects were to conduct BPS themselves, **IT WOULD IMPROVE THEIR DESIGNS' PERFORMANCE.**	☐	☐	☐	☐	☐
If architects were to conduct BPS themselves, **IT WOULD BE A GOOD WAY OF DEMONSTRATING TO THE CLIENT HOW A BUILDING PERFORMS.**	☐	☐	☐	☐	☐
If architects were to conduct BPS themselves, **IT WOULD SIMPLIFY BPS SPECIALISTS' WORK.**	☐	☐	☐	☐	☐
If architects were to conduct BPS themselves, it would improve **UNDERSTANDINGS AND COMMUNICATION BETWEEN ARCHITECTS AND BPS SPECIALISTS.**	☐	☐	☐	☐	☐
Architects should not conduct BPS themselves because **IT IS NOT THEIR PROFESSIONAL 'LOGO.'**	☐	☐	☐	☐	☐

SECTION 3: RIBA WORK STAGES

Stages of the architectural design process at which building performance simulations should be conducted.

PREPARATION		DESIGN			PRE-CONSTRUCTION			CONSTRUCTION		USE
A	B	C	D	E	F	G	H	J	K	L
☐ Appraisal	☐ Design Brief	☐ Concept	☐ Design Development	☐ Tech. Design	☐ Production Information	☐ Tender Documentation	☐ Tender Action	☐ Mobilisation	☐ Construction to Practical Completion	☐ Post Practical Completion

At which of the RIBA Work Stages (A-L) are you INITIALLY CONSULTED WITH to begin BPS calculations; simulating design performance.

In your opinion, at which of the RIBA Work Stages (A-L) does INITIAL COLLABORATION with the architects promise most benefit to building performance?

In your opinion, until which of the RIBA Work Stages (A-L) do you think BPS specialists should be kept ON BOARD A BUILDING PROJECT, as part of the design team?

SECTION 4: ATTITUDES TOWARDS BUILDING PERFORMANCE SIMULATION AND PART L OF THE BUILDING REGULATIONS

To what extent do you agree or disagree with each of the following statements, about **ARCHITECTS' ATTITUDES TOWARD ADOPTION AND USE OF BPS,** and its integration in the design process?

	Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree
Architects generally tend to have **POSITIVE ATTITUDES** toward adoption and use of BPS in building design projects.	☐	☐	☐	☐	☐
The potential benefits of BPS, and how it contributes towards decision-making is **FULLY PERCEIVED AND VALUED BY ARCHITECTS.**	☐	☐	☐	☐	☐
The numerical nature of BPS is **TOO REGULAROTY AND CONTROLLING.**	☐	☐	☐	☐	☐
BPS encourages **DESIGN-FLAIR AND CREATVITIY.**	☐	☐	☐	☐	☐
BPS is often done for the **SOLE PURPOSE OF COMPLIANCE WITH BUILDING REGULATIONS, STANDARDS AND CODES.**	☐	☐	☐	☐	☐
The 'language' of BPS is **DIFFICULT TO UNDERSTAND.**	☐	☐	☐	☐	☐
BPS does not come under **THE UMBRELLA OF 'REAL' ARCHITECTURE.**	☐	☐	☐	☐	☐
Preparation for BPS inputs and interpreting BPS outputs **ARE VERY BUREAUCRATIC TASKS.**	☐	☐	☐	☐	☐

To what extent do you agree or disagree with each of the following statements, about **PART L OF THE BUILDING REGULATIONS (CONSERVATION OF FUEL AND POWER)?**

	Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree
Part L of the building regulations plays **A KEY AND POSITIVE ROLE** in helping to create a comfortable built environment for users.	☐	☐	☐	☐	☐
Part L encourages **DESIGN-FLAIR AND CREATIVITY.**	☐	☐	☐	☐	☐
Part L is **VERY TOUGH** and targets are **TOO HIGH** to achieve in order to attain compliance.	☐	☐	☐	☐	☐
Part L is **CHANGED TOO FREQUENTLY** and it is difficult to keep up with the changes.	☐	☐	☐	☐	☐
Compliance with Part L is generally **AN HONEST MEASURE** of effective building performance.	☐	☐	☐	☐	☐

SECTION 5: RELATIONSHIPS AND COMMUNICATION BETWEEN ARCHITECTS AND BPS SPECIALISTS

To what extent do you agree or disagree with each of the following statements, about RELATIONSHIPS BETWEEN ARCHITECTS AND BPS SPECIALISTS?

	Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree
Generally, professional relationships between architects and BPS specialists tend to be **EASY AND STRAIGHTFORWARD.**	☐	☐	☐	☐	☐
Generally, there tends to be a **MUTUAL RESPECT** between architects and BPS specialists, and **AN APPRECIATION** for the work that each professional does.	☐	☐	☐	☐	☐
Relationships between architects and BPS specialists may be quite friendly on a personal level; but **ON A PROFESSIONAL LEVEL** the relationship can be **QUITE DIFFICULT.**	☐	☐	☐	☐	☐
Working with younger architects (early to mid-career) tends to be easier for BPS specialists, because younger architects have **A BETTER UNDERSTANDING OF BUILDING PHYSICS.**	☐	☐	☐	☐	☐
Working with younger architects (early to mid-career), who are **LACKING IN PRACTICAL EXPERIENCE**, tends to be difficult for BPS specialists.	☐	☐	☐	☐	☐
Working with older architects (late career stages; close to retirement) tends to be easier for BPS specialists, because they have **MORE PRACTICAL WORK EXPERIENCE.**	☐	☐	☐	☐	☐
Working with older architects (late career stages; close to retirement) can be difficult for BPS specialists because older architects are **FIRMLY ESTABLISHED IN THEIR WORKING PROCESS;** which do not accommodate for BPS requirements.	☐	☐	☐	☐	☐
Architects ALWAYS provide BPS specialists with **THE RIGHT INPUT DATA** for BPS calculations, e.g. accurate u-values, thermal bridging calculations and chosen material properties.	☐	☐	☐	☐	☐
Architects **FULLY UNDERSTAND THE AIMS** of BPS specialists' work; making the relationship a fruitful one.	☐	☐	☐	☐	☐
Architects **DO NOT ALWAYS ABSORB** any of the information given back to them from BPS specialists' calculations. To them it is 'just another report' that has been commissioned and undertaken; but **MAY NOT NECESSARILY** influence the building design.	☐	☐	☐	☐	☐
Generally, architects have a **FLEXIBLE WAY OF WORKING** with BPS specialists, and are **OPEN TO ANY SUGGESTIONS OR RECOMMENDATIONS** that are made as a result of the calculations.	☐	☐	☐	☐	☐
Architects tend to perceive BPS specialists' role **as AN INTEGRAL DESIGN TEAM MEMBER**; who directly impacts the building design	☐	☐	☐	☐	☐
Architects tend to perceive BPS specialists' role in the design team as a **NECESSITY REQUIRED** to prove that their building 'works.'	☐	☐	☐	☐	☐

To what extent do you agree or disagree with each of the following statements, about MUTUAL UNDERSTANDINGS AND COMMUNICATION BETWEEN ARCHITECTS AND BPS SPECIALISTS?

	Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree
CHANNELS of communication between architects and BPS specialists **TEND TO BE OPEN.**	☐	☐	☐	☐	☐
Architects are **FULLY ABLE TO UNDERSTAND AND INTERPRET** the information that BPS specialists communicate to them.	☐	☐	☐	☐	☐
Information communicated to architects through face-to-face meetings tends to be **MORE EFFECTIVE** than telephone communication or email.	☐	☐	☐	☐	☐
Architects are always **FULLY ABLE TO ENGAGE IN CONVERSATION** with BPS specialists.	☐	☐	☐	☐	☐
Architects' **LACK OF TECHNICAL KNOWLEDGE HINDERS EFFECTIVE COMMUNICATION** with BPS specialists.	☐	☐	☐	☐	☐
Differences in architects' and BPS specialists' natures **MAY INHIBIT MUTUAL UNDERSTANDINGS** between the two in collaborative settings.	☐	☐	☐	☐	☐
BPS specialists always communicate the results of their calculations in ways that are **FULLY COMPREHENSIBLE** to architects.	☐	☐	☐	☐	☐
BPS results communicated to architects **DO NOT ALWAYS SEEM TO HAVE THE DESIRED IMPACT** on the building design.	☐	☐	☐	☐	☐

SECTION 6: TRUST BETWEEN ARCHITECTS AND BPS SPECIALISTS

To what extent do you agree or disagree with each of the following statements, about TRUST* BETWEEN ARCHITECTS AND BPS SPECIALISTS?

*Trust is defined as *"a psychological state comprising the intention to accept vulnerability based upon positive expectations of the intention or behaviour of the other"* (Rousseau et al., 1998).

	Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree
Generally, there is a **TRUSTFUL DISPOSITION** between collaborating architects and BPS specialists.	☐	☐	☐	☐	☐
Architects always believe that BPS specialists **EXERT THEIR FULL POTENTIAL** in the collaborative effort, and do what is fully required of them.	☐	☐	☐	☐	☐
Architects and/or BPS specialists often engage in **OPPORTUNISTIC BEHAVIOUR.** *(Opportunistic behaviour is that which involves consciously taking advantage of circumstances for self-interest, with little or no regard for principles).*	☐	☐	☐	☐	☐
Architects and BPS specialists working together always fully believe in the **COMPETENCE OF EACH OTHER;** and their respective **KNOWLEDGE, SKILLS AND ABILITY** to do their respective tasks.	☐	☐	☐	☐	☐
Architects and BPS specialists sometimes do not trust each other, as a result of **PREJUDICES, BIASES AND MISPERCEPTIONS** of the others' work.	☐	☐	☐	☐	☐

SECTION 7: STEREOTYPING

From you experience, would you say that STEREOTYPICAL IMPRESSIONS* of architects' and BPS specialists' practices, working methods and ideologies exist between members of the two disciplines?

Yes ☐ No ☐ Sometimes ☐

*A stereotype is defined as, *"a fixed, over-generalised belief about a particular group or class of people"* (Caldwell, 1996).

What stereotypical impressions do architects generally tend to have of BPS specialists?

Please specify these here.

END OF QUESTIONNAIRE

THANK YOU!

You have completed the questionnaire.

Thank you very much for taking the time to complete this questionnaire. Please now click on ‘done’ to submit your answers.

APPENDIX G – Documents submitted to the Welsh School of Architecture Research Ethics Committee in October 2011; to gain approval for the data-collection procedures conducted in the quantitative research stage.

EC1110 . 090

WELSH SCHOOL OF ARCHITECTURE
ETHICS APPROVAL FORM FOR STUDENT PROJECTS

WSA

Tick one box:	☐ UNDERGRADUATE ☐ M.ARCH √ PHD
Title of project:	Understanding communication between architects and simulation specialists, for integration of building performance simulation in the architectural design process.
Name of student(s):	Sara Alsaadani
Name of supervisor:	Clarice Bleil De Souza, Don Alexander
Contact e-mail address:	alsaadanisa@cardiff.ac.uk
Date:	11th October, 2011

Participants		YES	NO	N/A
Does the research involve participants from any of the following groups?	• Children (under 16 years of age)		√	
	• People with learning difficulties		√	
	• Patients (NHS approval is required)		√	
	• People in custody		√	
	• People engaged in illegal activities		√	
	• Vulnerable elderly people		√	
	• Any other vulnerable group not listed here		√	
• When working with children: I have read the Interim Guidance for Researchers Working with Children and Young People (http://www.cardiff.ac.uk/archi/ethics_committee.php)				√

Consent Procedure	YES	NO	N/A
• Will you describe the research process to participants in advance, so that they are informed about what to expect?	√		
• Will you tell participants that their participation is voluntary?	√		
• Will you tell participants that they may withdraw from the research at any time and for any reason?	√		
• Will you obtain valid consent from participants? (specify how consent will be obtained in Box A)[1]			√
• Will you give participants the option of omitting questions they do not want to answer?			√
• If the research is observational, will you ask participants for their consent to being observed?			√
• If the research involves photography or other audio-visual recording, will you ask participants for their consent to being photographed / recorded and for its use/publication?			√

Possible Harm to Participants	YES	NO	N/A
• Is there any realistic risk of any participants experiencing either physical or psychological distress or discomfort?		√	
• Is there any realistic risk of any participants experience a detriment to their interests as a result of participation?		√	

Data Protection		YES	NO	N/A
• Will any non-anonymous and/or personalised data be generated or stored?			√	
• If the research involves non-anonymous and/or personalised data, will you:	• gain written consent from the participants			√
	• allow the participants the option of anonymity for all or part of the information they provide			√

Health and Safety	YES
Does the research meet the requirements of the University's Health & Safety policies? (http://www.cardiff.ac.uk/osheu/complete_risk_assessment/index.html)	√

If any of the shaded boxes have been ticked, the supervisor must explain in Box A how the ethical issues are addressed.

[1] If any non-anonymous and/or personalised data be generated or stored, *written consent* is required.

The list of ethical issues on this form is not exhaustive; if the supervisor is aware of any other ethical issue s/he should make the SREC aware of it.

Box A **The Project** (provide all the information listed below in a separate attachment)
1. Title of Project 2. Purpose of the project and its academic rationale 3. Brief description of methods and measurements 4. Participants: recruitment methods, number, age, gender, exclusion/inclusion criteria 5. Consent and participation information arrangements - please attached consent forms if they are to be used 6. A clear and concise statement of the ethical considerations raised by the project and how is dealt with them 7. Estimated start date and duration of project **All information must be submitted along with this form to the School Research Ethics Committee for consideration**

Supervisor's declaration (tick as appropriate)	
• I consider this research project to have **negligible ethical implications** and **the student can proceed with the research immediately** (*can only be used if none of the grey areas of the checklist have been ticked*).	
• I consider this project research to have **some ethical implications. Box A** clearly describes the ethical issues and how they are addressed. **The student has to await feedback whether the research has been approved by the SREC Chair or whether it will have to be considered by the Committee**. The student will receive feedback within 7-10 days.	
• I consider this project to have **significant ethical implications** and should be brought before the Ethics Committee. **Box A** clearly describes the ethical issues and how they are addressed. **The student MUST NOT proceed until the project has been approved by the Ethics Committee.**	
Signature **Name** **Date**	

Advice from the School Research Ethics Committee

STATEMENT OF ETHICAL APPROVAL
This project had been considered using agreed Departmental procedures and is now approved
Signature **Name** Wouter Poortinga **Date** 12/10/11
Chair, School Research Ethics Committee

Box A – The Project

1. **Research Title:** Understanding communication between architects and simulation specialists, for integration of building performance simulation in the architectural design process.

2. **Purpose of the Project and its Academic Rationale:** This project aims to understand why building performance simulation is poorly integrated in the architectural design process. Traditionally this area is explored from a technical and software-based perspective. However, this research takes into account the fact that the design process is one that is governed and affected by human-computer and human-human interaction. Therefore, it aims to explore reasons preventing uptake, use and integration of building performance simulation in building projects from a qualitative perspective.

3. **Brief Description of Methods and Measurements:** This stage of the research, for which consent is being requested, is the second stage of the research. The previous stage (for which consent had been previously approved) consisted of a set of semi-structured in-depth interviews with architects and simulation specialists. Throughout these interviews, topics discussed included background education, experiences, working processes, tools and techniques used throughout. As a result of the semi-structured nature of the interview process, a variety of perceptions, opinions, values and attitudes surfaced; related to the architectural working process and how building performance simulation is related with it. Analysis of the data has been conducted using a Grounded Theory approach.

   From the analysis, a further set of questions has arisen. These questions are mainly concerned with architects' opinions about building performance simulations and how/whether they should be (best) integrated in the design process. A questionnaire has been designed, aiming to find whether these opinions and generalizable among members of the wider architectural community (Appendix A and B).

4. **Participants: Recruitment Methods, Number, Age, Gender, etc.:** The designed questionnaire will be distributed online, through www.surveymonkey.com. E-mails will be sent to UK chartered practices, listed on the RIBA Directory, requesting their participation. A link redirecting them to the online survey will be provided in the e-mails. No minimum number of participants has been proposed for this research stage. With the aim of generalisation the researcher intends to reach as wide an audience as feasible, and yield as high a response rate as possible.

   The two main inclusion criteria for participants are as follows:

   a) That practices are UK-based and listed on the RIBA Directory.

   b) That practices demonstrate an awareness of building performance simulation on their websites, and indicate on some level that they simulations are used at some point throughout the design process. This may be either an in-house approach or a collaborative one.

5. **Consent and Participation Information Arrangements:** The proposed study does not pose a realistic risk of any participants experiencing either physical or psychological distress or discomfort. No sort of participant deception or manipulation is involved in the project at any of its stage. Data gathered and analysed in the previous stage has been done in confidentiality

and stored anonymously. In the online questionnaire, no personal information will be gathered. Information on the project; its aims and what respondents will be asked for is explicitly described on the first page of the online questionnaire (Appendix A and B). They are given an estimation of how much of their time it should take to fill in the questionnaire. Respondents are also informed that their participation is voluntary and that they may withdraw their involvement at any point should they so require. A tick-box has been provided before proceeding with the online questionnaire, for participants to acknowledge their understanding of the research and giving their agreement to participate (Appendix A and B).

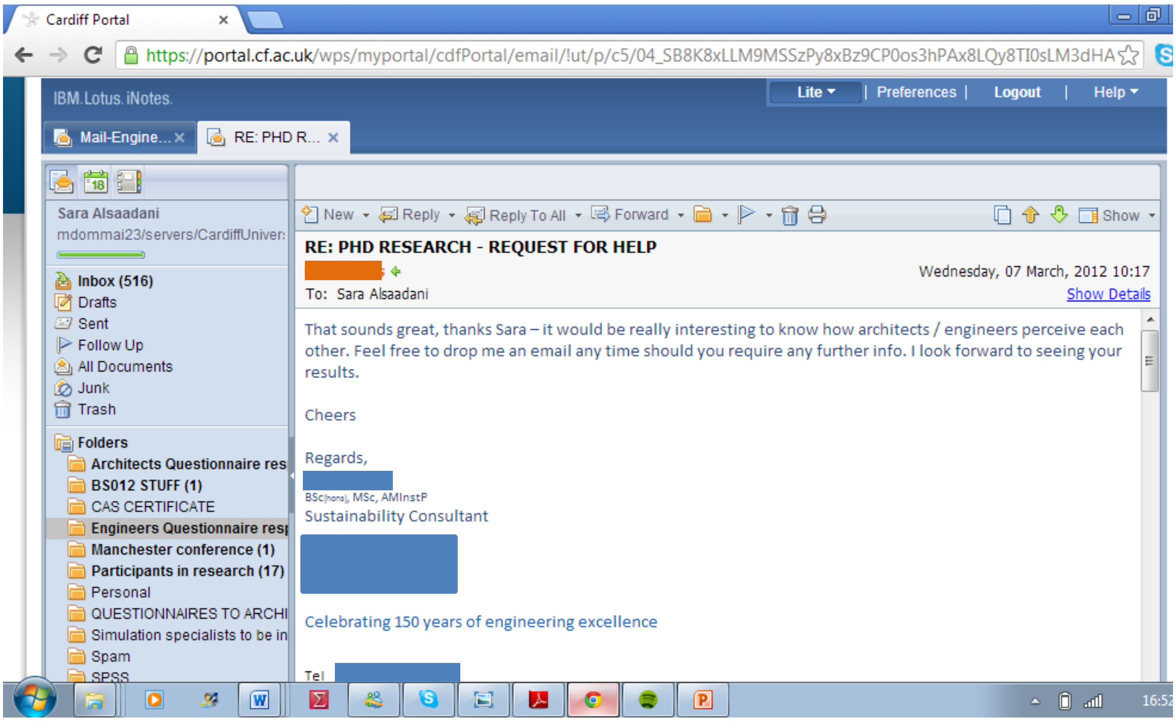
6. Statement of Ethical Considerations

This research project does not pose a risk on participants experiencing either physical or psychological distress or discomfort. The online questionnaire has been designed with the intent of finding whether previously collected data is generalizable; whether the wider population of the architectural community agree or disagree with opinions constructed during previous in-depth data collection. No personal information, or otherwise forms of personal identification are required from participants. Furthermore, the project does not involve any kind of participant deception, manipulation, distraction or misleading information. No sensitive data will be collected that could trigger upset, anxieties or any other adverse emotions. The information provided on the first page of the online questionnaire informs the participants in advance what the research entails, that their participation is voluntary and that they may withdraw at any time.

7. Estimated Start Date and Duration of the Project

It is intended that the online questionnaire will be distributed as soon as approval has been given by the School Research Ethics Committee. It is anticipated that the questionnaire will be available online for a duration of between 4-6 months; depending on the response rate experienced.

APPENDIX H – E-mails from BPS specialists demonstrating their interest in the research topic.



RE: PHD RESEARCH - REQUEST FOR HELP

[redacted]

Wednesday, 07 March, 2012 10:17

To: Sara Alsaadani

That sounds great, thanks Sara – it would be really interesting to know how architects / engineers perceive each other. Feel free to drop me an email any time should you require any further info. I look forward to seeing your results.

Cheers

Regards,

[redacted]

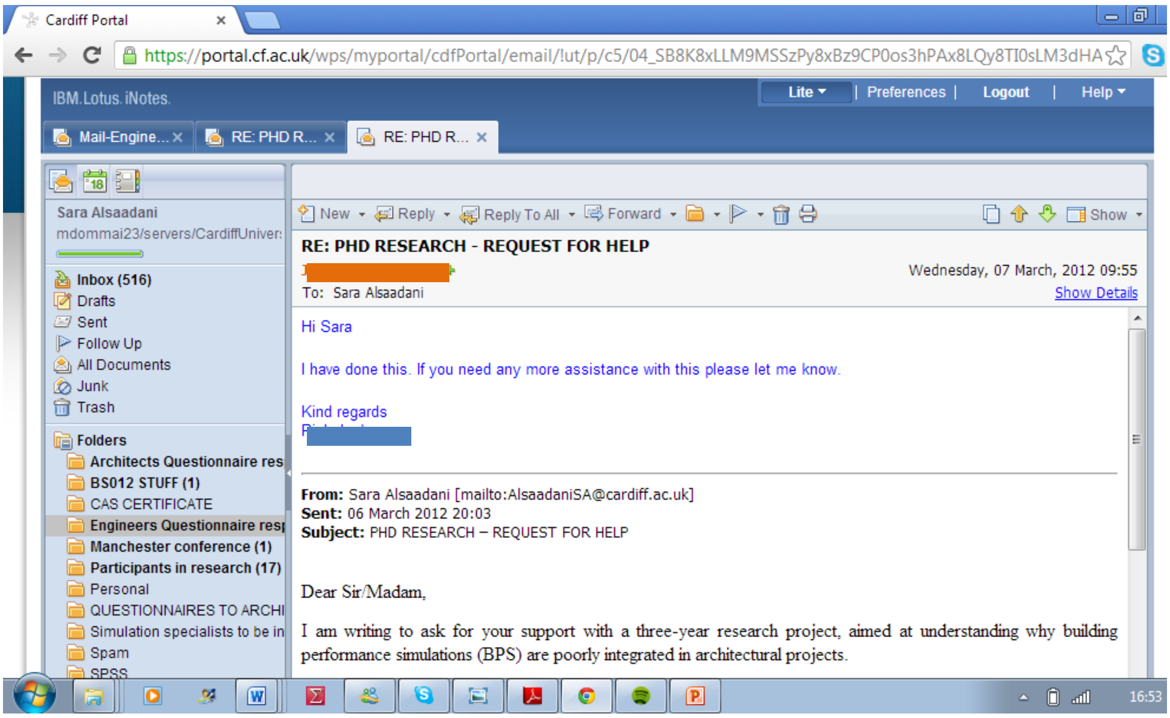
BSc(hons), MSc, AMInstP

Sustainability Consultant

[redacted]

Celebrating 150 years of engineering excellence

Tel [redacted]



RE: PHD RESEARCH - REQUEST FOR HELP

[redacted]

Wednesday, 07 March, 2012 09:55

To: Sara Alsaadani

Hi Sara

I have done this. If you need any more assistance with this please let me know.

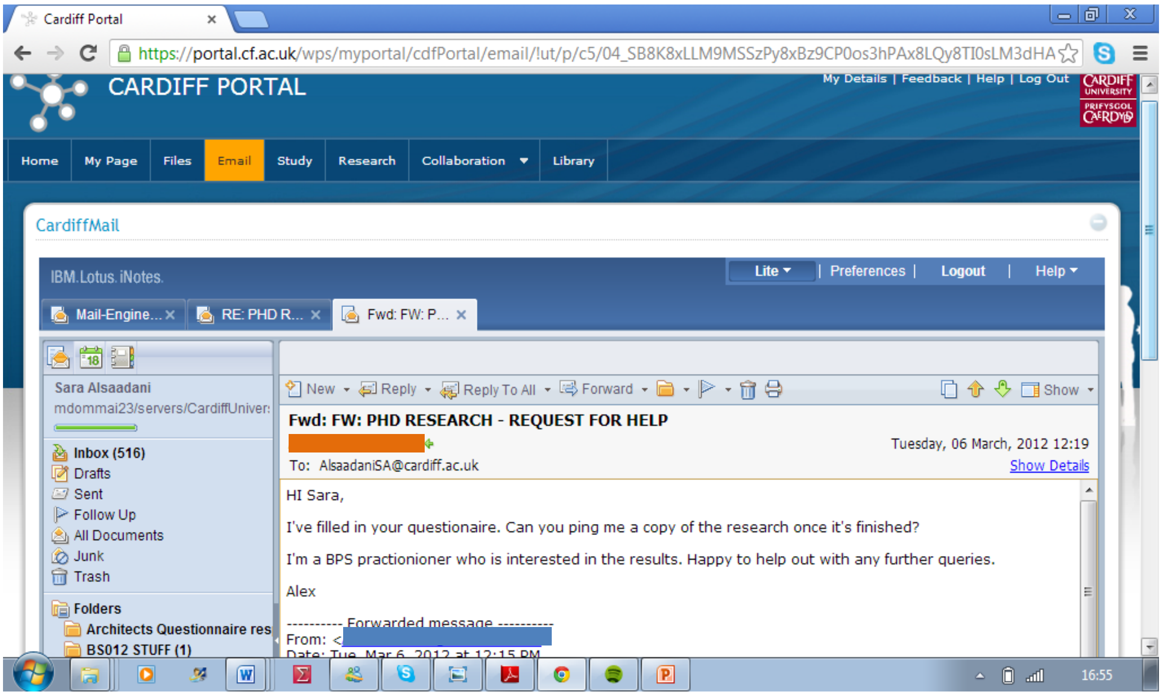
Kind regards

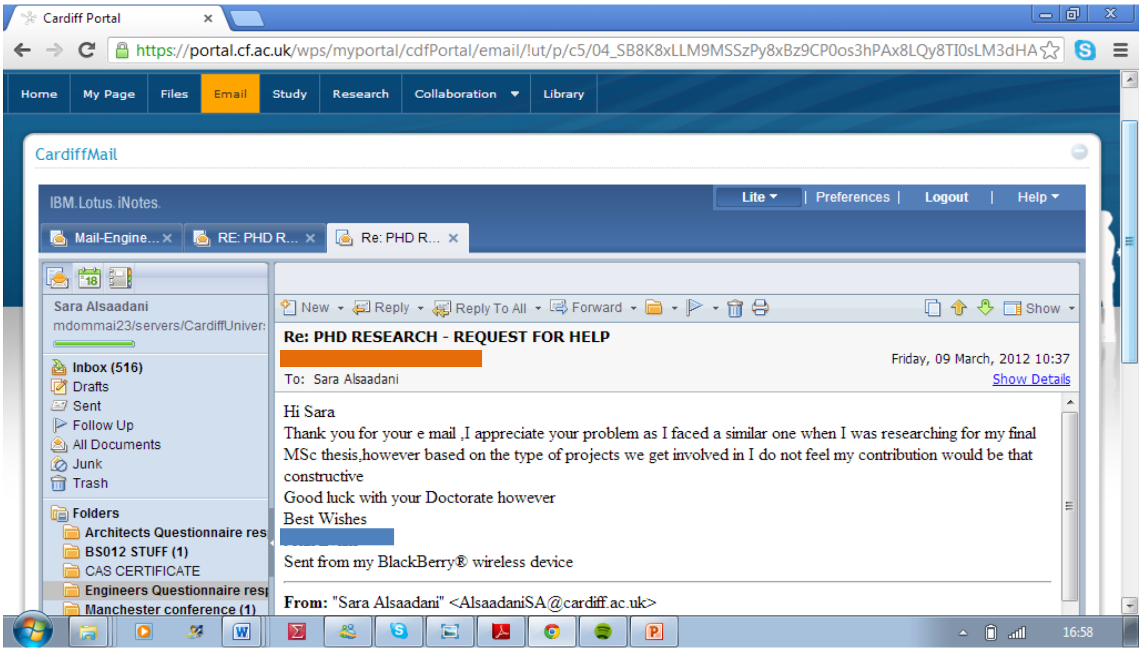
[redacted]

From: Sara Alsaadani [mailto:AlsaadaniSA@cardiff.ac.uk]
Sent: 06 March 2012 20:03
Subject: PHD RESEARCH – REQUEST FOR HELP

Dear Sir/Madam,

I am writing to ask for your support with a three-year research project, aimed at understanding why building performance simulations (BPS) are poorly integrated in architectural projects.


Cardiff Portal
https://portal.cf.ac.uk/wps/myportal/cdfPortal/email/!ut/p/c5/04_SB8K8xLLM9MSSzPy8xBz9CP0os3hPAx8LQy8TI0sLM3dHA
CARDIFF PORTAL
My Details | Feedback | Help | Log Out
Home
My Page
Files
Email
Study
Research
Collaboration
Library
CardiffMail
IBM Lotus iNotes
Lite
Preferences
Logout
Help
Mail-Engine...
RE: PHD R...
Fwd: FW: P...
Sara Alsaadani
mdommai23/servers/CardiffUniver
Inbox (516)
Drafts
Sent
Follow Up
All Documents
Junk
Trash
Folders
Architects Questionnaire res
BS012 STUFF (1)
New
Reply
Reply To All
Forward
Show
Fwd: FW: PHD RESEARCH - REQUEST FOR HELP
[redacted]
Tuesday, 06 March, 2012 12:19
To: AlsaadaniSA@cardiff.ac.uk
Show Details
HI Sara,
I've filled in your questionaire. Can you ping me a copy of the research once it's finished?
I'm a BPS practionioner who is interested in the results. Happy to help out with any further queries.
Alex
---------- Forwarded message ----------
From: <[redacted]
16:55


Cardiff Portal
https://portal.cf.ac.uk/wps/myportal/cdfPortal/email/!ut/p/c5/04_SB8K8xLLM9MSSzPy8xBz9CP0os3hPAx8LQy8TI0sLM3dHA
Home
My Page
Files
Email
Study
Research
Collaboration
Library
CardiffMail
IBM Lotus iNotes
Lite
Preferences
Logout
Help
Mail-Engine...
RE: PHD R...
Re: PHD R...
Sara Alsaadani
mdommai23/servers/CardiffUniver
Inbox (516)
Drafts
Sent
Follow Up
All Documents
Junk
Trash
Folders
Architects Questionnaire res
BS012 STUFF (1)
CAS CERTIFICATE
Engineers Questionnaire res
Manchester conference (1)
New
Reply
Reply To All
Forward
Show
Re: PHD RESEARCH - REQUEST FOR HELP
[redacted]
Friday, 09 March, 2012 10:37
To: Sara Alsaadani
Show Details
Hi Sara
Thank you for your e mail ,I appreciate your problem as I faced a similar one when I was researching for my final MSc thesis,however based on the type of projects we get involved in I do not feel my contribution would be that constructive
Good luck with your Doctorate however
Best Wishes
[redacted]
Sent from my BlackBerry® wireless device
From: "Sara Alsaadani" <AlsaadaniSA@cardiff.ac.uk>
16:58

APPENDIX I – Papers written and published from the PhD:

- Alsaadani, S. and Poveda, M. G. Z. 2011. Deciphering Design Process; Using qualitative methods to inform collaborative built environment research. *In:* Ruddock and Chynoweth eds. *COBRA 2011 Proceedings of RICS Construction and Property Conference*, September 12-13, 2011, Salford, UK, 1260-1271.

- Alsaadani, S. and Bleil De Souza, C. 2012. The social component of building performance simulation; Understanding architects. *In:* Cook, Wright and Mourshed, eds. *BS012 Building Simulation and Optimization*, Loughborough, UK, September 10-11, 332-339.

- Bleil De Souza, C. and Alsaadani, S. 2012. Thermal zoning in speculative office buildings: Discussing connections between space layout and inside temperature control. *In:* Cook, Wright and Mourshed, eds. *BS012 Building Simulation and Optimization*, Loughborough, UK, September 10-11, 417-424.